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ESTUARIES ON THE EDGE:

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The Vital Link Between Land and Sea

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The Vital Link Between Land and Sea

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Foreword by Ted Danson

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Founded in 1987, American Oceans Campaign
is a non-profit organization dedicated to the protection of marine ecosystems.

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American Oceans Campaign's Mission Statement

The Earth's environment is dependent upon a healthy ocean. Healthy oceans are in turn dependent upon our willingness to protect and preserve marine ecosystems. American Oceans Campaign (AOC) is using all of its resources to protect the vitality of America's and the world's coastal waters, estuaries, wetlands, and deep oceans.

AOC's approach to fulfilling this responsibility is to educate the public and local, state, federal, and international decision-makers on the need to stop abusing marine and coastal environments. AOC focuses on establishing strong public policy to protect these resources. AOC is committed to active grassroots support and scientific information as the key ingredients to making public policy.

AOC is equally committed to bringing to the ocean debate diverse coalitions of local, regional, and national environmental groups, elected officials, corporations, religious groups, labor, people of color, Native Americans and the women's movement. Ours is a mission of change. We invite all segments of society to join us.

With offices in Santa Monica, California and Washington, D.C, AOC has a full-time staff of ten, consisting of environmental attorneys and marine/coastal policy experts.

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—Dawn

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Foreword

by Ted Danson, President of American Oceans Campaign

Oceans are truly miraculous bodies of water spanning across 70 percent of the surface of this planet. Like the Earth, the human body is comprised of 70 percent water. Ironically, we also share the same percentage of salt in our veins as that found in the ocean.

Estuaries are the life force of the oceans. Serving as the transition zone between the land and the sea, estuaries provide the perfect metaphor to help us better understand the connections between ourselves and the oceans. Almost everything we put on the land runs off into the rivers and streams that wind through the country, eventually flowing into our estuaries and oceans. Freshwater from these rivers and streams, when mingled with the ocean's saltwater, forms the basis of the estuarine ecosystem. Saltwater makes up 97.5 percent of all the water on earth, leaving only 2.5 percent as freshwater. Therefore, the importance of allowing this natural mixing to occur without the invasion of pollutants is critical.

Estuaries, like the oceans and the human race, are resilient. Although fraught with pollution and suffering from the loss of habitat, they are still some of the most biologically productive and valuable ecosystems on earth. Amazingly, they produce more food per acre than the most productive midwestern farmland. The richness provided by estuaries can be seen both in terms of supporting living aquatic resources and in their role as economic engines for our society. About 75 percent of all fish and shellfish in the United States use estuaries as primary habitat, or as spawning or nursery grounds. This gains added significance when you realize that commercial and recreational fishing contribute $111 billion to the nation's economy and 1.5 million jobs.

Within reason, estuaries have the ability to protect themselves and the oceans from abuse. For example, most estuaries are bordered by protective natural barriers known as wetlands, that filter out pollution before it reaches the water. Some estuaries have sand dunes or surrounding barrier islands that absorb storm surges and protect against upland flooding. However, our natural coastlines have become so seriously degraded and developed that many of these natural filters and protective barriers no longer exist. All systems, be they estuarine or human, have limitations. If we continue the current level of assault and abuse, they will eventually fail to function and die. We must now work to restore these important resources.

American Oceans Campaign is a growing movement of individuals who understand the significance of our links to the oceans — and who want to actively work to protect these gifts for future generations. We view the oceans as our life-support system that we must work together to protect. We know that the health of our bodies is truly connected to the health of the oceans. As humans, we are dependent on the oceans for the oxygen that we breathe and for the food that sustains us. Yet, unfortunately, most of our daily actions on land inevitably harm the sustainability of the oceans.

American Oceans Campaign is pleased and honored to have the opportunity to work with such a renowned group of local experts as the members of the National Coastal Caucus. It is their expertise that has guided us in our efforts and their dedication that gives us hope for the future.

It is because of this valuable link to the oceans and ultimately to us, that American Oceans Campaign works fervently to protect estuaries. We hope that as you read this report, you will grow in your understanding of these connections and join with us. The oceans gave us life, it is time we returned the favor.

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Overview

by Robert Sulnick, Executive Director of American Oceans Campaign

Without a healthy ocean you can not have a healthy planet. The life force of the ocean germinates in the estuaries, from the wetlands out to the continental shelf. What this means is that all of the toxic waste to which we are addicted ultimately winds up in these tremendously rich and productive ecosystems. In addition to the toxic poisons, habitat destruction and sewage produced by our communities wreak havoc on our nation's estuaries. As the human population continues to increase by 90 million people each year, the stresses on our coastal waters become even more immense.

The resulting problems can, however, be resolved. In the United States, the protection of our nation's waters is governed by a number of federal and state laws, including: the Clean Water Act, Ocean Dumping Ban Act, Coastal Zone Management Act, Coastal Barriers Resources Act, Marine Plastics Pollution Research and Control Act, Marine Protection Research and Sanctuaries Act, and Oil Pollution Act. Clearly, the most important statute overseeing the protection of our estuaries is the Clean Water Act.

The original Clean Water Act (CWA) was signed into law in 1972. Since that time, with every reauthorization, Congress has acted to strengthen the law protecting our nation's waters. Then suddenly in January, 1995 we were faced with the new 104th Congress, which brought a dramatic change to our nation. The new Republican leadership proudly announced the agenda for their "revolution" and for the first time in history we were faced with a Congress intent on turning back the clock on environmental protections!

The dismantling of the CWA and other major environmental statutes began with what the new Congressional leadership referred to as their "Contract with America." Under the guise of ridding the country of bureaucracy and big government, and without ever mentioning the word "environment," the House of Representatives passed legislation to repeal 25 years of environmental and public health protections. Hidden in technical language, within budget bills, and in other unlikely pieces of legislation, they slipped in proposals to repeal some of the most important laws on the books. It took quite a while before the nation became apprised of what was really happening. Since this secret attack occurred with very little public debate, most Americans were unaware of the consequences of their actions in support of the Contract.

Unbelievably, this stealth attack was not enough to satisfy the corporate allies of the new Congressional leadership. Their actions became more direct. Feeling confident after a few initial victories, the new Congress began to blatantly reveal their extremist agenda by developing proposals to exempt certain big industries from complying with environmental laws.

Probably the most egregious assault was conducted by the House of Representatives in May of 1995. Although our nation has made tremendous strides in improving water quality since the first Clean Water Act was enacted, the 104th Congress was intent on gutting the Act. On May 16, 1995 the House passed H.R. 961 a bill that essentially repealed the Clean Water Act and gave special exemptions to big business and industry, thereby allowing pollution with impunity. The health of the nation's coastal waters, in particular estuaries, is absolutely dependent upon a strong CWA. Yet, H.R. 961 put these tremendously valuable resources in jeopardy by weakening virtually every provision of the existing law. The provisions in H.R. 961 mean that estuaries are likely to suffer some of the most dire consequences of these politically motivated actions.

Estuaries are among the most productive natural systems on earth, but they are extremely sensitive to changes in water quality and the loss of habitat. A

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few examples of how passage of H.R. 961 puts estuaries at risk include: weakening the toxic industrial discharge permitting program; exempting municipalities from the secondary treatment standard for sewage; gutting the program that addresses polluted runoff in coastal areas; interminably postponing the stormwater control program; and accepting a completely unscientific definition of wetlands resulting in the abolishment of any meaningful national protections. Since so many upland waters eventually end up in the ocean by passing through rivers and into estuaries, the weakening of any of the Clean Water Act's numerous provisions will mean less protection for our estuaries.

The National Estuary Program (NEP), section 320 of the CWA, directs the Environmental Protection Agency to identify estuaries of "national significance" and to assist communities in developing a plan to protect and restore them. If anything even closely resembling H.R. 961 becomes law, the NEP will become meaningless. It has been proven time and again that it is more efficient and cost-effective to prevent pollution in the first place, rather than to clean it up after the fact. By allowing polluters to have a free hand in regulating themselves, Congress is essentially giving away irreplaceable national resources in an act of blatant disregard for the public interest.

This report examines the values of and the threats to 28 estuaries, and how the NEP is working to help protect these valuable resources. The clock is ticking for these "nationally significant" estuaries, which have already been polluted and need further protection. As my friend Representative George Miller (D-CA) once said: "American Oceans Campaign is about a generational gift from one generation to another. Eventually all of our bad habits end up in the ocean and coastal waters, either through acid rain or water pollution, and we've got to understand that we must change those habits because if we in fact preserve the oceans, we have preserved the planet."

Now is the time to act to strengthen estuary protections, not to turn our back on them. We hope you agree and find this a valuable resource to help you meet this task.

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Introduction

Estuaries: Ecosystems on the Edge

Estuaries are dynamic bodies of water along our nation's coasts that are formed by the mixing of freshwater from rivers and streams with saltwater from the ocean. Typically, these waters are semi-enclosed by surrounding mainland, fringing wetlands, peninsulas, or barrier islands. Many of the renowned water bodies of the United States are estuaries — San Francisco Bay, Chesapeake Bay, Puget Sound, Long Island Sound, Casco Bay, and Tampa Bay, for example. In addition to bays and sounds, estuaries are commonly known as lagoons, sloughs, bayous, and inlets.

The intermixing of fresh and saltwater in this transition zone creates a distinct environment where aquatic communities thrive. An abundance of land and ocean nutrients, ample light which promotes the growth of aquatic vegetation, and a continuous mixing of the system by winds, tides, and river inflows create conditions which give life to some of the richest and most productive ecosystems in the world.

Each estuary is a unique blend of ecological, climatological, and geographical features. A sound, such as Puget Sound with an average depth of 450 feet,[1] is typically a deep estuary comprised of a long and wide ocean inlet. A lagoon, such as the Indian River Lagoon with an average depth of three feet,[2] is a shallow water body separated from the ocean by sandbars or coral reefs. A bay may have varying depths but can be distinguished by the fact that its outlet to the ocean allows currents to create distinct water circulation patterns.[3] The Chesapeake Bay, with a average depth of 24 feet, is the largest estuary in the United States.[4]

The values and functions of estuaries are considerable. Estuaries and their fringing wetlands play important roles in flood and erosion control, pollution filtration, water quality protection, wildlife conservation, fish production, coastal storm protection, and recreation. Many finfish and shellfish species depend upon estuarine habitats as primary habitat, or as spawning and nursery grounds. Estuaries provide essential habitat for over 75 percent of the United States' commercial fish catch.[5] In some areas of the nation, this percentage is even higher. In the Gulf of Mexico region, an estimated 90 percent of the commercial fish and shellfish species use coastal wetlands during one or more stages of their life.[6] Scientists have determined that estuaries produce more food per acre than the most productive mid-western farmland.[7]

Ironically, the allure of these areas jeopardizes their health and productivity. To support growing populations along the coasts, estuaries are frequently overused and misused by society. Over 45 percent of the nation's population lives in estuarine areas[8] — this percentage is expected to grow dramatically during the next few decades. Unfortunately, estuaries are disposal sites for human and industrial wastes; are dredged to create navigational routes for large ships, oil tankers, and other boats; supply "cooling waters" needed by power generation plants and other industrial operations; and receive various contaminants that stormwater picks up from streets, lawns, and construction sites. Estuarine wetlands, such as salt marshes and mangrove forests, are destroyed in order to open up areas for more shoreline development. The floors of estuaries are damaged by the accumulation of sediments, toxics, and nutrients, and by the dumping of dredged materials. These activities, along with others, have diminished the once-unquestioned appeal of these areas.

However, it is not just human activities along the coasts of estuaries that threaten these waters; activities throughout the estuary's entire watershed affect its water quality and productivity. Watersheds are generally defined as the geographic land area in which water runs off or drains into rivers, lakes, coastal waters, or estuaries. Many of the nation's estuaries have extensive watersheds which encompass portions of several states. For example, the watershed of Long Island Sound includes portions of New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont and Canada.

The countless benefits that estuaries provide make it essential that society protect these valuable ecosystems. Fortunately, the public is beginning to understand that significant economic resources are directly dependent upon the health and stability of estuaries. A national poll conducted after the "first 100 days" of the 104th Congress revealed that almost 69 percent of the public believes that environmental protection and economic development can go hand-in-hand.' Even when a choice must be made between the two, the public elects environmental protection over economic development — 63 percent to 23 percent in this May, 1995 poll.[10] In addition, 91 percent of the public thinks that laws and regulations designed to control water pollution are just about right or are not strict enough.[11]

With increased public education and the support of national, state, and local policymakers, we can overcome the failings of the past and protect our nation's estuaries for the future. The facts are clear, efforts at estuarine protection must advance, not retreat.

The Values of Estuaries

Estuaries are biologically rich and productive systems.

Since estuaries exist in the zone where rivers and streams meet the sea, plants and animals which are adapted to saltwater, freshwater, and brackish water inhabit these ecosystems. Transitional zones, or areas where two ecological zones meet, are more biologically rich because species from both zones coexist, forming unique ecological communities. In addition, many terrestrial and aquatic species inhabit estuarine areas.

The constant interchange of nutrients and the availability of sunlight in estuaries make these waters so productive. The shallow depth of some estuarine waters creates an environment in which significant amounts of sunlight can reach submerged aquatic plants, producing thriving benthic (bottom) plant communities. Microscopic organisms, known as phytoplankton, form the basis of the estuarine food chain. Large populations of aquatic life which depend on phytoplankton and lush underwater grasses flourish beneath the shallows of these waters. As a result, estuaries with high phytoplankton productivity support many animals. Studies in the early 1980s revealed an average of 8,700 organisms per square meter inhabited Casco Bay.[12]

Estuaries provide valuable commercial benefits and recreational opportunities.

The ecological productivity and broad appeal of estuaries make these coastal areas some of the most valuable "living places" in our nation. By the year 2010, it is estimated that more than 75 percent of the United States population will live within 50 miles of the coast.[13] The richness that estuaries bring to communities ranges from providing economic necessities to offering enjoyment for tourists. The beautiful vistas provided by our coasts have awed and inspired humans for centuries.

For many residents of coastal communities, estuaries and their resources are important for the livelihood of families. Approximately 28 million jobs are generated by commercial fishing, tourism, water-dependent recreation, and other industries based near estuaries and other coastal waters.[14] It is estimated that commercial and recreational fishing contribute $111 billion to the nation's economy and generate 1.5 million jobs.[15]

The nation's commercial fishing industry depends heavily on healthy estuaries and estuarine wetlands. Approximately 75 percent of the United States' fish catch uses estuaries during at least one stage of life — usually, the early stages of life. For juvenile fish and shellfish, lush eelgrass beds, seagrass beds, marshes, mangroves, and coral reefs provide food and shelter. Many of these species migrate to other waters, where they are commercially and recreationally caught.

Just as coastal populations have grown, so have the number of tourists who vacation along ocean and estuarine beaches. Sunbathing, swimming, surfing, beach combing, diving, snorkeling, nature watching, fishing, and pleasure boating provide enjoyment for millions of

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Why Protect Estuaries?

- Estuaries are among the most productive natural systems on earth. Estuaries produce more food per acre than the most productive midwestern farmland.
- Estuarine areas are home to over 45 percent of the United States' population.
- Estuaries and other coastal waters provide more than 28 million jobs for our nation.
- Over 75 percent of the United States' commercial fish catch depends on estuaries. In the Southeastern United States, 98 percent of the commercial catch and over 50 percent of the recreational catch are comprised of fish and shellfish that are dependent on estuarine and coastal wetlands.[1]
- An estimated 75 percent of Florida's game fish species and 90 percent of its commercial fish species depend on mangroves, a distinctive type of coastal wetland.[2]
- The economic value of commercial fisheries supported by estuaries is at least $18 billion annually.[3]
- Commercial and recreational fishing contribute $111 billion to the nation's economy and support 1.5 million jobs.
- Gulf of Mexico coastal wetlands provide essential habitat for 75 percent of United States' migratory waterfowl.[4]
- Approximately 45 percent of the nation's endangered and threatened species inhabit coastal areas. Almost 75 percent of the endangered and threatened mammals and birds rely on these coastal habitats.[5]
- About 80 percent of all fish and shellfish world-wide use estuaries as primary habitat, or as spawning or nursery grounds.[6]
- Thirty-one percent of the United States Gross National Product is produced in coastal counties.[7]

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people who visit our nation's coasts. However, very little national data have been compiled to help quantify the economic benefits derived from these activities. Thus, placing a dollar figure on these values is a difficult, if not impossible, task. Yet, some have tried to develop calculation methods. The existing information is sparse and hard to assess because most communities use different economic assumptions and baseline data in their analyses. Several studies simply highlight the vast numbers of people who depend upon clean and healthy coastal resources for recreational enjoyment. Examples of some of the more interesting statistics are listed below:

- In 1993, more than 180 million Americans visited coastal waters nationwide.[16]
- In 1991, 73.4 million recreational boaters spent $10.5 billion for products and services.[17]
- Over 35.5 million fresh- and saltwater anglers spent 511 million days fishing, in 1991.[18]

The tourism industry is beginning to gather data demonstrating the importance of coastal tourism to the national economy. Recent calculations of the revenue generated by coastal tourism include the following: $21.6 billion in Florida (1994); $12.1 billion in New Jersey (1994); $4.6 billion in Texas (1993), and $38 billion in California (1992).[19] The tourism industries of these and other coastal states depend on clean, safe waters.

In terms of economic output, the sport fishing industry contributes more to the United States' economy than the commercial fishing industry. Of the $111 billion in economic output that fishing generates for the national economy, sport fishing accounts for $69.4 billion.[20] Angler expenditures for fishing equipment, boats, and other trip-related services support thousands of small businesses across the nation. It is estimated that the sport fishing industry of the United States supports a total of 924,600 full-time jobs.[21] Over 205,000 of these full-time jobs are generated by saltwater sport fishing.[22]

As more research has uncovered the economic value of estuaries, people's willingness to support and maintain the environmental health of these systems has become more evident. For example, in the Galveston Bay area, a recent study indicates that the average household is willing to add seven dollars per month to its utility bill to restore the Bay.[23] Increasing property taxes within coastal communities also contribute significantly to local economies. Waterfront real estate taxes in the coastal counties of Florida sometimes comprise as much as 20 percent of the total property taxes paid.[24]

Estuarine systems improve water quality and perform life-sustaining functions.

Estuarine systems serve as filters for pollution. For example, the roots of mangroves and the shoots of salt marsh plants, situated along the shoreline of estuaries and their tributaries trap sediments, nutrients, toxic chemicals, pathogens, and other contaminants carried by water flowing into the wetland area. The contaminants eventually settle into the soils and are neutralized. By reducing the amounts and concentrations of contaminants, these natural areas protect the estuary's water quality, habitat, and wildlife. However, due to their shoreline location, many of these areas are primary targets for coastal development projects. When shorelines are developed and replaced by impervious surfaces, such as roofs and pavement, the beneficial filtering functions of these natural areas are lost.

Estuaries also support many filter-feeding organisms which help maintain clean waters. Healthy populations of filtering organisms, such as oysters, clams, and mollusks, contribute significantly to water filtration. One oyster, for example, while feeding on plankton, filters 25 gallons of seawater per day, or 27,375 gallons in a four-year life span.[25] Filter-feeding organisms accumulate pollutants in their tissues as they filter contaminated waters. Pathogens in these molluscan shellfish may be passed on to humans eating raw or partially cooked shellfish.[26]

The connection between human health and estuarine health is obvious for certain activities, such as eating estuarine-dependent fish and shellfish, or swimming. What is less obvious is that estuarine watersheds also provide critical drinking water sources for much of the nation. Approximately 10 percent of the entire United States' population, from New York City to Wilmington, Delaware, relies on tributaries of the Delaware Estuary watershed for drinking water.[27] Likewise, the freshwater of the San Francisco Bay's watershed is a precious commodity, supplying drinking water to 20 million people. Further, many competing agricultural and industrial uses of this water provide for economic stability in the San Francisco Bay region.[28] This further attests to the direct link between human health and estuaries, and the need to protect these life-sustaining waters.

Estuarine wetlands and barrier islands protect shorelines and inland areas from coastal storms and flooding.

Salt marshes, mangrove forests, freshwater marshes, forested wetlands, and barrier islands create natural buffers that minimize the impacts of coastal storms and wind on coastal and inland habitats. Coastal wetlands are able to withstand major storms without suffering lasting damage, while at the same time, protecting inland communities. In Florida, for example, thick mangrove stands stabilize the shore and prevent the damaging impacts of storm events.

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In addition, wetlands have the capacity to temporarily store large quantities of flood waters, releasing waters over an extended period of time into groundwater and adjacent waterbodies.

Estuaries support many plant and animal species.

Estuaries and their adjacent lands support a variety of habitats for plants and animals. Distinctive estuarine habitat types include eelgrass beds, seagrass beds, kelp beds, mangrove forests, salt marshes, freshwater marshes, upland forested wetlands, barrier islands, sand dunes, open waters, and others.

Many of these habitats support commercial and sport fish species. Lobsters, crabs, shrimp, oysters, scallops, and clams are examples of shellfish that depend on estuarine systems. Estuarine-dependent finfish species include menhaden, cod, flounder, spotted seatrout, mullet, and striped bass. In addition, anadromous fish (species that migrate from the ocean to freshwater streams in order to spawn), such as salmon, steelhead, shad, smelt, and alewife use estuaries during their migrations.

Colonial waterbirds, shorebirds, songbirds, seabirds, waterfowl, and raptors use estuaries and estuarine wetlands for a variety of purposes, including breeding, nesting, and foraging. In addition, estuaries provide feeding and resting points during bird migrations. Dynamic and colorful songbird species flourish in estuaries, estuarine wetlands, and adjacent upland habitats. Approximately 50 percent of the nation's migratory songbirds are linked to coastal habitats; while nearly 30 percent of North American waterfowl depend upon coastal habitat for wintering grounds.[29] For several endangered and threatened bird species, estuaries provide critical habitat. The bald eagle, piping plover, roseate tern, least tern, Aleutian Canada goose, wood stork, and whooping crane are a few of these protected species for which estuarine areas are vital.

Finally, both marine and terrestrial mammals inhabit estuarine areas. Some examples of these inhabitants include manatees, bottle-nosed dolphins, porpoises, seals, muskrats, beavers, and otters. Reptiles and amphibians, including numerous sea turtle species which are threatened or endangered worldwide, also use these aquatic habitats.

Threats to our Estuaries

Estuaries are adaptable ecosystems. However, they have not been able to adapt to the human impacts associated with rapid development and population growth. Because of their shallow depths and limited circulation, estuaries are highly susceptible to environmental degradation.[30] Historically, these waters have served as repositories for society's sewage, toxins, and garbage. In addition, estuarine wetlands and shorelines have been destroyed or modified to accommodate the pressures of development. After decades of abuse, these waters have become severely stressed.

In recent years, accounts of the impaired quality of estuarine waters and the diminishing productivity of these areas have been noted. Throughout the nation, degraded estuaries have led to the loss of commercial fishing jobs, closed shellfish harvesting areas, oxygen-depleting algal blooms and subsequent fish kills, and increased coastal storm damage due to the loss of wetlands and other natural lands. We are learning that our misuse and overuse of estuaries are threatening the viability of these ecologically and economically valuable waters.

The predominant human-induced threats to estuaries and estuarine waters are population growth and development, habitat loss, and pollution. According to State water quality reports submitted to EPA, 43 percent of the nation's assessed estuaries do not fully support one or more of their designated uses due to pollution and habitat degradation.[31] The degradation of our nation's estuaries should serve as an impetus to change our attitudes and behavior. The continued vitality of these systems and the economic stability of coastal communities and states hang in the balance.

Estuaries are harmed by population growth and coastal development.

The proximity of most estuaries to major population centers makes them especially vulnerable to pollution and dramatic habitat losses. In fact, human impacts are so far-reaching that even estuaries that are not considered urbanized are experiencing degradation. According to the National Academy of Sciences, unmanaged growth and development are the principal causes of water quality degradation, and of fish and wildlife declines in coastal areas.[32] A rising population means the generation of more waste, and in turn, increased stress on the systems designed to treat waste. Sewage treatment plants and individual septic systems have to be rigorously maintained in order to prevent malfunctions and the release of raw or partially treated sewage into estuaries. In addition, more nutrients, toxic chemicals, and other pollutants are inputted into the estuarine watershed as a result of population growth. Finally, as soils and wetlands are covered by impervious surfaces, such as pavement and roofs, their natural functions of pollution filtration and water absorption are lost.

Though coastal counties only comprise 11 percent of the nation's total land area (excluding Alaska),[33] during the past few decades estuarine areas have become popular places for people to live. Currently, population densities in coastal areas are four times greater than the national average.[34] Forty-five percent of the nation's population resides in estuarine areas.[35]

Large numbers of tourists visit our nation's coasts throughout the year, adding to the stresses already put upon these areas by year-round residents. For example, during the summer months, the Peconic Bays' area population exceeds 280,000 people — an increase of 165,000 people (or 143 percent) from the year-round resident population.[36] By the year 2000, the area's summer population is expected to be 365,000.[37] Although these conditions are normally limited to certain seasons, population surges do affect the water quality and habitat of estuaries.

Estuarine systems are degraded by the destruction of essential habitat.

Activities to support coastal populations and the growing recreational uses of estuaries are destroying their vital, natural habitats. Physical modifications of habitat and increased pollution loadings to estuaries are major causes of impairment of these waters.

Coastal wetlands, submerged aquatic vegetation, sand dunes, and beaches are typically the most threatened habitats of estuarine systems. Wetlands which line the shores of estuaries, such as mangroves and marshes, have been destroyed for commercial and residential development, mosquito control projects, marina and pier construction, agricultural production, highway construction, and other projects. The valuable functions of wetlands, ranging from providing fishery habitat to filtering pollution, are lost after these areas are destroyed.

In the 48 contiguous United States, over 104 million acres of our original wetlands base have been lost[38] — roughly, an area the size of California.[39] In addition, 92 percent of the original wetlands base of the San Francisco Bay area has been lost.[40] Presently, the United States continues to lose wetlands at a rate of 290,000 acres per year.[41] The State of Louisiana loses approximately 60 square miles of wetlands each year — many of which are coastal marshes.[42]

Submerged aquatic vegetation, such as eelgrass and seagrass beds, is damaged by dredging activities, boating activities and increased sediment and nutrient loadings into the estuary. Dredging operations to deepen navigational routes for ships occasionally dump dredged spoils on the estuary's floor, smothering submerged aquatic vegetation. In addition, increasing amounts of land-based sediments and nutrients associated with human activities are carried by rivers and streams to estuaries, creating turbid, cloudy conditions. When estuarine waters become too cloudy, sunlight cannot penetrate to the bottom, thereby, inhibiting plant growth. Between 1950 and 1982, seagrass coverage in Tampa Bay decreased from 40,627 acres to 21,647 acres — a 47 percent reduction[43] — because of increased pollution, development, and boating activities. Since 1982, seagrass coverage in the Bay has increased due to replanting efforts organized by local communities.

Sand dunes serve as natural protective barriers for inland coastal areas, buffering wind and wave action from storms. However, as development has affected areas closer to the water, sand dunes have become replaced by man-made erosion control structures, such as groins and jetties. Groins and jetties are built to keep sands from being deposited in shipping channels and currents. However, these

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structures also trap sand that, as part of the natural cycle of ocean currents, is likely destined for a neighboring beach, accelerating erosion.[44]

The rapid rate of development in many coastal communities has resulted in the destruction and modification of natural soils and vegetation. Replacing these natural areas with impervious surfaces, such as pavement and roads, allows greater concentrations of contaminants to discharge into estuaries through stormwater and snow melts. Unlike the natural soils and vegetation found in the estuarine watershed, concrete does not filter pollutants. The nutrients, pathogens, and toxic chemicals found in polluted runoff, stormwater, and snow melt impair the water quality and submerged aquatic vegetation of estuaries. With less natural soil coverage to absorb excess waters during storm events, greater flows of stormwater drain into estuaries. The increased flows also scour stream banks and deposit more sediments into estuaries.

In addition, loss of estuarine habitat causes dire consequences for aquatic animal populations. Underwater eelgrass beds serve as critical habitat for commercial and recreational shellfish and fish. As a result of pollution and habitat loss, shellfish populations have been reduced to fractions of their historic levels. Numerous species of threatened and endangered animals and plants depend on estuaries and coastal areas for essential habitat. These population declines should alert us to the importance of restoring these vitally important systems.

Pathogen contamination in estuaries closes shellfish beds and beaches.

Pathogens are disease-causing agents, such as bacteria and viruses, found in human and animal wastes. Pathogen contamination results when raw or inadequately treated sewage is discharged into estuaries. There are a number of potential sources of pathogens in the nation's estuaries, including individual septic systems, sewage treatment plants, combined sewer overflows (CSOs), agricultural runoff from pastures and farms, stormwater, and recreational boats.

In many estuaries, problems associated with human waste disposal are leading to pathogen contamination. Malfunctioning or improperly-sited individual septic systems can lead to wastewater leaching into the soil, eventually contaminating groundwater that leads to estuaries. In addition to septic systems, overloaded sewage treatment plants are responsible for introducing raw or partially treated sewage into estuaries. If too many homes and businesses are connected to a public treatment plant, the facility cannot adequately treat the wastewater prior to discharge.[45] In many communities, concerted efforts are underway to upgrade sewage treatment infrastructure and provide alternatives for homes with septic systems, in an attempt to reduce levels of pathogen contamination. Combined sewer overflows (CSOs) occur in sewer systems which combine stormwater drains with sewage conveyance lines. During heavy rains, these combined pipes are diverted to outfall points rather than proceeding to the wastewater treatment plant. As a result, raw or partially treated sewage is discharged into the nation's waters. Combined sewer systems serve over 40 million people in the United States[46] — including many residents of coastal cities. Finally, boaters who illegally dispose their waste directly overboard introduce pathogens to estuaries. According to federal law, boat owners must either use on-board toilets or pump out their wastes at approved on-shore facilities.

People swimming in contaminated waters or eating contaminated seafood risk contracting cholera, gastroenteritis, hepatitis, typhoid, and other illnesses. For this reason, many coastal communities monitor bathing beaches and shellfish beds for the presence of pathogens. Protocols for monitoring beaches to promote swimmer safety and notifying the public when standards are exceeded vary from state to state, and frequently vary from county to county. New Jersey is the only State with a statewide beach testing program which uses a bacteria standard and testing protocol, and has compulsory beach closure/public notification requirements.[47] Since 1988, 12,472 bathing beaches throughout the United States were either closed or posted health advisories due to swimmer safety concerns.[48] This total number is low and does not account for the number of unsafe beaches that remained open due to

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the lack of regular monitoring in some areas of the nation.

Consumption advisories for seafood and fish have become commonplace throughout the nation. One out of every three shellfish beds is closed to harvesting because of contaminated shellfish.[49] For many estuaries, the percentage of harvest-limited (either closed, restricted, or conditionally open) shellfish beds was 100 percent in 1990. Sarasota Bay, Tillamook Bay, Morro Bay, San Francisco Bay, and Hudson River/Raritan Bay were a few of the estuaries with no shellfish harvesting acreage classified as "approved" in 1990.[50]

Excessive loadings of nutrients create oxygen-poor conditions in estuaries that sometimes lead to massive fish kills.

Nutrient over-enrichment is becoming a leading problem in our nation's estuaries. In fact, many estuary restoration plans point to excessive nitrogen loading as the greatest threat to the sustainability of the system. Low concentrations of nitrogen and phosphorus in estuaries enable algae and phytoplankton to grow. However, human-induced loadings of nitrogen and phosphorus are significantly upsetting the balance of estuarine life. Nitrogen and phosphorus are introduced to estuaries by municipal wastewater treatment plant effluent; agricultural runoff and stormwater containing crop and lawn fertilizers; and atmospheric deposition.

Excessive levels of nitrogen and phosphorus can adversely affect estuarine life by stimulating the intense growth of algae. Frequently, algae will grow so densely that they block valuable sunlight needed for the growth of submerged aquatic plants. After the algae die, their decomposition requires a great amount of dissolved oxygen. This depletes dissolved oxygen levels for other aquatic life of the estuary. The resulting low oxygen ("hypoxia") and no oxygen ("anoxia") conditions can sometimes lead to massive fish kills in estuarine waters. During the fall of 1995, the lower Neuse River, a tributary of the Albemarle-Pamlico Sounds, was the site of a massive fish kill. It is estimated that up to five million fish died from the toxic alga, *Pfiesteria piscimorte*.[51] Algal blooms in estuarine waters can also cause foul odors and respiratory discomfort for humans. The inundation of waters by excessive levels of nutrients is often referred to as eutrophication.

One of the leading sources of nitrogen in estuaries is atmospheric deposition. Fossil fuel combustive processes in electrical production and automobile use are major sources of nitrogen loadings to coastal waters. In the Chesapeake Bay region, for example, between 18 and 30 percent of the nitrogen entering the Bay comes from atmospheric deposition, a large portion of which is generated by motor vehicles.[52]

Toxic chemicals contaminate the sediments of estuaries and afflict aquatic life.

Heavy metals and organic chemicals impair many of our nation's estuaries and often cause reproductive and developmental complications, and diseases in aquatic life. These toxic substances enter estuaries through industrial and municipal discharges, polluted stormwater, agricultural runoff, marine vessels, and atmospheric deposition.

Many toxic substances do not degrade, but persist in the sediments of the estuary's bottom habitat where they are absorbed by plankton and other bottom-dwelling species which make up the basis of the estuarine food chain. Eventually, toxics "bioaccumulate" in the tissues of organisms and make their way throughout higher levels of the food chain, ultimately affecting fish, birds, and humans. Toxic contamination in humans may cause increased risk of cancer, neurological disorders, and birth defects. The "bioaccumulation" of toxic chemicals throughout the food chain presents particular problems for subsistence fishers in urbanized waters.

Some heavy metals commonly found in elevated levels in estuaries include arsenic, cadmium, chromium, copper, lead, mercury, and zinc. Organic chemicals, such as pesticides, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and dioxin, are also causing significant problems in our estuaries. Compounds containing chlorine and bromine are some of the most persistent toxic chemicals. PCBs and the banned pesticide DDT are familiar halogenated compounds that have remained in the estuarine environment for decades after their initial loading.[53] Dioxin is another persis-

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tent organic chemical that threatens estuarine aquatic life and increases human risk of cancer. Dioxin is a by-product of many industrial processes, such as bleaching paper pulp with chlorine and incinerating plastic-containing wastes. In February, 1994, health officials in Maine issued a consumption advisory for lobster tomalley due to unacceptably high levels of dioxin. Pregnant women, nursing women, and women of child-bearing age were warned that eating the tomalley would increase the risk of cancer.[14] In addition, a 1993 study conducted by American Oceans Campaign and the University of California at Los Angeles revealed the presence of 160 different toxins, many of which were mutagens and carcinogens, in five storm drains entering Santa Monica Bay. Both polychlorinated biphenyls (PCBs) and chlordane, banned from use in the 1970s, were among the poisons found in urban Los Angeles stormwater.[15]

Conclusion

The wealth of resources we gain from estuaries is in danger. As the human population has moved to these ecological edges, our insolent, polluting ways have followed closely behind. Our nation's estuaries deserve better. Estuaries have brought us life, nourishment, economic rewards, and cultural enrichment. It is time we strengthen our committment to protecting estuaries.

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National Estuary Program

In the mid-1980's, Congress began to recognize the need to focus federal attention on the environmental problems plaguing our nation's estuaries. Estuaries, the places where salt water and freshwater merge, are unique and highly productive waters that are critical to the ecological and economic bases of our nation. In particular, fisheries, wildlife, recreation, and tourism are heavily dependent on healthy estuarine systems. Yet, despite their value, almost every estuary in the United States is experiencing tremendous stress from pollution, development, and rapid population growth in coastal cities and counties.

Legislative History

During its consideration of the 1987 Amendments to the Clean Water Act (the Water Quality Act of 1987), Congress created the National Estuary Program (NEP). The NEP was established under section 320 of the Clean Water Act and was modeled after two other Clean Water Act (CWA) programs: the Great Lakes Program (section 118), and the Chesapeake Bay Program (section 117).

The Great Lakes Program is the oldest watershed program in the nation. Authorized in 1970, it includes both the United States and Canada. The Great Lakes Program involves a phased-in process that identifies and defines priority problems in the Lakes, establishes their probable causes, and develops solutions to address them. The 1977 Chesapeake Bay Program is a federal/state partnership, involving three States and the District of Columbia, created to improve the environmental quality of the Bay. The Chesapeake Program uses a collaborative problem-solving approach that involves all interested stakeholders in each phase of the Program, and secures commitments to carry out recommended actions. The lessons learned by these two federal legislative initiatives have helped lay the foundation for the NEP.

In the debate surrounding the authorization of the NEP, Congress clearly stated that it was in the national interest to maintain the ecological integrity of estuaries through the long-term planning and management program set forth under section 320. The purpose of the NEP is to address the many complex issues, including the increase in coastal population and the resulting demands for development, that contribute to the deterioration of the major estuaries in the United States. The goals of the Program include the protection and improvement of water quality, as well as the enhancement of living resources.

Background

The National Estuary Program is managed by the Environmental Protection Agency (EPA). The EPA is required to identify "nationally significant" estuaries and to coordinate the development of Comprehensive Conservation and Management Plans (CCMPs) to restore and protect the ecological health and biological integrity of these estuaries. Individual estuaries are nominated into the NEP by their respective Governors. The EPA Administrator then reviews the nominations and accepts estuaries into the Program on the basis of the following factors:

- the ecological significance of the estuary;
- the biological productivity of the estuary and its contribution to commercial and recreational fish and wildlife resources;
- the impact of commercial, residential, recreational, or industrial activities on the health of the estuary; and
- the degree to which comprehensive planning management may contribute to the ecological integrity of the estuary.

Over the years, the appeal of the participatory nature of the Program, and its goals have grown quite significantly. Since its formation, the NEP has expanded from six estuaries to its current list of 28. Of the

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estuaries that EPA has designated as "nationally significant," each is at a different stage of development: either creating a management framework; characterizing problems impairing the estuary; developing a comprehensive plan to address the problems; or implementing actions of the management plan.

Participation

Of the 23 States which border oceans, 17 have estuaries in the National Estuary Program. Although it does not border the Atlantic Ocean, Pennsylvania participates in the Delaware Estuary Program, due to the fact that a significant portion of the State lies in the watershed of the Estuary. Pennsylvania also participates in the Chesapeake Bay Program. In addition, Puerto Rico is involved in the NEP due to the designation of San Juan Bay as an estuary of "national significance."

The 18 States that currently participate in the NEP include: Alabama, California, Connecticut, Delaware, Florida, Louisiana, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Texas, and Washington. The estuaries and their corresponding States were integrated into the NEP in a phased-in process or "tiered" approach. Since 1987, EPA has expanded the Program every few years by designating a new "Tier" for inclusion in the NEP. Thus far, five "Tiers" (or groups) of estuaries have been established. The first Tier was established in 1987-88, Tier 2 was set up in 1988, Tier 3 in 1990, Tier 4 in 1992, and Tier 5 estuaries were designated in 1995.

The roots of the NEP actually go back further than the 1987 Amendments to the CWA. In response to a Congressional directive in 1985, EPA established four estuary programs: Narragansett Bay in Rhode Island, Buzzards Bay in Massachusetts, Long Island Sound in New York and Connecticut, and Puget Sound in Washington. A year later, EPA determined that the Program should be extended to two new coastal areas. So, in 1986 EPA added San Francisco Bay in California and Albemarle/Pamlico Sounds in North Carolina. Up to this point these Programs were supported by broad legislative authorities; but upon passage of the 1987 Amendments they were soon incorporated into the NEP.

In 1987 and 1988, NEP management conferences were convened for the six estuaries mentioned above, as well as for: New York - New Jersey Harbor Estuary, Delaware Inland Bays, Santa Monica Bay, Sarasota Bay, Galveston Bay, and Delaware Estuary. Five additional estuaries were added to the Program in 1990: Casco Bay, Massachusetts Bays, Indian River Lagoon, Tampa Bay, and Barataria-Terrebonne Estuary Complex. Peconic Bays, Tillamook Bay, San Juan Bay, Corpus Christi Bay were added in 1992. Finally, the most recent group of estuaries were added to the NEP in 1995. They included: Barnegat Bay, Maryland Coastal Bays, Columbia River, Mobile Bay, Morro Bay, New Hampshire Estuaries, and Charlotte Harbor.

Management Plan

The development of the CCMP is an arduous process. Identifying the priority problems and their solutions, and maintaining concurrence among all stakeholders throughout the process can be a difficult task. The CCMP is intended to address all uses affecting the restoration and maintenance of the chemical, physical, and biological integrity of the estuary. The plans typically include recommended actions on a full range of issues, such as habitat protection, polluted runoff controls, stormwater pollution, resource management, and land-use planning. The challenges addressed in the Plan can sometimes take decades to overcome. Therefore, it's critical that the Program ensure a high level of citizen participation in order to maintain long-term community support for implementation of the Plan.

Management Conference

Before work on developing the CCMP can commence, the EPA and the State(s) negotiate a Conference Agreement and convene a Management Conference. Members of the Management Conference include representatives of the relevant federal, state, and regional government agencies, local governments, affected industries, educational institutions, local citizens, and other users of the waterbody. The primary purpose of the Management Conference is to oversee the development of the CCMP for the estuary.

One of the first duties of the Management Conference is to set up a management structure for developing the CCMP. The Management Conference usually consists of working committees such as a Policy Committee, Management Committee, Science and Technical Advisory Committee, and a Citizens Advisory Committee. Some structures also include a Local Government Committee and a Financial Planning Committee. The Management Conference is then charged with identifying the environmental problems facing the estuary, recommending interim corrective actions, outlining compliance schedules to address the pollution problems, and ultimately, constructing a CCMP that gains approval of the State Governor(s) and the EPA Administrator. Once the CCMP is formally approved and actual implementation is set to begin, the involvement of the Management Conference varies among different Programs. In some situations, the Management Conference stays in place to oversee implementation of the CCMP; in others, a new entity is established; and in still others, the structure dissolves, and thus full implementation is much less likely to occur.

The CWA states that Management Conferences shall be convened for "up to" five years. The Management Conferences set up in the early stages of the NEP were given a full five years (some even longer) to identify and prioritize problems, to oversee interim corrective actions, and to develop a CCMP. During the last few years, the timeframe for the newer Programs has been gradually reduced. In 1992, EPA determined that new estuaries in the NEP would have four years to complete the process, and the estuaries entering the Program in 1995 were given only three years to conduct a "streamlined" NEP planning process.

The reduction in the time period for developing CCMPs and the movement toward "streamlined" Programs have raised concern among members of the National Coastal Caucus (NCC) and other environmental and citizen participants in local NEPs. Many believe that by shortening the process they will not have adequate opportunity to educate the public, ensure broad-based citizen involvement, and ultimately, have their own voices heard. Although most participants want to move from planning to implementation as quickly as possible, they have explained that it can take several years to develop the level of trust among stakeholders necessary to hammer out a mutually agreeable CCMP. Flexibility and non-duplication of efforts are important, but the process should not be so rushed that it defeats its purpose. There is also concern that "streamlined" NEPs are based on pre-existing information and research that may have been gathered in such a way as to exclude or limit public comment. To try to address these issues, the NCC recommends the option of extending, for the full five years, the planning process for estuaries that may need more time for studying and planning, or that have had a difficult time incorporating the concerns of citizens into the Program.

Implementation

Whether it takes three, four or five years, implementationstudying and planning alone will not restore these estuaries. Although implementation of some interim actions does occur prior to approval of the CCMP, full implementation of the Plan is not guaranteed. Clearly, the success of the NEP depends upon implementation; yet, the funding necessary for implementation efforts is not always available. The lack of federal commitment to the implementation phase of the Program has proven to be a significant shortcoming. The CWA provides that funding for interim actions may come from the NEP, from the Management Conference participants, or from other sources. Federal assistance is also provided to aid in the development of the CCMP; however, the certainty of direct federal financial support for the Program ends after the CCMP is approved. For this reason, it has been left up to the Management Conference to establish a strategy for securing the funds needed for implementing the restoration plans.

Notwithstanding the fact that section 320(f)(2) of the CWA states that "[u]pon approval of a conservation and management plan under this section, such plan ***shall be implemented***" (emphasis added), it simply does not always occur. The section continues to state that "[f]unds authorized to be appropriated under title II and VI and section 319 of this Act ***may*** (emphasis added) be used in accordance with the applicable requirements of this Act to assist States with the implementation of such plan."

Title II is the section of the CWA that authorizes federal grants for the construction of wastewater treatment plants. Title VI provides for the distribution of capitalization grants to each State for the purpose of establishing a water pollution control revolving loan fund. Finally, section 319 allows for federal grants to be

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made for implementation of management programs to control polluted runoff. Access to these CWA funds, in addition to State and local resources, is usually considered by Management Conferences in developing the financing mechanisms for CCMP implementation. However, once this limited funding is made available it is up to the State(s) to determine how the NEP will fare as it competes with other programs for its funding allocation.

Several alternative forms of financing have also been used to fund implementation of CCMPs, including: attracting private capital, issuing municipal bonds, securing intergovernmental transfers, collecting fees, and levying taxes. Washington State, for example, issued an eight-cent-per-pack cigarette tax to help finance its water quality protection plan. In addition, several wastewater treatment plants in California were financed with fees paid by land developers, based on the amount of treatment that their new developments would require.

Recommendation

It is an undeniable truth that as the NEP expands, fewer federal dollars will be available for planning or implementation of CCMPs. It is for this reason that the NCC urges the EPA to proceed cautiously as it considers the addition of new estuaries into the Program. It is the belief of the NCC representatives that it is better to have a few estuaries develop and implement solid plans, than to have a whole host of estuaries participate in a program that has very few resources to ensure its success.

The NEP has taken several important steps forward in reaching its goals. One of its strengths is its watershed approach to addressing the problems of the estuary. By identifying, examining, and correcting environmental problems that may originate upstream, the restoration plans of the estuary have a substantially better chance of success.

A related strength of the NEP is its thorough examination of the sources of the estuary's degradation. The CCMPs are designed to consider a myriad of issues: stormwater pollution, nutrient enrichment, heavy metals, sewage treatment, septic systems, industrial discharges, wetlands losses, fishery landing trends, wildlife populations, land-use practices, and others. Past approaches to restoration and protection have typically concentrated on just one type or source of pollution. Although many of these limited efforts are making progress, a more complete understanding of the cumulative effect of all the estuary's problems will produce more tangible and longer-lasting results. There is some concern that the new "streamlined" NEP process may also provide a less comprehensive review of the estuary.

A third strength of the NEP is the range of participation it attracts from interested parties. Theoretically, the Management Conference of each estuary is composed of stakeholders or user groups with a wide diversity of interests. The Conference provides an opportunity for collaboration and building consensus among the varied interests. Joint decision-making in the planning stage, although difficult to achieve, can lead to far fewer hurdles during the implementation phase.

In summary, the NEP under its current financial constraints can only be expected to achieve a limited amount of success. To improve its effectiveness, there needs to be greater access to federal dollars for implementing restoration plans, and stronger mechanisms to ensure full citizen participation during the development and implementation of the CCMP. If the NEP is ever to achieve its objective of fully restoring these "nationally significant" estuaries, it is essential that the Program undergo a smooth transition from the identification of problems to the implementation phase. To aid in this progression, true citizen participation must be deemed more than a goal — it should become a stringent requirement of the NEP.

During the last several years, American Oceans Campaign through the National Coastal Caucus, has been gathering comments on how best to strengthen the NEP. It has worked cooperatively with local Program Directors, as well as with the EPA, to strengthen and continue to improve the NEP. The NEP is an important and worthwhile program that can and does serve as an important model for other watershed planning programs. However, the participatory nature of the NEP makes its process vulnerable to manipulation by political pressures and economic interests. It is our hope that the Program will build on its wide range of experiences and continue to develop new and innovative ways to resolve problems and to engage citizens in the Program.

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[illegible]	[illegible]	CCMP Approved
Tier 1		
Albemarle-Pamlico Sounds	1987	1994
Buzzards Bay	1987	1992
Long Island Sound	1987	1994
Narragansett Bay	1987	1993
Puget Sound	1987	1991
San Francisco Estuary	1987	1993
Tier 2		
Delaware Estuary	1988	Expected 1996*
Delaware Inland Bays	1988	1995
Galveston Bay	1988	1995
New York-New Jersey Harbor Estuary	1988	Expected 1996*
Santa Monica Bay	1988	1995
Sarasota Bay	1988	1995
Tier 3		
Barataria-Terrebonne Estuarine Complex	1990	Expected 1996*
Casco Bay	1990	Expected 1996*
Indian River Lagoon	1990	Expected 1996*
Massachusetts Bays	1990	Expected 1996*
Tampa Bay	1990	Expected 1996*
Tier 4		
Corpus Christi Bay	1992	Expected 1998
Peconic Bays	1992	Expected 1997
San Juan Bay	1992	Expected 1998
Tillamook Bay	1992	Expected 1998
Tier 5		
Barnegat Bay	1995	Expected 1998
Charlotte Harbor	1995	Expected 1998
Columbia River	1995	Expected 1998
Maryland Coastal Bays	1995	Expected 1998
Mobile Bay	1995	Expected 1998
Morro Bay	1995	Expected 1998
New Hampshire Estuaries	1995	Expected 1998

*Draft CCMP available

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Regional Characteristics of Estuaries

The blending of salt and fresh water makes estuaries unique among aquatic ecosystems. Although estuaries are similar in composition, they have unique characteristics that distinguish them from one another. The National Oceanic and Atmospheric Administration (NOAA) has divided the estuaries of the United States into five distinct regions (not including the Tropical region) based on their physical and hydrologic features: North Atlantic, Middle Atlantic, South Atlantic, Gulf of Mexico, and Pacific. The major characteristics of these estuarine regions are summarized below.

North Atlantic Estuaries

Estuaries of National Significance
- Casco Bay in Maine
- Massachusetts Bays in Massachusetts
- New Hampshire Estuaries in New Hampshire

Estuaries in the North Atlantic span from the U.S./Canadian border in the north to Cape Cod Bay in the south. Rocky shorelines and steep river beds formed by glacial movement characterize these estuaries. Salt marshes are less common in North Atlantic estuaries due to the steep, rocky terrain within the region. With tides generally exceeding ten feet in height, circulation in these waters is strong.

Middle Atlantic Estuaries

Estuaries of National Significance
- Buzzards Bay in Massachusetts
- Narragansett Bay in Rhode Island
- Long Island Sound in Connecticut and New York
- New York-New Jersey Harbor in New York and New Jersey
- Peconic Bays in New York
- Delaware Estuary in Delaware, New Jersey, and Pennsylvania
- Delaware Inland Bays in Delaware
- Maryland Coastal Bays in Maryland
- Barnegat Bay in New Jersey

Formed by glacial melting, the Middle Atlantic estuaries extend from Buzzards Bay down to the Chesapeake Bay. Forested wetlands and salt marshes are the most common wetland types in this region. These relatively shallow estuaries experience tides of less than ten feet. Freshwater inflows and tidal influences produce complex circulation patterns in this region. Chesapeake Bay in Maryland, Virginia, and Pennsylvania has served as a model program for estuaries of national significance.

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South Atlantic Estuaries

Estuaries of National Significance
- Albemarle-Pamlico Sounds in North Carolina
- Indian River Lagoon in Florida

Extending from North Carolina to southern Florida, estuaries in the South Atlantic contain a diversity of habitats, including extensive marshes, and barrier island systems. Due to this region's flat coastal plain, barrier islands, and small tidal range (between two and seven feet), estuarine circulation in the South Atlantic heavily depends upon wind currents. Due to their characteristically shallow depths, total water volume in the South Atlantic estuaries is remarkably low.

Gulf of Mexico Estuaries

Estuaries of National Significance
- Sarasota Bay in Florida
- Tampa Bay in Florida
- Barataria-Terrebonne Estuarine Complex in Louisiana
- Galveston Bay in Texas
- Corpus Christi Bay in Texas
- Charlotte Harbor in Florida
- Mobile Bay in Alabama

Estuaries in the Gulf of Mexico extend from the southern tip of Florida, westward to the border of Texas and Mexico. Many of these estuaries are characterized by channels that were formed by major river deltas, such as the Mississippi and Atchafalaya Rivers, that flow into the Gulf. This region contains the greatest amount of coastal wetlands in the country. Forested wetlands, such as mangrove swamps, dominate the eastern Gulf; salt marshes dominate the west.

Pacific Estuaries

Estuaries of National Significance
- Puget Sound in Washington
- Tillamook Bay in Oregon
- San Francisco Bay in California
- Santa Monica Bay in California
- Morro Bay in California
- Columbia River in Oregon and Washington

Spanning the entire Pacific Coast, estuaries in the Pacific region are characterized by narrow water bodies surrounded by immense rock formations. Much of the Pacific coastline is mountainous with some low-lying coastal plains and rivers. The Pacific Coast's estuaries contain the least number of coastal wetlands among all estuaries. Water depths in these estuaries range from over 1,000 feet in Santa Monica Bay to six feet in Tillamook Bay.

Tropical Estuaries

Estuaries of National Significance
- San Juan Bay in Puerto Rico

Tropical aquatic systems differ significantly from temperate aquatic systems in a variety of ways. Specifically, tropical aquatic systems are characterized by higher and more constant water temperatures, fewer nutrients, and greater biological diversity. In addition, these systems contain some of the most sensitive and biologically-rich habitats in the world, including coral reefs and mangrove forests.

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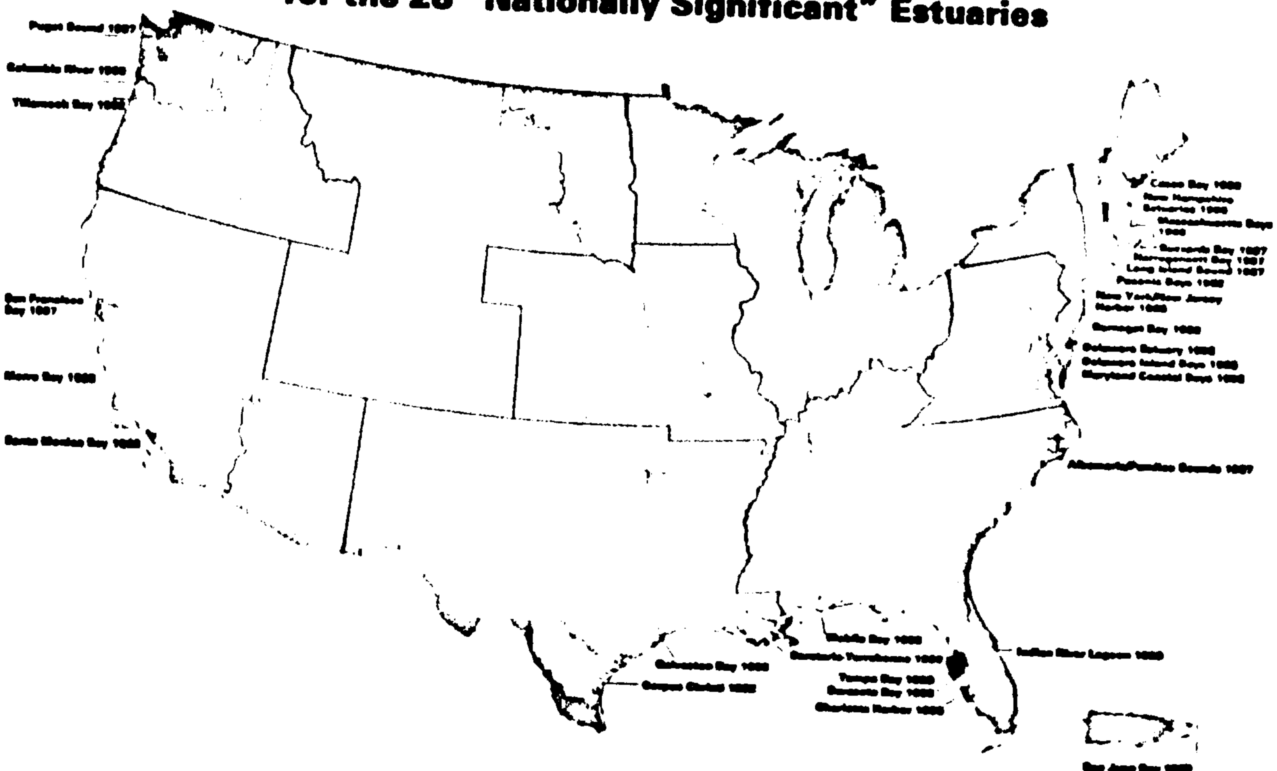
National Estuary Program Watershed Map for the 28 "Nationally Significant" Estuaries



Definition:
Watershed-The entire surface drainage area that contributes water to a lake, river, groundwater supply, or coastal waterbody.

Sources: USGS, NOAA, ArcUSA
Scale approx. 1:20,000,000
November 1990

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Nationally Significant Estuaries

The National Estuary Program (NEP) was established under the 1987 Amendments to the Clean Water Act. In authorizing the NEP, Congress recognized the need to protect an important but endangered resource — our nation's estuaries.

Since 1987, 28 of the nation's estuaries have been deemed "nationally significant" and accepted into the National Estuary Program. These 28 estuaries span each of our nation's coasts — from Casco Bay, Maine to Indian River Lagoon, Florida on the Atlantic Coast; from Charlotte Harbor, Florida to Corpus Christi Bay, Texas on the Gulf of Mexico Coast; and from Santa Monica Bay, California to Puget Sound, Washington on the Pacific Coast.

Governors nominate estuaries for inclusion in the National Estuary Program and must demonstrate why their particular estuary is considered to be "nationally significant." The Environmental Protection Agency reviews the nomination on the basis of the following factors:

- the ecological significance of the estuary;
- the estuary's biological productivity and its contribution to commercial and recreational fish and wildlife resources;
- the impact of commercial, residential, recreational, or industrial activities on the health of the estuary; and
- the degree to which comprehensive planning management may contribute to the ecological integrity of the estuary.

Realizing the scope of the NEP and balancing the need for national representation, EPA then weighs the information against the criteria and makes its selection.

The EPA Administrator has accepted new estuaries into the National Estuary Program every few years. Thus far, five "Tiers" (or groups) of estuaries have been designated and have received federal funding to assist in the development of a locally-driven Comprehensive Conservation and Management Plan (CCMP). Each of the local estuary programs is at a distinct stage in its CCMP development: creating a management framework; characterizing problems impairing the estuary; drafting the CCMP; or implementing actions of an approved CCMP.

This chapter of *Estuaries on the Edge* reviews all 28 estuaries of the National Estuary Program. However, comparatively less information is available for the seven, "Tier 5" estuaries than for others in the Program. Each excerpt presents a brief physical "portrait" of the estuary, a survey of the ecological and economic values of the estuary, and a review of the identified threats to the continued vitality of the estuary. This is followed by an examination of the local program's operation and activities to restore the estuary. Finally, a brief introduction to the activities of the National Coastal Caucus and other local conservation and environmental organizations to protect and restore these valuable waters is presented.

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Albemarle-Pamlico Sounds
in North Carolina

Our estuaries and our Sounds support a way of life, a vital economy, and a healthy future for our children.

—Todd Miller, Executive Director
North Carolina Coastal Federation

Portrait of the Sounds

In 1987, the Albemarle-Pamlico Estuarine Study began examining the water quality and habitat problems of the Sounds and the impact that the greater watershed area has on the estuarine system. The Albemarle-Pamlico system, situated in northeastern North Carolina, is the second largest estuary in the United States (only the Chesapeake Bay is larger). The system is actually made up of seven Sounds — Albemarle, Pamlico, Currituck, Croatan, Bogue, Core, and Roanoke. It also includes five major river basins, as well as beaches, marshes, and bottomland forests. The Sounds contain approximately 3,000 square miles of estuarine waters.[1] The Albemarle-Pamlico Sounds are relatively shallow, with an average depth of 13 feet.[2] The estuary is 26 feet at its deepest point.[3]

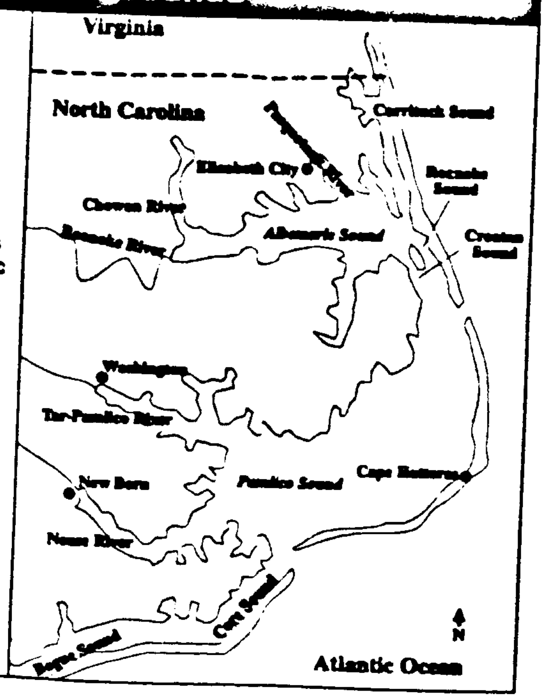
The watershed area of the Sounds measures 30,000 square miles and includes portions of 36 counties in North Carolina and 16 counties and independent cities in southeastern Virginia.[4] Nearly

Albemarle-Pamlico Sounds

Area of surface water	3,000 square miles
Area of watershed	30,000 square miles
Average depth	13 feet
Population	2 million people
Values	• Fisheries generate $98 million* • Sport fishing generates $1.3 billion in economic output* • Home to 11 National Wildlife Refuges
Threats	• Pathogen contamination • Toxic pollution • Nutrient loadings and Hog production • Habitat loss and degradation
CCMP status	Approved in 1994

Designated as a "Nationally Significant" Estuary in 1987.

*State figures



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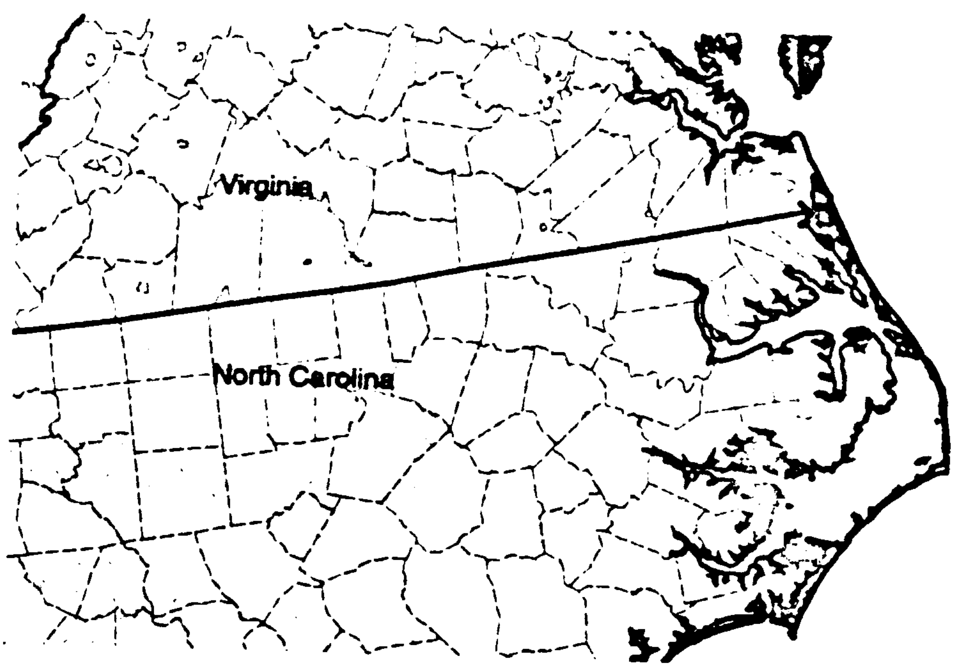
Albemarle/Pamlico Sounds Watershed



Watershed

Major Rivers

State Boundary

County Boundary

Albemarle/Pamlico Sounds

Scale: approximately 1: 2,771,250
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-10

EPA
Office of Wetlands, Oceans & Watersheds

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two million people live in this massive watershed, which covers approximately one-third of the land area in North Carolina.[5] The watershed includes almost 9,300 miles of freshwater rivers and streams.[6] Groundwater sources and five major rivers — the Chowan, Roanoke, Pasquotank, Tar-Pamlico, and Neuse Rivers — deliver freshwater to the Sounds.[7] A chain of barrier islands, with only a few inlets, separates the Sounds from the Atlantic Ocean.

Various types of habitat can be found within the watershed, including pocosins, pine savannas, hardwood swamp forests, bald cypress swamps, salt marshes, brackish marshes, freshwater marshes, and submerged aquatic vegetation.[8]

Values of the Sounds

The physical beauty of the Sounds and the commercial and recreational opportunities they offer lure many residents and tourists to the area. The Albemarle-Pamlico system is one of the most biologically productive estuaries in the United States.[9] Due to their variety of habitat and high level of productivity, the Sounds support numerous species of wildlife, fish, shellfish, and plants. Eleven National Wildlife Refuges can also be found in the area.

Recreation/Tourism

A variety of recreational activities attract millions of visitors to the Albemarle-Pamlico Sounds each year. Currently, ten percent of the local work force is employed by the tourism industry of the Sounds.[10] The populations of the counties in the Sounds swell significantly with tourists during the summer months. In 1990, for instance, Brunswick County's population increased by 300 percent during the tourist season.[11] Sport fishing, boating, sunbathing, camping, and bird watching are a few of the popular activities of the area. Between 1970 and 1984, the number of registered boats in the Albemarle-Pamlico Sounds increased by 155 percent. Between 1971 and 1991, the number of marinas increased by almost 300 percent.[12]

Recreational fishing is a booming industry in the estuary. More than 60 percent of the recreational fish in North Carolina use the Sounds for spawning and nursery grounds.[13] In 1991, recreational fishing in North Carolina generated approximately $1.3 billion in economic output and employed nearly 22,000 people.[14] In 1991, approximately 626,000 saltwater anglers spent over 3.5 million days fishing off the coasts of North Carolina.[15] Fifty-two percent of the anglers were non-residents of the State.[16]

The watershed of the Sounds includes 11 National Wildlife Refuges — Great Dismal Swamp, Back Bay, Mackay Island, Currituck, Roanoke River, Alligator River, Pocosin Lakes, Pea Island, Mattamuskeet, Swan Quarter and Cedar Island. The watershed also contains the Cape Lookout and Cape Hatteras National Seashores, the Croatan National Forest, and many state-owned parklands. These public lands offer fishing, hiking, and boating opportunities to visitors, and provide havens for a variety of wildlife.

Fisheries/Seafood

In 1994, the combined value of the South Atlantic region's commercial finfish and shellfish industries totaled approximately $215 million. Many of the commercially valuable species in the South Atlantic region depend upon the health of the Albemarle-Pamlico Sounds for survival. In 1994, North Carolina's total commercial finfish and shellfish landings totaled nearly 197 million pounds, valued at $98 million.[17] The Albemarle-Pamlico Sounds produce more than 50 percent of North Carolina's total commercial fishery landings each year.[18]

Despite its abundant fisheries production, fish and shellfish populations in the Sounds are declining due to overfishing, habitat loss, pollution, and disease. Over the past decade declines have been noted in the Sounds' populations of river herring, Atlantic croaker, Atlantic sturgeon, Eastern oyster, red drum, striped bass, summer flounder, and weakfish,[19] jeopardizing more than 20,000 jobs in North Carolina and a billion dollar (combined commercial and recreational) fishing industry.[20] Although disease has contributed to reduced oyster landings since a record year in 1987 when 1.4 million pounds were harvested, the Albemarle-Pamlico system is the largest oyster-producing estuary in the South Atlantic region.[21]

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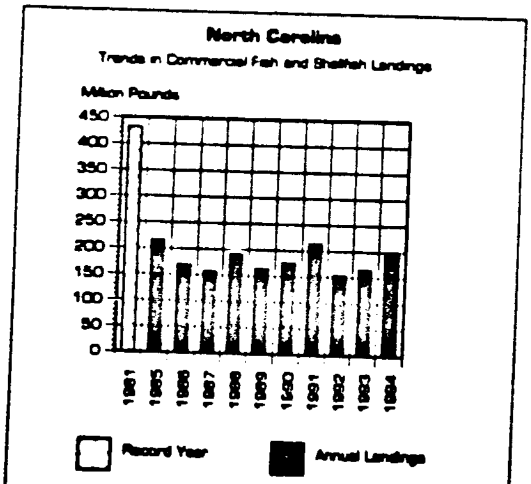

Data Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service

Approximately 90 percent of the commercially valuable fish species in North Carolina depend upon estuaries like the Albemarle-Pamlico Sounds during some part of their life cycle.[22] The Sounds' tributaries and shallow embayments provide an estimated 25,000 acres of primary nursery area for over 75 species of finfish and shellfish.[23] These nursery areas are used by many fish species which populate other east coast fisheries, and provide numerous commercial and recreational benefits to local communities.

Wildlife

The Sounds provide essential habitat for a variety of animal populations. Snow geese, tundra swans, sea ducks, and other migratory birds use the estuary for wintering habitat. In addition, egrets, herons, geese, and ducks rely on the estuary's salt marshes for feeding grounds.[24] Pamlico Sound provides important feeding grounds for juvenile loggerhead sea turtles.[25] Non-tidal wetlands and swamps are used by black bears, racoons, marsh rabbits, deer, otters, and bobcats.[26]

Many federally-protected endangered and threatened species use the valuable estuarine habitats found in the Albemarle-Pamlico Sounds watershed. For instance, the green sea turtle, loggerhead sea turtle, bald eagle, brown pelican, and piping plover are threatened species whose populations depend upon estuarine wetlands in North Carolina. The hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, roseate tern, red wolf, and West Indian manatee are endangered species whose populations depend upon estuarine wetlands.[27] The Albemarle-Pamlico region is home to fourteen endangered plant and animal species, five threatened species, and several species of special concern.[28]

The Alligator River National Wildlife Refuge borders Pamlico Sound. This Refuge is the site of a reintroduction program for the red wolf, once extinct in the wild. Endangered red cockaded woodpeckers and many songbird species can also be found in the Refuge.[29]

Threats to the Sounds

The Albemarle-Pamlico Estuarine Study has identified habitat loss and water quality declines caused by pathogen contamination, toxic pollution, and nutrient loadings as the foremost problems affecting the health of the Sounds.[30] Agricultural runoff, stormwater discharges, and runoff from construction sites and forested lands are significant sources of the habitat degradation and pollution currently plaguing the system.

North Carolina is the leading meat producer in the nation.[31] Large animal industries in North Carolina have contributed overwhelmingly to pollution loadings in the State's estuaries. Inadequately treated hog waste has become a particular concern as of late because of the increasing number of hog farms in North Carolina, and the impact that their wastes have on estuaries and their tributaries. Corporate hog farming is an expanding business in the State of North Carolina, especially in the coastal region. In fact, more than 75 percent of North Carolina's hog population is raised in the State's 15 coastal counties. In Duplin County, which borders three counties in the Sound's watershed area, hogs outnumber people 25 to one. North Carolina is second only to Iowa in hog production.[32]

Pathogen Contamination

Pathogens are disease-causing bacteria and

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viruses found in human and animal wastes which enter estuaries through many sources including, contaminated agricultural and urban runoff, sewage treatment plant discharges, boating waste and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the incidental ingestion of pathogens in contaminated water. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters. The State of North Carolina does not regularly test its beach waters for pathogen contamination. If beaches are closed or health advisories issued, it is done by county health departments.[33]

The areas most susceptible to fecal contamination in the Sounds are the shallow, near-shore areas, which often provide the highest-quality and most productive shellfish habitat. Pathogen contamination is responsible for the closure of over 21,000 acres of the Sounds' productive shellfish harvesting acres. An additional 15,000 acres are closed temporarily following storm events.[34] Between 1980 and 1990, the amount of shellfish harvesting area subject to closure increased by 98 percent in the Croatan Sounds, 62 percent in the Roanoke Sound,[35] and 54 percent in the combined Core/Bogue Sound portion of the Albemarle-Pamlico estuary.[36]

Toxic Pollution

Pesticides and toxic chemicals severely impair the water quality of the Sounds. The subwatersheds of Albemarle and Pamlico Sounds have the first and fifth highest pesticide use, respectively, per unit of cropland, of the nation's estuarine watersheds.[37] A 1992 toxic pollution study in the region identified four river systems — the Chowan, Pasquotank, Roanoke, and Neuse — as having levels of toxins capable of harming aquatic life, wildlife, and human health.[38] Zinc, copper, lead, mercury, cadmium, and dioxin are of particular concern.[39] Probable sources of toxic contamination in the Albemarle-Pamlico system include metal-plating operations on the Neuse River; textile manufacturing on the Pamlico, Roanoke, Chowan, and Neuse Rivers; and Department of Defense activities at Cherry Point Marine Station.[40]

Particles of toxic metals and organic chemicals settle in the sediments of the estuary and its tributaries. These toxins can persist in the system for decades; and eventually they are consumed by aquatic organisms and passed through various levels of the food chain. Fish tissue samples gathered at 75 sites in the region have revealed levels of copper, mercury, lead, and cadmium that surpass healthy levels for wildlife. In some portions of the estuary, fish contain levels of mercury and dioxin that are unsafe for human consumption.[41] Fish consumption advisories have been issued in many portions of the Sounds and their tributaries.

Nutrient Loading and Hog Production

Nutrients such as nitrogen and phosphorus are introduced to the estuary by agricultural runoff, hog production, sewage treatment plants, urban stormwater, atmospheric deposition, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Sounds and their tributaries. As algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Sounds, but they also require a great amount of dissolved oxygen to decompose. Low dissolved oxygen conditions (called hypoxia) can result in large fish kills.

Numerous algal blooms and fish kills have been documented in the Sounds over the past decade. During the summer of 1995, a massive fish kill occurred after a so-called "hog waste lagoon" breached and spilled 25 million gallons of waste into the New River.[42] Hog waste spills can kill aquatic life in rivers and streams, and can contaminate the groundwater with high levels of nitrogen. According to a North Carolina State University report, there are potentially hundreds of hog waste lagoons in the State with sizable leaks that can contaminate groundwater.[43] Ammonia gas emitted from hog waste lagoons and barns enters the atmosphere and returns to the earth through rainfall. Scientists in the State are linking ammonia with algal blooms because of its nitrogen content.[44] Other problems arise when hog

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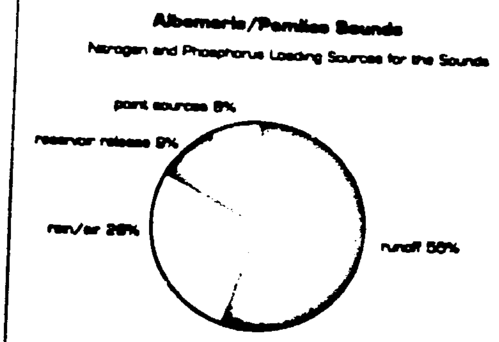

Source: Albemarle-Pamlico Estuarine Study. A Guide to Environmental and Economic Stewardship in the Albemarle-Pamlico Region: A Comprehensive Conservation and Management Plan Summary 7

waste is applied to agricultural land as fertilizer. Runoff from these lands can damage the rivers and streams by pouring excess nutrients and pathogens into them. Finally, the odor from corporate hog farms severely reduces the quality of life for residents and diminishes property values in the area.

In the fall of 1995, the lower Neuse River was the sight of a massive fish kill. Up to five million fish died from a toxic alga which was believed to be triggered by nutrient over-enrichment.[45] A North Carolina State University scientist has recently discovered that the alga causes open sores in fish.[46] Blooms of this toxic dinoflagellate, *Pfiesteria piscimorte*, are believed to be responsible for almost one-quarter of the fish kills in the Neuse and Pamlico Rivers in 1992 and 1993.[47]

As a result of nutrient loading, the Neuse River has been designated as one of the nation's 20 most threatened rivers.[48] The Chowan River was afflicted by a major algal bloom in the summer of 1993.[49] In the Tar-Pamlico River, 90 algal bloom occurrences were documented between 1986 and 1989; and 140 fish and crab kills were reported between 1985 and 1989.[50] In 1987, a Red Tide algal bloom decimated the bay scallop population in the Core and Bogue Sounds.[51] Between 1986 and 1989, three large fish kills occurred in the Roanoke River basin[52] and 41 fish kills were recorded in the Neuse River Basin.[53] Many of these were caused by low dissolved oxygen levels.

Habitat Loss and Degradation

Only one percent of North Carolina's coastal plain remains in its natural state.[54] Losses among coastal wetlands, freshwater wetlands, and forested lands in the watershed threaten the long-term sustainability of the Sounds. The State of North Carolina has lost 49 percent of its original 11 million acres of wetlands;[55] one-half of these losses have occurred in the coastal plain.[56] The United States Fish and Wildlife Service reports that between 1973 and 1983, North Carolina lost more wetlands than any other southeastern State.[57]

In the Albemarle-Pamlico Sounds watershed, wetlands have been converted primarily for agricultural, forestry, and urban uses. The greatest losses and alterations of wetlands have occurred in the area's pine savannahs and pocosins.[58] The old growth longleaf virgin pine forests, which had previously blanketed the North Carolina coastline, are gone. Fragmented stands of old second-growth pines and rows of loblolly pines (a non-native tree species in the State) have replaced these once-magnificent forests.[59]

Regardless of their location and type, wetlands are critical to a healthy estuary. As previously stated, in North Carolina, 90 percent of the commercially valuable fish and more than 60 percent of the recreationally valuable fish use spawning and nursery areas in the estuaries of the Sounds that are closely linked to wetlands. In addition to their importance to fisheries, wetlands naturally filter nutrients and pollutants before these contaminants reach the water.[60]

As development pressures mount within the watershed, natural coverage is being replaced by more impervious surfaces, such as pavement and roofs. Once these areas are replaced, the system loses its natural filtering and absorption capabilities. Thus, stormwater enters the estuary and its tributaries in greater volumes and with higher concentrations of pollutants. Water quality impairments and erosion of shorelines and riverbanks are typical results of uncontrolled coastal development. Coordinated land use management is essential to ensure that population growth does not severely degrade the water quality and living resources of the Sounds.

Additional Concerns

The dramatic rate of population growth and development in the region presents great obstacles to the restoration of the Sounds. Since 1960, 250,000 people have moved to the coastal counties of North Carolina, an increase of more than 50 percent. By 1990, 710,000 people resided in the State's coastal counties. Currently North Carolina has the 10th highest population in the nation.[61] In addition to the demands placed on the estuary by the growing number of residents, millions of tourists visit the Sounds each year.

Increased population places greater demands on freshwater resources in the region. Specifically, the expanding use of groundwater by businesses, farms, and residents in the watershed is depleting the aquifers which feed the Sounds with freshwater. Withdrawals from Black Creek aquifer have increased from 100,000 gallons per day in 1900 to 40 million gallons per day in 1990. Approximately 3.7 million people, 60 percent of the State's population, rely on groundwater for their source of water.[62]

Trash accumulated on estuarine beaches also threatens the ecosystem and its wildlife inhabitants. On September 17, 1994, volunteers cleared 395,793 pounds of marine debris from 450 miles of beach area in North Carolina. Of the total amount of marine debris collected, 56.1 percent was plastic, 13.4 percent was metal, 12.2 percent was paper, and miscellaneous materials totaled 18.3 percent.[63]

Albemarle-Pamlico Estuarine Study

The Albemarle-Pamlico estuary was accepted into the National Estuary Program in 1987 when it was designated as an estuary of "national significance." At that time the Albemarle-Pamlico Estuarine Study (APES) was established to provide a cooperative research and management program between the EPA and the North Carolina Department of Environment, Health and Natural Resources. Representatives of municipal and state governments, federal agencies, academic institutions, and citizens groups participated in developing a Comprehensive Conservation and Management Plan (CCMP). The APES program has significantly raised the visibility of estuarine issues in the entire region. For instance, citizen involvement and interest in coastal issues have increased and government programs protecting estuaries have been expanded. Full implementation of the CCMP is the critical next step in ensuring that the Albemarle-Pamlico resources be preserved for future generations.

The planning process was guided by a Management Conference that consisted of 95 individuals representing four committees. These individual stakeholders came from many diverse groups, including farmers, foresters, fishers, environmentalists, developers, business and industry leaders, university researchers, government agencies, and local elected officials.[64] The third and final draft CCMP was completed in November, 1993. It was signed by the Governor of North Carolina and approved by the EPA Administrator in 1994. Unfortunately, however, once the plan was approved, the APES program office was disbanded. As a result, no agency is officially responsible for ensuring that the plan is implemented, and there has been very little coordination between agencies overseeing current programs of the plans.

The CCMP identifies five major goals, with objectives and management actions designed to accomplish each goal. Action Plans have been developed for the following categories: water quality, vital habitats, fisheries, stewardship, and implementation. During the six years it took to develop the plan, APES participated in several interim action and public education projects. New methods were demonstrated to protect marshes and aquatic habitat, control storm runoff, compost waste from crab processing and agricultural practices, and reduce fisheries bycatch by using new types of fishing gear. As a result, historic spawning areas for shad and herring have been reopened, and scallop beds that were decimated by the 1987 Red Tide have been replenished. Due to the extensive research conducted by the APES program, more is known about the estuary than ever before. For instance, scientists have discovered more about the toxic dinoflagellate that has been responsible for a significant number of the estuary's major fish kills; seagrass beds have been identified; and a mapping system has been developed to help local governments assess the environmental impacts of proposed projects.[41]

The "Implementation" section of the CCMP states that the success of the CCMP and the future of the estuary depend upon continuing communication among the stakeholders that developed the plan. However, it does not recommend any viable process to ensure that coordination and implementation actually occur. Although it recommends the formation of a Coordinating Council and five Regional Councils, it is up to individual policymakers to decide whether to implement these recommendations, and so far it appears that this process is going very slowly. For instance, to date only one Regional Council — the Neuse River Basin Council — has been created. Deadlines for the creation of the Tar-Pamlico Basin Council and others, however, have been postponed on numerous occasions. In order to ensure that implementation of the CCMP occurs in a timely fashion, the North Carolina Department of Environment, Health and Natural Resources must move forward with council formation.

The CCMP is a common sense guide for environmental protection of the estuary. It provides the necessary tools for continued management, coordination, and cooperation; but without a body to ensure that the guidelines are adhered to, many believe that the plan will simply end up on a shelf collecting dust. Although committees have been created to implement the CCMP, efforts aimed at implementing even the most basic elements of the plan have been minimal.

National Coastal Caucus

Founded in 1982, the North Carolina Coastal Federation (NCCF) is a private, nonprofit conservation organization working with citizens for a clean coastal environment. NCCF seeks to protect the area's coastal environment, culture, and economy through: regulatory reform, government accountability, environmental law, coordination of citizen advocacy groups, and environmental education.

Members, staff, volunteers, and the Board of Directors of NCCF have served in numerous capacities in the development of the CCMP of the APES. Specifically, NCCF has served on the Citizens Advisory Committee and has consistently encouraged implementation of both the interim actions identified in the CCMP, as well as the full plan.

The Pamlico-Tar River Foundation (PTRF) was founded in 1980 to protect and improve the environmental quality of the Pamlico-Tar River, its estuaries, and watershed. Over the past 16 years, the organization has developed into a strong grassroots organization with a diverse membership from throughout the watershed. Through education, advocacy, and research, PTRF has achieved its mission of providing a voice for the river. PTRF was instrumental in including the Pamlico systems in the National Estuary Program.

Members, staff, and volunteers of PTRF served in numerous capacities in the APES program. PTRF conducted several environmental education and outreach projects for the APES region and started the Albemarle-Pamlico Citizens Water Quality Monitoring Network. PTRF played an active role in the development of the CCMP through the Citizens Advisory Committee. Currently, PTRF supports and encourages implementation of the actions recommended in the CCMP. The current Executive Director of PTRF was formerly a policy analyst for APES who helped to develop the CCMP.

Currently, the NCCF is working to enhance protection of estuarine habitats, including wetlands, shorelines, and submerged aquatic vegetation. The NCCF is helping to establish more comprehensive riverbasin-wide planning to protect watersheds, reduce water pollution from runoff, and restore water quality and usefulness of degraded waters, including the South River and others. NCCF also encourages the State to buy and otherwise protect outstanding natural areas and to better protect and restore vital wetlands habitat. For instance, NCCF has been working to stop the development of Bird Island by encouraging the State to purchase it and by offering sizeable private contributions. Bird Island is the only undeveloped barrier island in North Carolina west of the Cape Fear River. Surrounded by almost 1,800 acres of salt marsh, the island is a last refuge for both migratory and resident wildlife. In the face of proposals to turn the island into oceanfront housing, NCCF is committed to keeping it the way it is now.

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Over the years, the NCCF has participated in other activities designed to protect the Sounds. It is working to make land-use planning under the Coastal Area Management Act (CAMA) work more efficiently and to bring state and local resources together to improve the process. The NCCF encourages the use of more sophisticated technology, including Geographic Information Systems (GIS), to make the process swifter and simpler. The NCCF also encourages broad public support and State action to reverse the precipitous downward trends in living marine resources. To this end, the NCCF works towards better management of marine fisheries, and better enforcement of existing fisheries laws and regulations. The NCCF sought and received financial resources to ensure that the now-obsolete Quaker Neck Dam near Goldsboro be removed. The grants make it possible to open up more than 130 miles of the Neuse River for spawning by open-ocean fish such as shad, striped bass, and river herring.

"Coastal Adventures" is a program conducted by the NCCF education staff to increase knowledge about the value of the Sounds. This program takes participants through coastal estuarine habitats such as hardwood and pine forests, and tidal marshes. In addition, participants examine habitats for rare plant and animal species, and explore the back salt marshes to observe fish, crabs, and other marine life. The NCCF will continue its restoration and educational efforts through public outreach programs and the distribution of its newsletter *Coastal Review*, and will simultaneously work to ensure that six years committed to the APES planning process is not wasted. The advocacy programs of the NCCF consistently stress the need for the coordination and non-duplication of efforts by different governmental agencies.

Since 1980, PTRF has believed that the informed public is necessary for the protection of our natural resources. As a result, the organization maintains a library of their own educational materials, including guides and displays for teachers, students, and the general public. PTRF presents about 100 lectures and programs each year to schools, civic groups, and local government bodies. They hope to establish a permanent education center to focus on the issues of estuarine resource management. In addition, PTRF has produced and published important research on wastewater treatment, manna siting, and water quality.

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Barataria-Terrebonne Estuarine Complex *in Louisiana*

The Barataria-Terrebonne Estuary has fed the most productive fishery in the lower forty-eight states, but is now the fastest disappearing coastline in the country. The time is increasingly short to decide which will be its legacy.

—Doug Daigle, Programs Director
Coalition to Restore Coastal Louisiana

Portrait of the Estuary

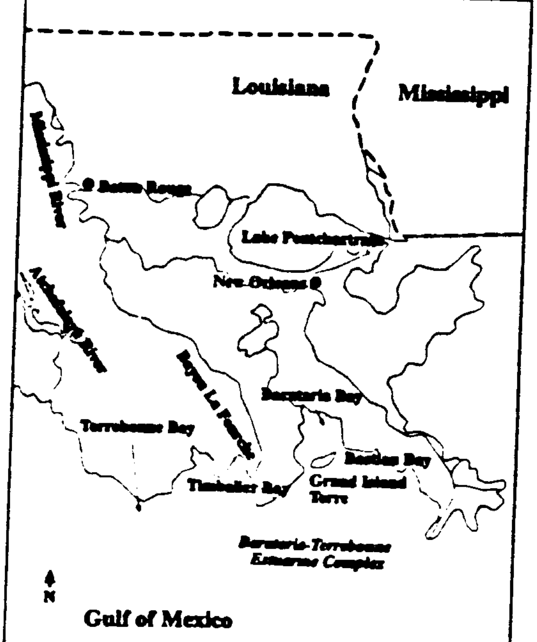
The Barataria-Terrebonne National Estuary Program is examining the problems of water quality, hydrology change, and habitat loss in the Barataria-Terrebonne Estuarine Complex and the impact that the greater watershed has on the estuarine system. The complex lies between the Mississippi River and the Atchafalaya Basin in south-central Louisiana. It is comprised of the Barataria, Terrebonne, Bastion and Timbalier bays and a number of channels and freshwater lakes. The Estuary's northern boundary is the city of Morganza and its southern boundary is the city of Grand Isle. The total water and wetland surface area of the Estuary is 6,300 square miles.[1] The average depths of the two largest Bays in the system, Barataria and Terrebonne, are a shallow five and six feet, respectively.[2]

Barataria-Terrebonne Estuarine Complex

Area of surface water	6,300 square miles
Average depth	5 to 6 feet
Population	591,000 people
Values	• Sport fishing generates $1.2 billion in economic output* • Fisheries generate $336 million* • 25% of North America's dabbling duck winter in the coastal marshes*
Threats	• Alteration of water flows • Habitat loss and degradation • Nutrient loadings • Pathogen contamination • Toxic pollution
CCMP status	Final expected in 1996

Designated as a "Nationally Significant" Estuary in 1990.

*State figures



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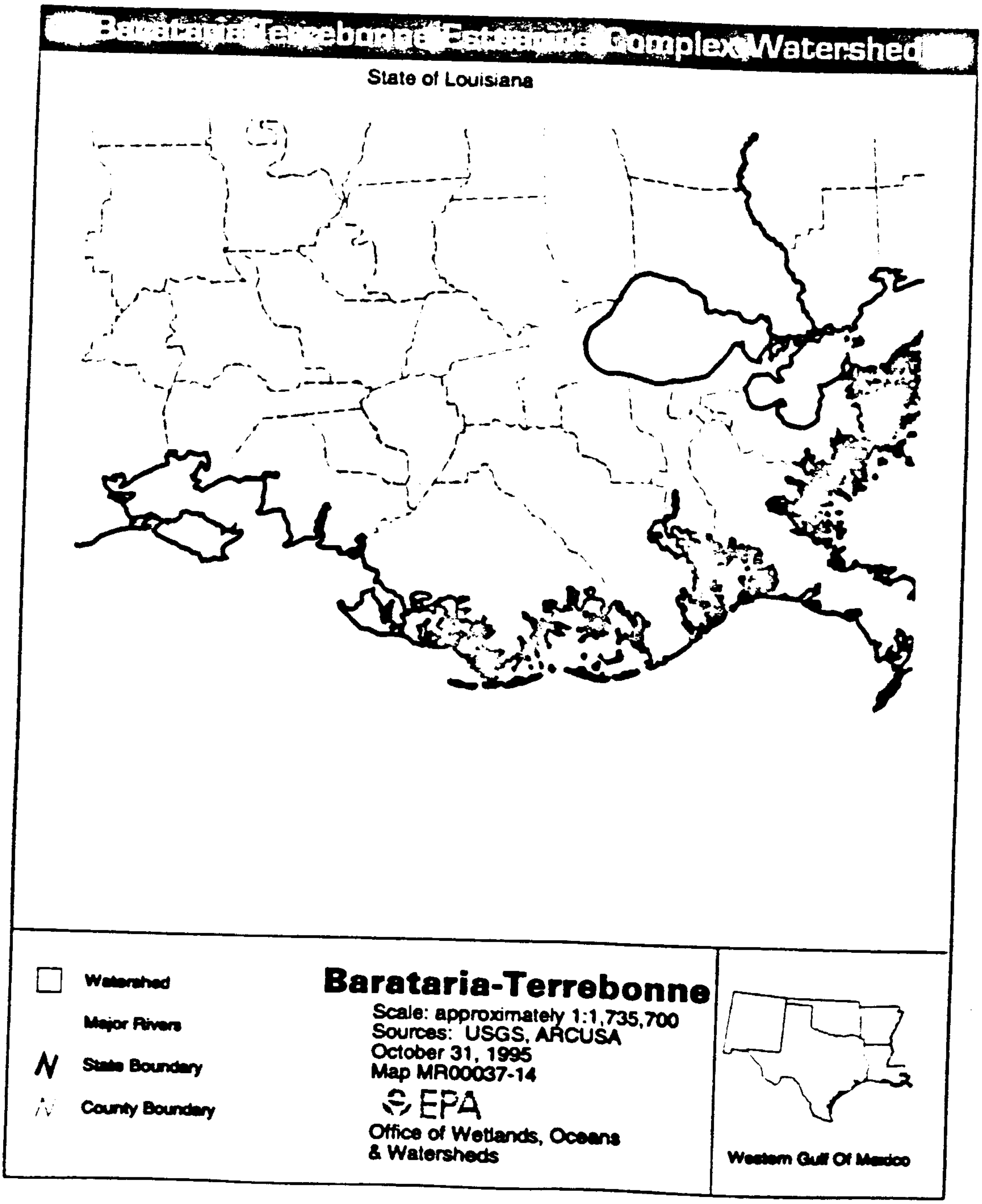
Barataria-Terrebonne Estuarine Complex Watershed
State of Louisiana
Watershed
Major Rivers
State Boundary
County Boundary
Barataria-Terrebonne
Scale: approximately 1:1,735,700
Sources: USGS, ARCUSA
October 31, 1995
Map MR00037-14
EPA
Office of Wetlands, Oceans
& Watersheds
Western Gulf Of Mexico

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The greater watershed area of the system, which covers all or portions of 16 parishes, has a population of approximately 591,000 people.[3] The population density for the watershed is 142 people per square mile.[4] The population of Jefferson Parish, portions of which are in the watershed, is expected to increase by 104,000 people between 1988 and 2010.[5]

Both natural rivers and artificial channels carry freshwater through the northern part of the system. Some of the more significant channels include the Bayou Perot, Bayou Rigollets, Houma Navigation Channel, and the Barataria Waterway.[6] Large volumes of freshwater flowing from the Mississippi River enter the deep waters of the Gulf. The freshwater is then carried westward by strong currents to the Barataria Bay. So, as tides bring the diluted waters back to shore, the salinity levels of the southern portion of Barataria Bay are decreased.[7] Three barrier island chains separate most of the Estuary from the open waters of the Gulf of Mexico. Numerous passes and inlets provide the connection with the Gulf waters.

An abundance of habitat types can be found in the Barataria-Terrebonne Estuarine Complex. These include upland forests, baldcypress and tupelogum swamps, marshes, freshwater lakes, ridges, and open water. The coastal marshes are an integral part of this ecosystem and are a special national resource. An estimated 14 percent of the system is comprised of marshes.[8]

Within the watershed, agriculture is a significant land use. Over 295,000 acres in the watershed are used for sugarcane production and over 46,000 acres are used for pasture and rangeland.[9]

Values of the Estuary

The waters and coastal marshes of the Barataria-Terrebonne estuarine system are symbolic of the wealth of natural resources along Louisiana's Gulf coast. But, for the residents of the watershed, they are significantly more than symbols. The system supports a commercial shellfish and fish harvest that, in volume, rivals the harvests of the entire Atlantic coast. The wetlands of the system provide numerous benefits to the State of Louisiana. A recent academic study examined the economic value of wetlands for fishery production, storm protection, recreation and other functions and calculated the total value of one acre of Louisiana wetland to be as high as $8,977. The market value of one Louisiana wetland acre on the real estate market is as high as $400.[10]

The Barataria-Terrebonne Estuary provides numerous recreational opportunities, such as sport fishing, hunting, bird watching, and photography, that attract visitors from across the nation. Revenues from commercial seafood landings, sport fishing, and hunting in the Estuary approach $1 billion annually.[11]

The area also contains valuable mineral resources, including crude oil, natural gas, sulphur, and salts. The extraction of these minerals, however, has contributed to the destruction of coastal wetlands. Ensuring that the natural resources of the estuarine system are preserved and sustained is often placed in direct competition with human activities.

Recreation/Tourism

The fisheries, wildlife, and natural areas of coastal Louisiana are important components of the tourism industry of the entire State. In 1991, recreational fishing (including freshwater fishing) in Louisiana generated approximately $1.2 billion in economic output and employed nearly 18,500 people.[12] In the same year, about 240,000 saltwater anglers spent over 2.6 million days fishing off the coasts of Louisiana.[13] The licensed saltwater anglers in the State have invested almost $1 billion in boats, gear, and other equipment in their recreational hobby.[14]

In addition to providing a wealth of sport fishing resources, the Barataria-Terrebonne system's swamps and marshes are among the leading areas in the nation for watching birds.[15] Organized swamp and marsh tours are common. Photography, boating, camping, and picnicking are other activities which bring residents and visitors to the region.

Fisheries/Seafood

Many of the commercially valuable species in the Gulf of Mexico region depend upon the health of the Barataria-Terrebonne Estuary for survival. In 1994, the combined market value of commercial finfish and shellfish landings in the Gulf totaled approximately $806 million. For the same year, the State of Louisiana's commercial finfish and shellfish landings totalled approximately 1.7 billion pounds, valued at $336 million.[16]

Louisiana has the most valuable and the greatest finfish and shellfish landings in the continental United States.[17] Estuaries are critical to fisheries production in Louisiana. In fact, 95 percent of the State's total finfish and shellfish catch for 1992 was estuarine-dependent.[18] The Barataria-Terrebonne Estuary's landings averaged 70 percent of the State's total value for the four-year period between 1989 and 1992.[19] Over 35,000 people are employed by the commercial fishing industry of Louisiana.[20]

The Barataria-Terrebonne region is often referred to as the nation's "fishmarket," due to its immense commercial fishery yields. The Estuary's annual commercial harvest of fish and shellfish is over 611 million pounds.[21] The coastal marshes of the Estuary provide important spawning and nursery grounds and provide shelter for substantial numbers of fish and shellfish.

Some of the more prominent commercial finfish of the area include menhaden, black drum, spotted sea trout, mullet, and red snapper, all fish which depend upon estuaries for at least one stage of their life cycles. Brown shrimp, white shrimp, hard-shell blue crabs, oysters, and crawfish are some of the leading shellfish and crustacean fisheries of the system.[22] For the four-year period between 1989 and 1992, the Barataria-Terrebonne Estuary accounted for an average of 86 percent of Louisiana's total oyster landings.[23]

Wildlife

The Barataria-Terrebonne system provides habitat for an abundance of wildlife. The Estuary is inhabited by over 200 bird species, 30 mammal species, 26 reptile species, and 14 amphibian species, along with numerous species of fish and invertebrates.[24] At least 187 different finfish species inhabit the estuarine complex.[25]

The Barataria-Terrebonne Estuary provides important nesting and wintering habitat for a large number of waterbirds and waterfowl. In addition, it contains unique foraging habitat for wading birds, sea birds, and migratory birds. The Estuary supports 71 of the State's 143 waterbird nesting colonies, including white ibis, great egret, and little blue heron. Millions of resident and migratory ducks and geese use the Estuary's forested wetlands and marshes. Nesting colonies of pelicans, terns, and skimmers use its barrier islands and beaches. It is estimated that over 400,000 geese and 25 percent of North America's dabbling duck population use the State's coastal marshes for wintering grounds.[26] In addition, 50 percent of the continental population of mottled duck dwells in the Estuary year-round.[27] Throughout North America, duck populations are steadily declining, due in part to disappearing breeding and migratory habitat. Local, state, federal and private initiatives are being taken to protect wetlands habitat for waterfowl populations.

Minks, otters, racoons, nutria, muskrats, alligators, and diamondback terrapins are a few of the other animals which inhabit the Estuary. Nutria and muskrat eating habits are affecting the species composition and density of wetland vegetation.[28] Muskrats feed on brackish marsh plants and nutria eat baldcypress seedlings and other plants of the Estuary's freshwater marshes to such a degree that large areas of the system are being "eaten out" by the growing populations of these animals. It is estimated that 55,000 acres of marsh have been destroyed by these "eat outs," which often result in erosion problems.[29]

Of Louisiana's 31 animal species that are federally-listed as threatened or endangered, 14 are dependent on wetland habitats.[30] The endangered hawksbill sea turtle, Kemp's ridley sea turtle, least tern, and bald eagle; and the threatened green sea turtle, loggerhead sea turtle, piping plover,[31] and leatherback sea turtle,[32] use the wetlands and estuaries in Louisiana. Due to habitat loss and degradation, a number of additional species are considered to be at risk. These include the diamondback terrapin, American alligator, snapping turtle, black skimmer, North American dabbling duck, and the mottled duck.[33]

Threats to the Estuary

The Barataria-Terrebonne Estuary System is a great economic and ecological resource for Louisiana and the nation. Although natural conditions have played a part in changing the nature of the Estuary, the human activities that have put it at risk may be easier to resolve. Various studies initiated by the Barataria-Terrebonne National Estuary Program point to a compelling need to preserve and restore the Estuary and its resources. The priority problems of the Estuary Complex are identified as the alteration of natural water flows, habitat loss, toxic pollution, nutrient loadings, and pathogen contamination. Increased population growth and urban development are concerns that intensify each of these priority problems. One risk associated with industrial development can be seen in the fact that between 1990 and 1994 there were 597 oil spills in the Bayou Lafourche.[34]

Alteration of Water Flows

The alteration of freshwater pathways to the Estuary is reducing the natural levels of sediment loadings in the system. Normally, the streams and rivers that feed into the Estuary deposit sediments, especially during periodic floods, when the stream banks overflow. As this sediment accumulates, a natural process of land-building occurs. The marshes that form as a result of this process provide innumerable benefits to the wildlife resources of the Estuary.

Since the turn of the twentieth century, a variety of human actions have combined to disrupt nature's marsh construction. Dams built along the Missouri and Arkansas rivers reduce the volume of sediments which ultimately reach the bottom of the Mississippi River. Flood control levees prohibit the natural riverbank overflows that sustain the estuarine marshes. Channelization of the lower Mississippi River impedes its tendency to alter course. Finally, the closing of the Bayou Lafourche at Donaldsonville affects the delivery of water and sediment to the Estuary.[35] These and other factors are altering the balance of habitat types and actually causing the land in the Barataria-Terrebonne Estuary Complex to disappear! The rate of loss for all land (most of this land is wetlands) in the Barataria Bay area was 7,120 acres per year between 1978 and 1990. For the Terrebonne Bay area, the rate of loss was 6,500 acres per year.[36]

The construction of channels and canals within the Barataria-Terrebonne watershed is leading to saltwater intrusion into historic freshwater portions of the Estuary.[37] An estimated 6,950 miles of canals have been built in the coastal plain to support oil and gas exploration and production.[38] The increased traffic along these canals also increases soil erosion along the banks. As a result of these and other projects, the coverage of marshes in the Barataria-Terrebonne system is reduced; greater portions of the Estuary are more saline; water circulation is disrupted; and the natural pollutant filtering processes are hindered. In order to decrease water salinities and restore marshes, one of the CCMP Action Plans calls for the construction of water control structures and the reintroduction of freshwater to the Estuary.[39]

Habitat Loss and Degradation

Forty-one percent of the nation's coastal wetlands are in Louisiana.[40] However, these wetlands are disappearing at an alarming rate. Between 1978 and 1990, the average annual loss of coastal wetlands was 24,203 acres (37.8 square miles).[41] In other words, during this period an area of Louisiana's coastal wetlands the size of Washington, D.C. was destroyed every 20 months. The Barataria-Terrebonne region of Louisiana's coast is suffering the greatest losses of wetlands.

Natural and human activities are responsible for the wetland losses in coastal Louisiana. The natural causes of wetlands loss include sea level rise, subsidence, lack of sedimentation, saltwater intrusion, "eat outs" by muskrats and nutria, tidal scour, and waves. Canal construction, dredging and filling, levee building, and toxic discharges are human actions which destroy wetlands.[42]

Not only do the system's wetlands provide critical habitat for a significant portion of the nation's estuarine-dependent fisheries and for migratory birds along the Mississippi Flyway, but they also serve important public protection functions. Coastal wetlands reduce the impact of storm tides, absorb flood waters, filter pollutants, and in many areas of the nation provide a source of ground and surface waters needed for drinking water

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supplies. The values coastal wetlands alone provide for the region are virtually inestimable. However, a recent study conducted by the University of Maryland has come up with a way to assign a dollar value to the wetlands habitat in Louisiana. The study estimates that one acre of Louisiana wetland yields up to $846 in commercial fishery benefits; $181 in recreational benefits; and $7,549 in storm protection benefits. The study also concluded that since Louisiana loses wetlands at a rate of 60 square miles per year, it loses $93 million annually.[43]

Barrier islands are also disappearing. Barrier island beaches are eroding at a rate of 15 to 30 feet per year.[44] Since 1880, the State has lost approximately 16,000 acres of barrier islands.[45] As this process continues, the estuarine habitat and coastal communities will receive less protection from coastal storms. Also, significant losses of estuarine habitat are likely to result after barrier islands are permanently washed over by tides from the Gulf of Mexico.[46]

Efforts to restore the marshes and barrier islands of the estuarine system are in process. Some of the initiatives call for pumping sand to increase the width of barrier island beaches, limiting groins and seawalls on islands largely untouched by human activity, and using water control structures to deliver more water and sediments to the marshes.[47]

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the Estuary by urban stormwater, sewage treatment plants, atmospheric deposition, agricultural runoff, and boater discharges. The loadings of nitrogen and phosphorus into the Estuary from the Mississippi and Atchafalaya rivers doubled between 1950 and 1995.[48] Excessive levels of these nutrients stimulate the growth of algae in the Estuary. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation, but also require a great amount of dissolved oxygen to decompose. The decomposition process depletes the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills.

Since 1980, 188 fish kills have been documented in the Estuary. Some of these kills have been attributed to the runoff of herbicides and other toxic contamination associated with oil and gas extraction activities.[49] An algal bloom during September of 1994 killed approximately 200,000 fish.[50]

In the nearby waters of the Gulf of Mexico, nutrients carried by the Mississippi River are causing a massive "dead zone" measuring 6,000 square miles (greater than the size of Connecticut).[51] Each summer off the coasts of Louisiana and Texas, this "dead zone" appears after hypoxic conditions result from the delivery of excessive levels of nutrients. The water does not contain the necessary levels of dissolved oxygen required to sustain most marine life. It is widely believed that the nutrients loading into the system are derived from non-point sources throughout the Mississippi River drainage basin (the Mississippi River drains 41 percent of the continental United States).[52]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated waters. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

In 1994, State water quality inventories indicated that fecal coliform was a suspected or potential problem in 33 of the 55 assessed waterbodies in the Terrebonne Basin, and in 18 of the 27 assessed waterbodies in the Barataria Basin.[53] Almost one-half of the Barataria Estuary's oyster beds are closed each year because of sewage-related contamination.[54] The oyster harvest areas of Bay Junop were closed in 1973, 1987, and 1988 because of pathogens.[55]

Louisiana abandoned its official program of testing its ocean and bay beach waters for swimmer

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safety in 1988. A more limited approach of testing for "hot spots" is being considered but has not been accepted. Since the State has been monitoring its shellfish beds, it has discovered that 28 percent of the assessed estuarine areas do not meet State standards for primary body contact activities.[56]

Toxic Pollution

The water quality of the Barataria-Terrebonne Estuary System is currently threatened by pesticides, herbicides, polycyclic aromatic hydrocarbons (PAHs), DDT, chlorinated aromatic compounds (such as polychlorinated biphenyls), and heavy metals. Heavy metals which are found in elevated levels include cadmium, arsenic, lead, copper, and mercury. In addition, the pesticides mirex, aldrin, dieldrin, and heptachlor have been identified in fish tissue samples taken from the bays and lakes of the system.[57] Industrial, petrochemical and municipal discharges, septic systems, polluted urban stormwater, agricultural runoff, and atmospheric deposition are the primary sources of these chemical contaminants in the Estuary.[58]

Over 60 facilities are located along the stretch of the Mississippi River between Baton Rouge and New Orleans.[59] These plants threaten the Estuary with a variety of municipal and industrial chemical inputs. In 1993 alone, toxic emissions from industries State-wide exceeded 465 million pounds, making Louisiana the State with the greatest amount of toxic discharges into air, land and water for the fifth consecutive year.[60] Since high levels of contaminants are carried by the Mississippi and Atchafalaya rivers to the Estuary, the impacts of toxic contamination are more pronounced at the fringes of the system. Some of the identified toxic "hot spots" of the system are Segnette, Bayou Choctaw, Lower Grand River, Lake Verret, and Lake Palourde.[61]

Particles of toxic metals and organic chemicals settle in the sediments of the Estuary. Many of these toxins persist in the system and are eventually consumed by aquatic organisms. Over time, these toxins "bio-accumulate," and are passed up the food chain. Because of the persistent nature of these contaminants, chemicals which were introduced to the system decades ago may have a present-day effect on the wildlife, water quality, and human populations of the estuarine system. Toxic contamination impairs the immune, reproductive and endocrine systems of aquatic wildlife. In addition, there is growing concern about the human health risks associated with eating contaminated seafood. This is a special concern for individuals who subsist on fish and shellfish caught in urban waters.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The amount found in just one day was staggering — on September 17, 1994, volunteers cleared over 139,000 pounds of marine debris from 217 miles of Louisiana beach area. Of that total amount, 70.4 percent consisted of plastics, 11 percent was metal, 6.9 percent was glass, and 11.7 percent was other debris.[62]

The Barataria-Terrebonne National Estuary Program

The Barataria-Terrebonne Estuarine Complex was officially designated as an estuary of "national significance" in 1990 when it became part of the National Estuary Program. The Barataria-Terrebonne National Estuary Program (BTNEP) was established to help in the development of a Comprehensive Conservation and Management Plan (CCMP) for the Estuary. In December, 1993 the Management Conference of the BTNEP finalized a draft framework for the CCMP. In 1994, this framework for the CCMP was distributed for public review and comment. In December, 1995 a detailed draft CCMP was completed and made available for public review and comment. The final CCMP is expected to be approved by the Governor and the Administrator of the EPA in June, 1996.

The consensus nature of the Program laid the groundwork for many stakeholders to become engaged in the BTNEP, including: fishing and agricultural interests, oil and gas industry, shipbuilding industry, landowners, environmentalists, and the general public. The BTNEP was also responsible for

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ensuring the coordination of efforts among multiple agencies, and to facilitate joint scientific research and CCMP implementation.

The start-up phase required the BTNEP to organize a Management Conference with five committees to oversee and develop all program efforts. The second phase was the Characterization Phase. One of the first steps in this planning process was to identify the Estuary's priority problems. Seven problems were identified by the BTNEP, these include: hydrological modification, reduced sediment flows, habitat loss and modification, changes in living resources, oxygen-starved water bodies, pathogen contamination, and toxic substances.[61] Today, as part of the CCMP Development phase, the program is developing detailed action plans to address these critical pollution problems.

To accomplish all of this the BTNEP conducts numerous ongoing technical studies and public participation projects. Some of these projects include the following: Reduction of Biological Oxygen Demand in Seafood Processing Wastewater Study; Mapping Oyster-Producing Areas in the Estuarine System; Storm Water Drainage Stations: Location, Mapping, and Recommendations for Evaluation Study; Survey of Nutria Vegetation Damage; Conversion of Abandoned, Dead-End Canals to Marshlands; Monitoring Fecal Coliform; and Estuarine Workshops for Teachers.

To evaluate the success of management scenarios, the BTNEP uses state-of-the-art predictive models. These models simulate the impacts of hydrologic alterations and landscape changes on the environment.[64] This type of information is then used to support restoration advocacy and specific projects as a joint effort of the BTNEP, local grassroots groups like the Coalition to Restore Coastal Louisiana, and the State of Louisiana.[65]

As the planning phase of the BTNEP drew to a close, a major step was taken with the creation of the Barataria-Terrebonne Estuary Foundation (BTEF). This is to ensure that the plans developed by the BTNEP are actually implemented and that the public will have a major role in that work. Historically, the weak point of resource management plans created under the National Estuary Program has been the lack of any independent entity dedicated to making sure that the various agencies and interests who drafted the plans actually abide by them. The hope is that the BTEF will fill that void.

The BTEF is a nonprofit, charitable organization with a 15-member Board of Directors. The creation of the Foundation was called for in the CCMP currently being finalized by the BTNEP. The Coalition to Restore Coastal Louisiana (CRCL) helped with the preparation of the Foundation's organizational documents and is committed to helping the Foundation get off to a strong start. The Coalition's Executive Director was one of the incorporators and will serve on the Foundation's board of directors. Besides ensuring that the BTEF is funded and serves as a "watch dog" group for implementation of the CCMP, the CRCL is particularly concerned that the Program's Ecological Management Action Plans are adequately implemented. CRCL is trying to ensure that key Ecological Management Action Plans such as "Preservation and Restoration of Barrier Islands, and Freshwater and Sediment Diversions" do two essential things. First, they urge that the Coastal Wetlands Planning, Protection and Restoration Act and the Louisiana Department of Natural Resources Plans for restoration be accepted, supported, and incorporated into the CCMP by reference. Second, CRCL recommends the Action Plans detail who the implementing agencies and entities are, and how the actions will be accomplished.

Probably the biggest remaining problem challenging the restoration of the Estuary is the lack of funding. A plan exists to restore the Estuary, yet there are limited resources to aid in this task. Federal assistance can no longer be assured and the State will have difficulty allocating any funding for the Program.[66] The creation of the BTEF is a good first step but it is critical that its priority be addressing the lack of funding for implementation of the Plan.

National Coastal Caucus

The Coalition to Restore Coastal Louisiana (CRCL) is a non-profit organization formed in 1988 to address and advocate for the restoration and preservation of the Mississippi River Delta. Years of neglect and cavalier treatment have significantly impaired this unique national resource. Simply put, coastal Louisiana is disappearing at a rate of 25-40 square miles per year. Indeed, roughly every fifteen minutes an area of coastal land the size of a football field vanishes and is replaced by open water. The CRCL believes that unless major steps are taken to address this situation the entire coastal ecosystem faces collapse within the next several decades.

From the onset, the CRCL recognized that because many of the problems facing coastal Louisiana were the result of human activity, it would take human intervention to solve them. This could only be accomplished by forging a working partnership between the public, state and local governments, and the federal government, which is the very nature of the BTNEP.

The Coalition has been involved in the BTNEP since its inception. Early on, the staff and members of CRCL became integral parts of the Management Conference which developed the goals and objectives that have since driven the BTNEP process. As the BTNEP program progressed, CRCL staff and members were active on several Management Alliances, including the Ecological, Water Quality and Coordinated Planning Alliance, and drafted several Action Plans.

The CRCL has received and executed several contracts with the BTNEP. These contracts include the Public Outreach Conferences to receive feedback on the draft Action Plans, Wetland Science Workshops, and hands-on events for the public and educators. The CRCL will soon execute a contract to conduct an Environmental Technology Expo which will serve as an educational showcase and a forum for the BTNEP to exchange information with technology vendors on available technologies and unmet needs. In what may be the most important Coalition contribution, the organization was instrumental in forming the Barataria-Terrebonne Estuary Foundation, a non-governmental organization, to ensure that the CCMP is implemented. CRCL has also been involved in efforts to get the Atchafalaya River Basin included as a "mini" estuary program with reduced levels of funding, in the study area of the BTNEP. This branch of the Mississippi is the only portion of the coast that is actually building a delta, and therefore needs to be protected.

The CRCL is involved in a wide range of other activities and issues. On the grassroots level, Coalition board members are joining with parishes and local governments in southwestern Louisiana to oppose plans for "Trans-Texas Waterway" that would (as planned) divert 600 million gallons of freshwater from the Sabine River daily to serve Houston and outlying areas. Given the already severe coastal losses in southwest Louisiana, cutting off a substantial part of the flow of freshwater and sediments from the Sabine seems short-sighted.

CRCL is also engaged in advocacy programs at the federal level. CRCL, along with a number of grassroots groups are working to counter the bills going through Congress, especially H.R. 961 and its counterparts in the Senate. These groups are especially concerned about the new wetlands declassification and its effects on coastal Louisiana.

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Barnegat Bay
in New Jersey

Portrait of the Bay

The Barnegat Bay National Estuary Program was established to examine the water quality and habitat problems of the Barnegat Bay estuarine system and the impact that the greater watershed has on the estuary. Barnegat Bay and Little Egg Harbor comprise the Barnegat Bay estuarine system. This system, located along the central shore of New Jersey, borders Ocean County. With a maximum depth of about 23 feet in some areas, Little Egg Harbor is a deeper estuary than Barnegat Bay.[1] The depth of Barnegat Bay ranges from 3 to 13 feet.[2]

The entire watershed of the Barnegat Bay system measures 660 square miles.[3] Residential development is the primary land use in the watershed.[4] Only five square miles of the watershed (less than one percent) is used for traditional agricultural production, farms, and berry production.[5] Since 1950, Ocean County's population (the watershed contains most of Ocean City) has expanded by 775 percent.[6] More development in the area is concentrated around the Barnegat Bay area rather than Little Egg Harbor.

Barnegat Bay	
Area of watershed	660 square miles
Depth	Ranges from 3 to 23 feet
Values	• Recreational fishing generates $1.3 billion* • Tourism in Ocean County generates over $1 million • Habitat for several federally listed threatened and endangered species
Threats	• Stormwater and polluted runoff • Nutrient loadings • Pathogen contamination • Habitat loss and degradation
CCMP status	Expected in 1998

Designated as a "Nationally Significant" Estuary in 1995

*State figure

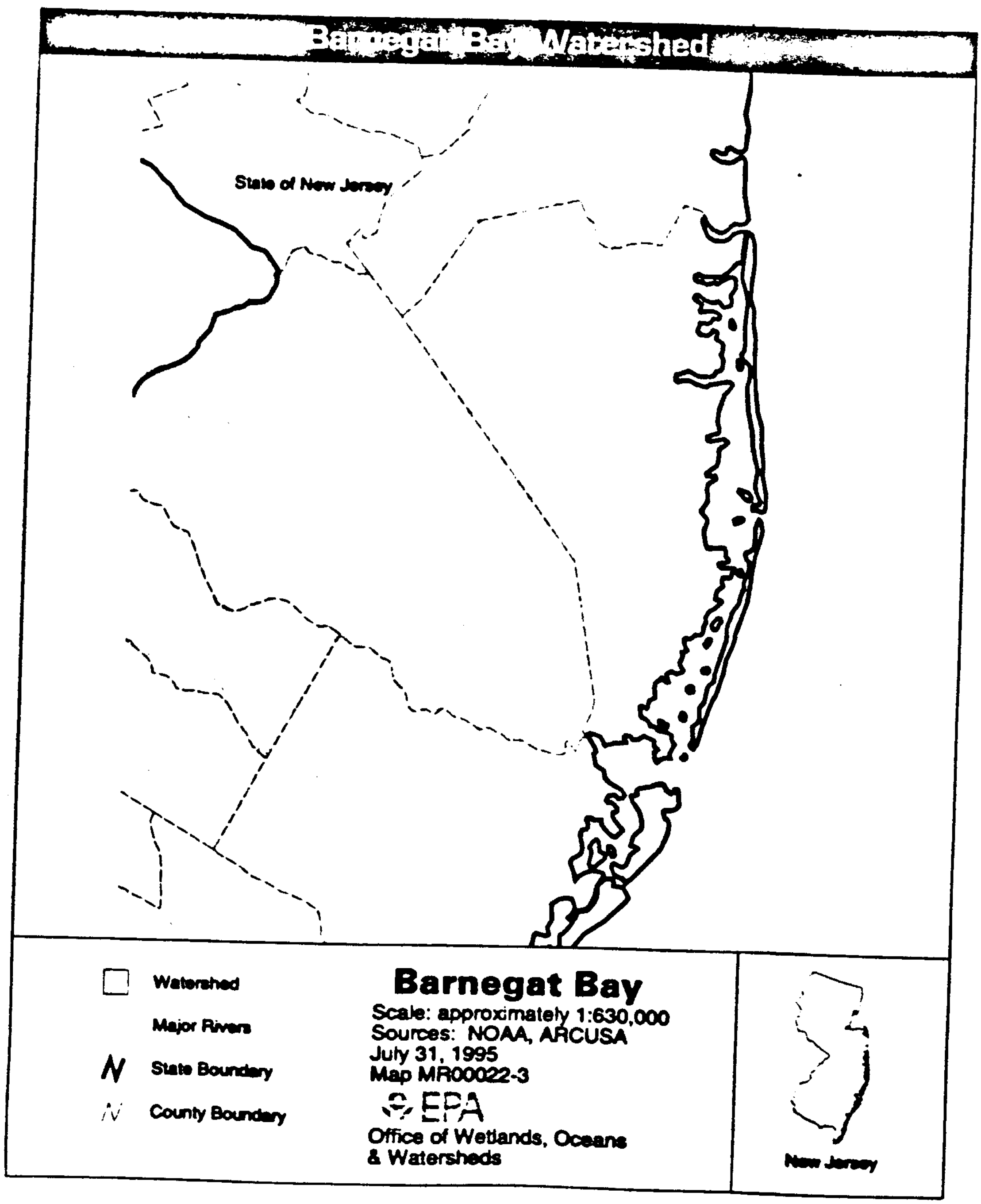
The principal sources of freshwater to the system include the Metedeconk River, Kettle Creek, Toms River, Cedar Creek, Forked River, Mill Creek, West Creek, and Tuckerton Creek.[7] In the northern section of the system, the Manasquan River connects with Barnegat Bay via the Bay Head-Manasquan Canal; however, there is not a substantial interchange of fresh and saltwater between the Bay and River.[8] Portions of the Manasquan River are also included in the study.

A barrier island system runs along the eastern edge of Barnegat Bay, separating it from the Atlantic Ocean. The Bay's main connection to the Atlantic Ocean is through the Barnegat Inlet. Historical data on the influence of the Inlet may no longer be applicable. The United States Army Corps of Engineers recently completed a large-scale reconfiguration of the Inlet; the full impact of this project on the circulation and flushing patterns of the estuarine system are beginning to be examined.

Barrier islands also adjoin the shallower portions of Little Egg Harbor. Marshes fringe the southern and western edges of Little Egg Harbor.[9]

Values of the Bay

Barnegat Bay and Little Egg Harbor provide immeasurable benefits for both the wildlife that depend on its plentiful resources and for the surrounding communities that count on it to help generate jobs and revenue for the local economy. The Barnegat Bay system also supports diverse


Barnegat Bay Watershed
State of New Jersey
Watershed
Major Rivers
State Boundary
County Boundary
Barnegat Bay
Scale: approximately 1:630,000
Sources: NOAA, ARCUSA
July 31, 1995
Map MR00022-3
EPA
Office of Wetlands, Oceans
& Watersheds
New Jersey

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fisheries, tourist attractions, recreational opportunities, and critical wildlife habitat.

Tourism/Recreation

Tourism in Ocean County generates about $1 million annually.[10] Recreational activities, such as boating and fishing, are attractive activities which lure many visitors to this portion of the New Jersey coast. Motor boats, sail boats and yachts also use portions of the system. In 1988, over 53,000 boats used Barnegat Bay.[11] A total of 116 marinas and other boat launching sites are situated within the watershed.[12] Canoeists and kayakers are drawn to the waters within the Island Beach State Park, the Edward B. Forsythe National Wildlife Refuge, and the Manahawkin Wildlife Management Area.

Both Little Egg Harbor and Barnegat Bay are important to the State's recreational fishing industry as fishing grounds and as important habitat for juvenile fish which may be caught in other areas of the State. Recreational fishing is a popular summer activity in the Little Egg Harbor, and thereby helps to support a number of small businesses which cater to anglers. In 1991, recreational fishing in New Jersey generated approximately $1.3 billion in economic output and employed approximately 17,000 people.[13] In 1991, approximately 746,000 saltwater anglers spent over six million days fishing off the coast of New Jersey. Thirty-two percent of the anglers were non-residents of the State.[14]

Fisheries/Seafood

The Barnegat Bay system contributes valuable fishery resources to the mid-Atlantic region of the United States. In 1994, the combined value of the mid-Atlantic commercial finfish and shellfish landings totaled approximately $149 million. In that same year the State of New Jersey's commercial finfish and shellfish landings totaled approximately 202 million pounds, valued at approximately $100 million.[15]

Barnegat Bay and Little Egg Harbor sustain important local and regional fisheries. The estuaries and their surrounding wetlands are important nursery areas for a variety of shellfish and finfish, many of which are commercially valuable and/or prized by recreational anglers. In 1988, the estimated value of commercial landings of inshore hard clams, blue crabs, white perch, and American eels in Ocean County was $2.7 million.[16] Prominent species of finfish found in the system include winter flounder, white perch, inland silverside, northern pipefish, bluefish, and striped bass.

The most valuable commercially-caught species in the area is the inshore hard clam. In some years revenues derived from hard clam represent as much as 60 percent of the total value of commercial fisheries in Ocean County.[17] In 1988, the value of hard clam landings was nearly $2.2 million.[18] Between 40 and 50 percent of all commercial inshore hard clam landings in New Jersey occur in Ocean County waters.[19] Another important species found in Barnegat Bay is the blue crab. Blue crab landings from this area comprise about 10 to 15 percent of the State's total blue crab landings.[20]

Wildlife

The Barnegat Bay system is used by an abundance of wildlife. Thousands of waterfowl and shorebirds use the estuarine area for nesting and wintering grounds, and for stopover points during migrations. Common bird species which nest in the Bay area include the great egret, piping plover, herring gull, and laughing gull. Additionally, tri-colored herons, least terns, black skimmers, and snowy egrets nest in the area, however, the populations of these bird species are in decline. Migratory birds using the Atlantic flyway can be spotted during the fall months on the Island Beach State Park, a large tract of undeveloped shore.[21]

New Jersey has nineteen species federally-listed as threatened or endangered.[22] The Bay system provides important habitat for several of these species, including the endangered least tern, piping plover and the threatened Ipswich sparrow.[23] The diamondback terrapin, a candidate for federal protection, also uses the Bay area for breeding grounds.[24]

Threats to the Bay

The problems of the Barnegat Bay estuary system are currently being explored. Studies indicate that the most significant threats to the system are contaminated stormwater and polluted runoff, nutrient loadings, pathogen contamination, and habitat loss. Population growth and accompanying development within the watershed are principal factors of each of these environmental problems.

Stormwater and Polluted Runoff

To support the rapidly growing population in the region, land usage within the watershed has increasingly become more developed and urbanized. As a result of this development, wetlands, forests and other natural areas have been replaced with impervious surfaces, such as roofs and pavement. The increase in impervious surface area affects the water quality of the Barnegat Bay system and its tributaries. Without natural land to absorb excess rain and filter contaminants, greater concentrations of contaminants in more significant flows reach the estuary. Oil and grease from streets and parking lots, bacteria, lawn care products, and heavy metals are introduced to the estuary by stormwater. Due to the land use patterns of the Bay system, polluted runoff is a greater concern in the northern portion of the system. There is a significant need for a more detailed analysis regarding the impact that human land-based activities have on the water quality of the estuary.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by urban stormwater, sewage treatment plants, atmospheric deposition, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. Thus, excessive nutrient loadings in estuaries can jeopardize economic stability of fisheries-dependent communities. The over-enrichment of nutrients in waterbodies is called eutrophication.

In the Barnegat Bay and Little Egg Harbor, fertilizers and pesticides used on domestic lawns are considered to be major contributors to the high nitrogen levels of the estuary. The shallow Barnegat Bay and embayments of the system are susceptible to the effects of nutrient loadings. Recently, a "brown tide" organism, *Aureococcus anophagefferens*, has been observed in the Bay. This organism has afflicted submerged aquatic vegetation and shellfish populations of the Peconic Bays.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through urban stormwater, sewage treatment plant discharges, boating waste, and individual septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from ingestion of pathogen-contaminated seafood or water. For this reason, beaches and shellfish beds are closed or restricted when standards for fecal coliform bacteria or total coliform are exceeded. Fecal coliform and total coliform are indicators of pathogens. New Jersey has an extensive recreational beach monitoring program that includes mandatory closure requirements when water quality standards for swimmer safety are exceeded. Following heavy rains, many beaches along the New Jersey shore are closed for public health reasons.

Shellfish bed restrictions caused by high levels of pathogens are common in the northern portion of Barnegat Bay and its tributaries.[25] In 1990, 44 percent of all shellfish beds in Barnegat Bay were harvested-limited, primarily due to pathogen contamination.[26]

Habitat Loss and Degradation

The loss or modification of habitat is another concern that jeopardizes the health of Barnegat Bay. Issues that will continue to be addressed include the impacts of dredging operations on marinas and the Intracoastal Waterway, as well as the protection of barrier islands, coastal wetlands, and submerged aquatic vegetation.[27]

Eelgrass in the estuary has been adversely affected by increased nutrient inputs and human activities, such as dredging and boating. However,the extent of the damage is unknown because mapping of the eelgrass coverage has not been conducted since 1986, and therefore, current information is not complete.

New Jersey has lost over 584,000 acres, or 39 percent, of its original wetlands.[28] Many of these wetlands losses have occurred along New Jersey's coasts. In the Barnegat Bay watershed, significant acreage of both coastal and freshwater wetlands has been modified or destroyed. Between 1953 and 1973, over 37,000 acres of tidal wetlands were destroyed in Ocean County — a loss of over 30 percent.[29]

The local population of the Barnegat Bay area has participated in campaigns to acquire critical habitat for the public trust.[30] The coordination of habitat acquisitions for the protection of wildlife has been identified as a priority by the Management Conference of the Barnegat Bay Estuary Program.

Floatable Debris

Trash accumulated on estuarine beaches also threatens the ecosystem. The amount found in just two days was staggering — on October 15 and 22, 1994, volunteers cleared over 73,700 pounds of marine debris from 171 miles of New Jersey's beaches. Of the total amount of marine debris collected, 66.3 percent was plastics, 10.4 percent was paper, 8.2 percent was metal, and 15.1 percent was from other materials.[31]

The Barnegat Bay National Estuary Program

With the Environmental Protection Agency's acceptance of Barnegat Bay into the National Estuary Program, it became one of the most recent group of seven estuaries added to the Program. On July 6, 1995 Barnegat Bay was officially designated an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Shortly thereafter, the EPA convened a Management Conference responsible for coordinating the development of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect the Barnegat Bay. The CCMP is expected to be completed in three years.

A management plan for Barnegat Bay already exists due to a decade of work by interested parties. Local citizens have played integral roles in developing the existing plan and in nominating Barnegat Bay to be included in the NEP. These citizens are interested in commencing interim actions of the existing restoration plan.

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Buzzards Bay
in Massachusetts

Buzzards Bay is a multiple use estuary. We rely on its waters for food and shellfish production, in addition to its value for recreation, tourism and pleasure. On the darker side, Buzzards Bay is also used as an outfall for sewage discharges and road runoff, and as a major shipping and transit route through the Cape Cod Canal. Despite large areas of undeveloped land remaining within its watershed, one of the major threats to Buzzards Bay is excessive nutrient loading. We are slowly learning how to balance these uses, with emphasis on the regional challenges of proper watershed planning, development, and protection of natural resources. Our vision for the future is to stay vigilant and protective of this beautiful and diverse estuary for generations to come.

— Pamela Truesdale, Executive Director
The Coalition for Buzzards Bay

Portrait of the Bay

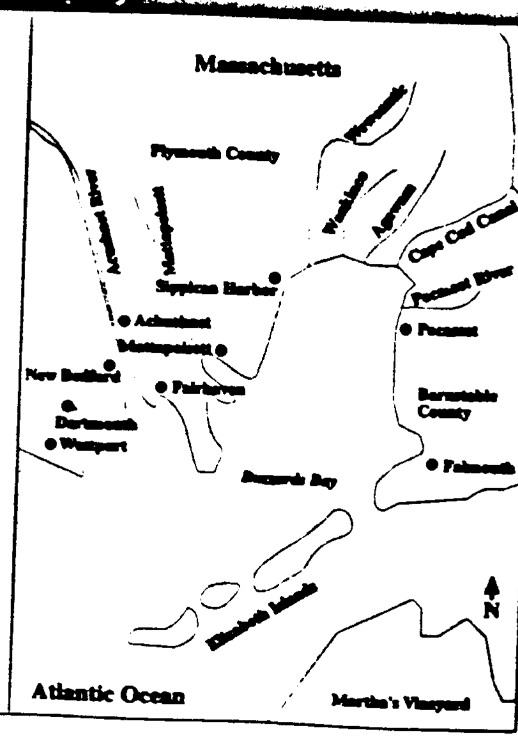
The Coalition for Buzzards Bay is working in concert with the Buzzards Bay Project to examine the water quality and habitat problems of the Bay and the impact that the greater watershed area has on the estuarine system. The surface water area of Buzzards Bay measures approximately 228 square

Buzzards Bay

Area of surface water	228 square miles
Area of watershed	432 square miles
Average depth	36 feet
Shoreline	280 miles
Population	236,000 people
Values	• Fisheries generate $206 million*
	• Sport fishing generates $767 million in economic output*
	• Habitat for 98% of endangered roseate terns in North America
Threats	• Nutrient loadings
	• Pathogen contamination
	• Toxic pollution
	• Population growth and development
	• Floatable debris
CCMP status	Approved in 1992

Designated as a "Nationally Significant" Estuary in 1988.

*State figures



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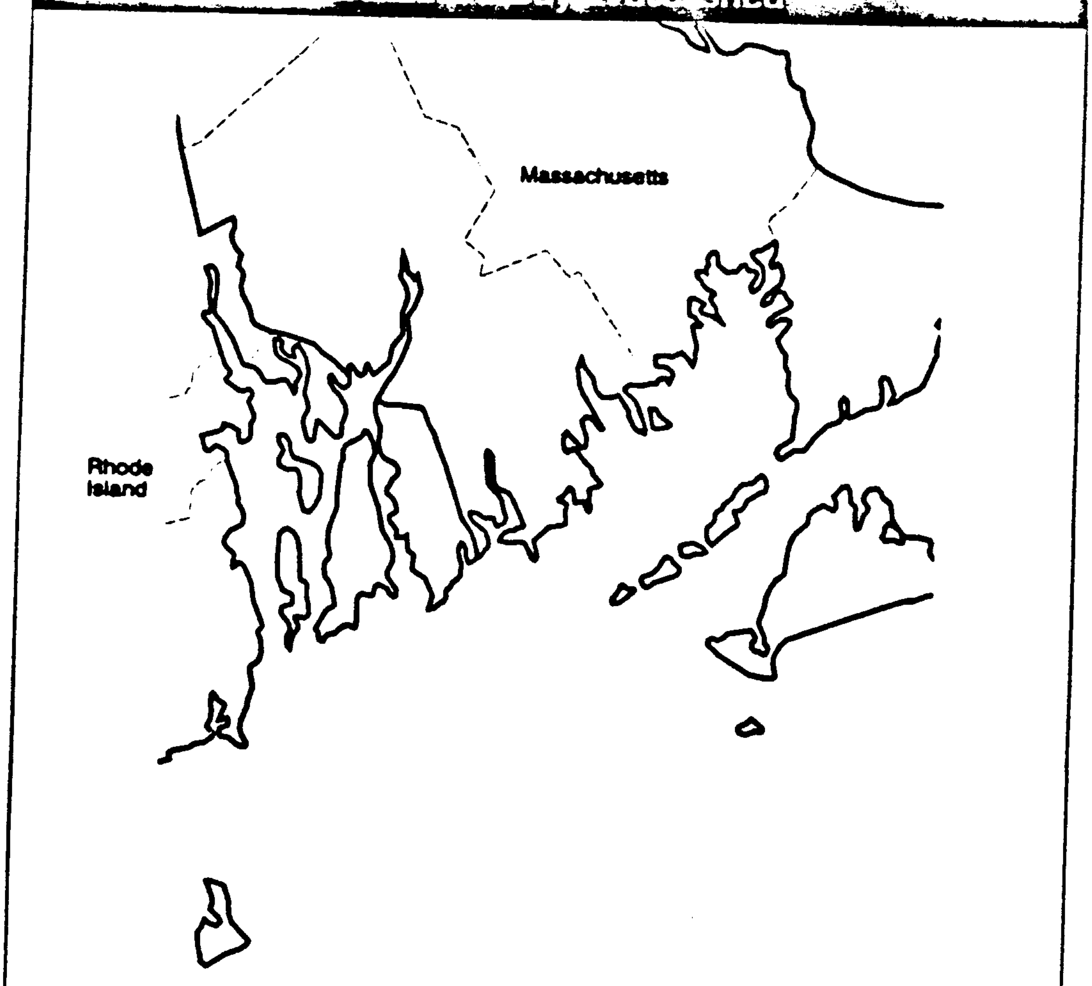
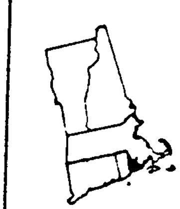
Buzzards Bay Watershed





Buzzards Bay
Scale: approximately 1:596,305
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-4
EPA
Office of Wetlands, Oceans & Watersheds

miles.[1] The Bay is bordered by southeastern Massachusetts to the west, the Elizabeth Islands to the south, and Cape Cod to the east. The Cape Cod Canal in the northern part of the Bay connects Buzzards Bay to Cape Cod Bay. Buzzards Bay contains 280 miles of jagged shoreline, of which 11 miles are public beach. The average depth of the Bay is 36 feet.[2]

The Buzzards Bay watershed area encompasses approximately 432 square miles. Within this area, the population exceeds 236,000 people, representing a density of 540 people per square mile. Seventeen municipalities are entirely or partially located within the watershed.[3] Of these, the city of New Bedford and the coastal communities of Dartmouth, Falmouth, and Fairhaven have the largest populations. In fact, New Bedford constitutes approximately 40 percent of the watershed population.[4] Also included in the watershed are two of the fastest growing counties in New England, Barnstable and Plymouth counties.[5]

Groundwater and a number of rivers provide the freshwater flow into the Bay. Along the western shore, the prominent rivers delivering freshwater to the Bay include the Agawam, Wankinco, Weweantic, Mattapoisett, Acushnet, Paskamanset, Westport and several others. Groundwater is the major freshwater source on the eastern shore. The smaller streams that drain this portion of the watershed include the Herring Brook and the Back, Pocasset, and Wild Harbor rivers.[6]

The jagged coastline creates a wealth of diverse tidal habitat for marine life, including, approximately 5,000 acres of salt marsh, 5,000 acres of tidal flats, 1,700 acres of barrier beaches, and subtidal areas.[7] More than 10,500 acres of eelgrass beds, which support a diversity of marine life, can also be found in the Bay.[8]

Values of the Bay

Buzzards Bay affords numerous benefits for residents and tourists of southeastern Massachusetts. Valuable commercial shellfishing resources, tourist attractions, scenic vistas, and good water quality are just a few of the reasons why people flock to Buzzards Bay. In addition, nearby academic and scientific institutions, such as Woods Hole Oceanographic Institution (WHOI) and the Marine Biological Laboratory, conduct extensive research on coastal waters in the Bay.

Recreation/Tourism

Buzzards Bay provides numerous recreational opportunities for tourists and residents within the watershed. Tourists in the coastal counties of Massachusetts spent an estimated $1.5 billion in 1993.[9] Boating, sport fishing, and sunbathing on area beaches are common activities in the area. Nearly 20,000 marine vessels pass through Cape Cod Canal annually and about 10,000 vessels anchor in the Bay throughout the summer.[10]

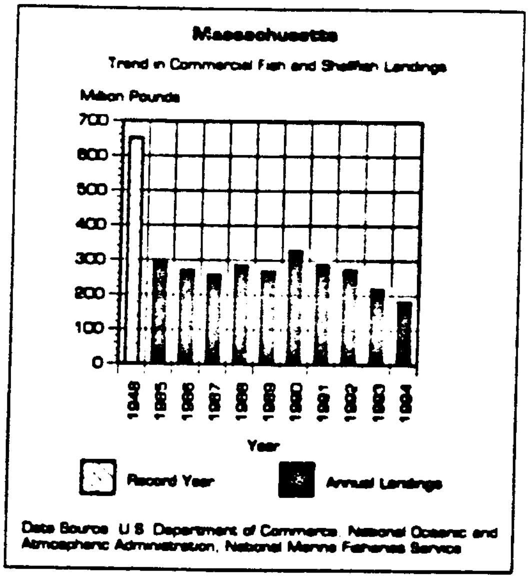
In order to maintain the interests of tourists and to expand the tourist and recreational revenues generated in the Bay area, it is essential that the water and beaches are kept clean. A significant amount of revenue is generated each year by public beach parking. For example, parking sticker sales at just three Massachusetts' beaches netted $1.6 million in 1990.[11]

Recreational fishing in Massachusetts generated approximately $767 million in economic output and employed nearly 10,450 people in 1991.[12] Saltwater fishing alone draws thousands of persons to Massachusetts each year. In 1991, approximately 393,000 saltwater anglers fished a total of 3.2 million days off the Massachusetts coast. Thirty percent of these fishermen were non-residents of Massachusetts.[13]

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the New England region totaled approximately $583 million.[14] Many of the commercially valuable species in the New England region depend upon the health of Buzzards Bay for survival. In 1994, the State of Massachusetts' commercial finfish and shellfish landings totaled approximately 183 million pounds, valued at $206 million.[15] Massachusetts is second only to Maine in annual landings of lobster.

Buzzards Bay is highly acclaimed for its shellfish harvests. In 1988, the value of the Bay's commercial



shellfish harvest was $4.5 million — almost 24 percent of the total State shellfish harvest.[16] Bay towns issued 485 commercial, 9,144 nonresident, and 3,168 recreational shellfish permits in 1994.[17] In the same year, the Bay's combined commercial and recreational quahog, bay scallop, soft shell clam, and oyster harvest was valued at $6 million.[18]

While Buzzards Bay provides critical nursery habitat for lobster larvae, its warmer temperatures and sandy bottom inhibit the development of a larger fishery for adult lobsters, which prefer colder waters. Nevertheless, the Bay's lobster harvest produces approximately 253,000 pounds, an average annual retail value of one million dollars to the local economy. In 1988, the total value of the Buzzards Bay lobster fishery, including lobster landings, gear, and vessels was approximately $2.3 million. In that same year, approximately 250 commercial lobstermen fished for lobsters in Buzzards Bay.[19]

Wildlife

Geographically, Cape Cod represents the division between the colder climate waters of the Gulf of Maine and the more temperate, mid-Atlantic coastal region.[20] As a result, species diversity is uncommonly high in the Bay. Since the Bay is situated on the edge of this transition zone, it is in the southernmost range for many northern species and the northernmost for many semi-tropical creatures.

Waterbirds, including the osprey, populate the islands and shoreline of Buzzards Bay. Decades ago, the osprey population was decimated by DDT-related reproductive problems. By the late 1980s, years after the banning of DDT, osprey sightings began to slowly occur again throughout the Bay. Wading birds, such as snowy egrets and black-crowned night herons, use the shoreline of the Bay for nesting grounds. A number of waterfowl, such as common eiders, Canada geese, canvasbacks, and black ducks also inhabit Buzzards Bay.[21]

A few species of marine mammals can also be found in the Bay. The most common is the harbor seal, which primarily uses Gull Island in the Bay for wintering habitat. On rare occasions, grey seals, whales, porpoises, and dolphins can be observed in the Bay.[22]

Massachusetts has twenty-two species on the federal endangered and threatened species list,[23] of which seven are wetlands-dependent.[24] The threatened bald eagle and piping plover, and the endangered roseate tern are protected bird species which use the estuarine wetlands in Massachusetts during their life cycles.[25] Bird Island of Buzzards Bay remains a critical nesting area for 98 percent of the roseate terns in North America. In addition, endangered leatherback and Kemp's ridley sea turtles live in the Bay.[26]

Threats to the Bay

Despite localized toxic contamination in the Acushnet River adjacent to New Bedford, the site of the largest marine Superfund project in the nation, Buzzards Bay has avoided many of the Bay-wide water quality problems to the degree that they plague other more urbanized coastal watersheds on the eastern seaboard. Nevertheless, land use practices and a growing population have degraded the Bay's natural resources, particularly in the Bay's 32 small embayments and harbors where the impacts of inappropriate development activities affect the estuary most severely. The limited flushing capacity of these areas further intensifies the decline of valuable resources such as eelgrass and shellfish habitat.

The Buzzards Bay Program has identified excessive nutrient loadings, pathogen contamination, and toxic contamination as the priority threats to the health of the ecosystem.[27] Land use practices and marine debris pose additional threats to the Bay system.

Nutrient Loadings

Excessive nutrient loading poses the greatest long-term threat to Buzzards Bay. Nutrients, such as nitrogen and phosphorus, are introduced to the estuary through a variety of sources, such as individual septic systems, sewage treatment plants, agricultural runoff, atmospheric deposition, and lawn care products. Groundwater underflows, point source outfalls, and stormwater deliver the nutrients to the estuary. Nutrient enrichment causes increased algae growth that eventually starves the water of oxygen. Nutrient impacted waters can become visibly cloudy thereby blocking sunlight needed by eelgrass beds. In addition, drift algae smother shellfish beds. Algae require a great amount of dissolved oxygen to decompose, creating low oxygen conditions which stress fish life and cause foul odors.

Over 62 percent of the nitrogen contribution to the Bay comes from sewage treatment plants and combined sewer overflows.[28] The sewage outfalls are situated in the deeper and better flushed portions of the Bay; as a result, the effects of nitrogen loadings are restricted to the areas around the outfall.[29] In the shallower embayments of the estuary, the majority of nitrogen is from individual septic systems. In fact, septic systems far from the coast can contribute excessive nutrient loadings through groundwater transport if they lie in the watershed of an embayment or harbor. Due to the diminished flushing capacities of these embayments, the effects of nitrogen inputs are more significant.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from ingestion of pathogens. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria or enterococcus (indicators of pathogen contamination) are present in coastal waters.

Sewage treatment plants and individual septic systems are significant sources of pathogens which enter Buzzards Bay. Over 37 million gallons of treated sewage from five municipal wastewater treatment plants enter Buzzards Bay each day.[30] Occasionally, these plants will malfunction and release wastewater containing pathogens. The construction of a secondary treatment facility in New Bedford will soon eliminate the largest source of primary treated sewage to the Bay. Combined sewer overflows in New Bedford, however, continue to discharge large amounts of untreated, raw sewage during significant rainfalls when the city's antiquated collection system is unable to handle the combined sewage and stormwater flow. There are 38 CSO discharges in the New Bedford and Clark Cove areas of the Bay.[31]

Localized pathogen contamination of many smaller embayments and the resulting closure of shellfish beds and swimming beaches are mainly attributed to old, failing septic systems along the shore and the conversion of many summer communities into year-round neighborhoods. Almost one-half of the watershed's residents use septic systems and cesspools to dispose of their sanitary waste.[32]

Between 1985 and 1990, the percentage of harvest-limited shellfish beds in Buzzards Bay increased from seven to 48 percent.[33] In January 1995, 13,648 acres of shellfish beds were closed due to fecal coliform contamination, and 3,949 acres were conditionally restricted based on rainfall and seasonal events.[34] Closed shellfish beds create economic problems for the shellfishermen and local communities dependent upon shellfish resources. In the New Bedford Harbor, it is estimated that the lost value of closed quahog beds is $5 million. In addition, the annual loss of revenue caused by the closed lobster fishery in the Harbor is $250,000.[15] These closures cause fishermen to begin fishing for less desirable species. As more commercial fishermen seek fewer fish, increased pressures for maintaining productive populations arise.

The positive effects of shellfish bed reopenings were revealed in 1992, when Clark's Cove in New Bedford was reopened after nearly 80 years of public health closure. The first year of shellfish revenues from the Cove resulted in more than one million dollars.[16]

Toxic Pollution

Between the 1940s and 1970s, industries within the greater New Bedford area contaminated the Bay with polychlorinated biphenyls (PCBs), hydrocarbons, and trace metals. High PCB levels are responsible for the closure of 18,000 acres of productive lobster and fishing grounds around New Bedford Harbor.[17] Sediment, lobster, fish and shellfish samples from the New Bedford area reveal significant levels of toxic pollutants. Samples of lobster tomalley and hepatopancreas are sometimes close to the FDA limit.[18]

Population Growth and Development

Each of the major threats mentioned above is directly related to the region's historic and continuing population growth and the misuse of land. Since 40 percent of the land situated within one-half mile of the Bay's coast is forested, land management is critical to the future of this estuary. Maintaining the benefits of forests, wetlands, and other natural habitats will assist in restoring the Bay. Wetlands and other natural lands absorb and filter pollutants before they can enter the Bay, as opposed to pavement, roofs, and other impervious surfaces that aid in the direct discharge of pollution into the Bay. Thus far, Bay-wide efforts have not adequately addressed open space protection and land use planning. Communities surrounding the Bay must better manage the effects of polluted stormwater resulting from urban and residential development.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. During the period between September 17 and October 10, 1994 several beach clean-ups were conducted in which volunteers cleared 50,000 pounds of marine debris from 200 miles of Massachusetts beaches. Of the total amount of marine debris, 61.8 percent was plastic, 13.9 percent was paper, 8.9 percent was metal, and 15.4 percent was other debris.[19]

The Buzzards Bay Project

In 1985, the Environmental Protection Agency completed a study of estuaries which revealed the ecological health crises facing the nation's coastal waters. As a result of this research, Buzzards Bay was selected in 1988 as one of the original estuaries of "national significance" to be included in the National Estuary Program. The Massachusetts Office of Coastal Zone Management in cooperation with EPA Region I has authority over the Buzzards Bay Project (BBP). In 1992, the Buzzards Bay Comprehensive Conservation and Management Plan (CCMP) became the second plan in the NEP to be approved by the EPA Administrator. It is now in its fourth year of implementation. In the same year, the Buzzards Bay Action Compact which endorsed the implementation of the eleven action plans outlined in the CCMP, was also signed by the twelve coastal municipalities in the watershed.[20]

Key stakeholders of the Bay Project are the citizens and the municipalities, each of which has its own needs and priorities that are not always consistent with one another. As a result, the Citizens Advisory Committee of the BBP split into two independent non-profit organizations during the early stages of the planning process. The voice of the citizens and environmental groups joined under the umbrella of the Coalition for Buzzards Bay, while the cities and towns have representation under the Buzzards Bay Action Committee.

The principal mission of the Buzzards Bay Project is to provide financial and technical assistance to municipal governments to help reverse the major problems of the Bay. The BBP

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engaged the municipal governments early on in the process of developing the CCMP. It was clear that the local governments had the greatest authority, particularly under the "home rule" concept in Massachusetts, as well as the capacity to manage the polluted runoff problems plaguing the Bay. Through NEP funding, mini-grants are provided to communities to fund model projects addressing water quality declines and resource management issues. Modest forms of financial assistance have been able to augment considerable local actions to protect the Bay. Tax incentives have also proven to be a valuable land use tool contained in the CCMP. Land owners are offered tax incentives in exchange for the development rights to their properties.

National Coastal Caucus

The Coalition for Buzzards Bay is leading citizen efforts to save the Bay. The Coalition for Buzzards Bay (CBB), a private non-profit organization founded in 1987, currently includes nearly 2,800 members. CBB promotes environmental education and awareness in its work to protect and restore Buzzards Bay and its greater watershed.

The CBB currently has three programs which enlist citizen participation. The Coalition was granted NEP funding to establish a citizen monitoring network. This network of 100 volunteers tests 87 sites within embayments throughout the Bay on a weekly basis.[41] This program is one of the most ambitious citizen monitoring projects in the nation. Results are used to assess current conditions and trends as well as target areas for cleanup activities. The CBB's Water Quality Monitoring Program involves citizens in hands-on action and is the largest, ongoing monitoring effort in the Bay. CBB has completed four years of data collections from the water quality monitoring program, and has provided a "snapshot" view of the health of Buzzards Bay. This analysis, in turn, is used by the communities within the watershed to determine nitrogen loading limits and developmental buildouts. The Program has also developed a model nitrogen management strategy to control the residential nitrogen inputs to Buttermilk Bay, a small embayment near the Cape Cod Canal. This land use approach to coastal resource planning is currently being applied to four additional embayments in Buzzards Bay.

CBB also has a corps of trained volunteers who monitor key local governing boards such as Conservation Commissions, Boards of Health, and Planning Boards, who are responsible for decisions which affect Buzzards Bay. Under the "home rule" concept, local ordinances can be written to be more protective than state laws. These Coalition monitors work to ensure that the decisions made by these agencies reflect a consistency throughout the region to protect the Bay and its watershed.

Educational efforts include school projects in the City of New Bedford as well as community efforts to discourage dumping into local storm drain systems. CBB has created a nature trail for the schools, organized beach cleanups and promoted bi-lingual stenciling of storm drains which discharge directly into Buzzards Bay. They have also sponsored an annual 1.18 mile swim across part of the Bay to celebrate the improving water quality.

The "Municipal Report Card" is a progress report released annually by the CBB that critiques municipal governments' efforts to meet CCMP goals, and has been highly effective at targeting and engaging communities in Bay restoration.

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Casco Bay
in Maine

Casco Bay isn't dead. It doesn't have a fatal wound either. But, it's suffering from a lot of cuts. This presents an inescapable opportunity for us. As in dozens of estuaries around the country, the problems are of a human scale — we can work on them; we can see the results; we can win. It is vitally important that Friends of Casco Bay continues its activities toward improving the health of the Bay and that the community support implementation of the Casco Bay Estuary Project Management Plan. We have the opportunity to get to a point where we won't have to revive what isn't dead; we won't have to save what isn't threatened; we won't have to pay big dollars for mistakes we didn't make.

— Joe Payne, Casco BayKeeper
Friends of Casco Bay

Portrait of the Bay

Casco Bay is located on the southeastern coast of Maine. The Bay's shoreline stretches for 578 miles from Cape Elizabeth on the west to Cape Small Point on the east. The Bay measures 229 square miles in size.[1] Its average depth is 42 feet.[2]

The Casco Bay watershed area encompasses 985 square miles in southern Maine.[3] It is the most industrialized watershed in the State.[4] Forty-one municipalities are located within the Casco Bay watershed, including the cities of Freeport, Falmouth, Westbrook, Portland and South Portland.[5] The watershed's population is 251,000.[6] Twenty-seven percent of Maine's coastal population lives near Casco Bay.[7]

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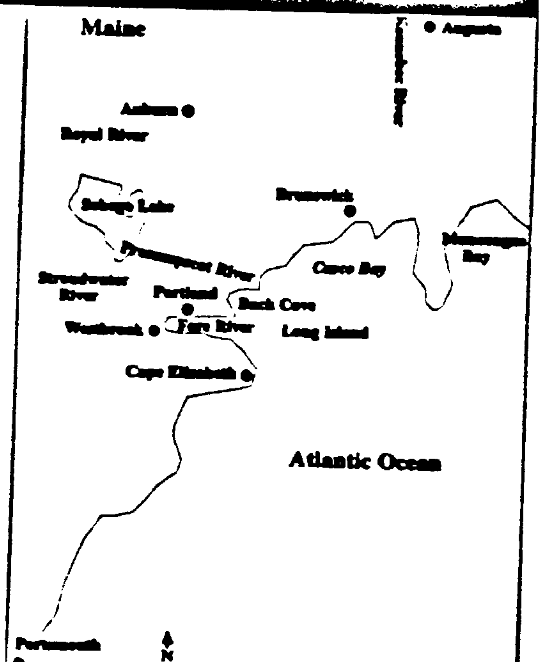
Casco Bay

Area of surface water	229 square miles
Area of watershed	985 square miles
Shoreline	578 miles
Average depth	42 feet
Population	251,000 people
Values	• Fisheries generate $243 million*
	• Boating generates $85.2 million*
	• 750 islands provide habitat in the Bay
Threats	• Pathogen contamination
	• Nutrient loadings
	• Toxics/contaminated sediments
	• Floatable debris
CCMP status	Final CCMP expected in 1996

Designated as a "Nationally Significant" Estuary in 1990.

*State figures



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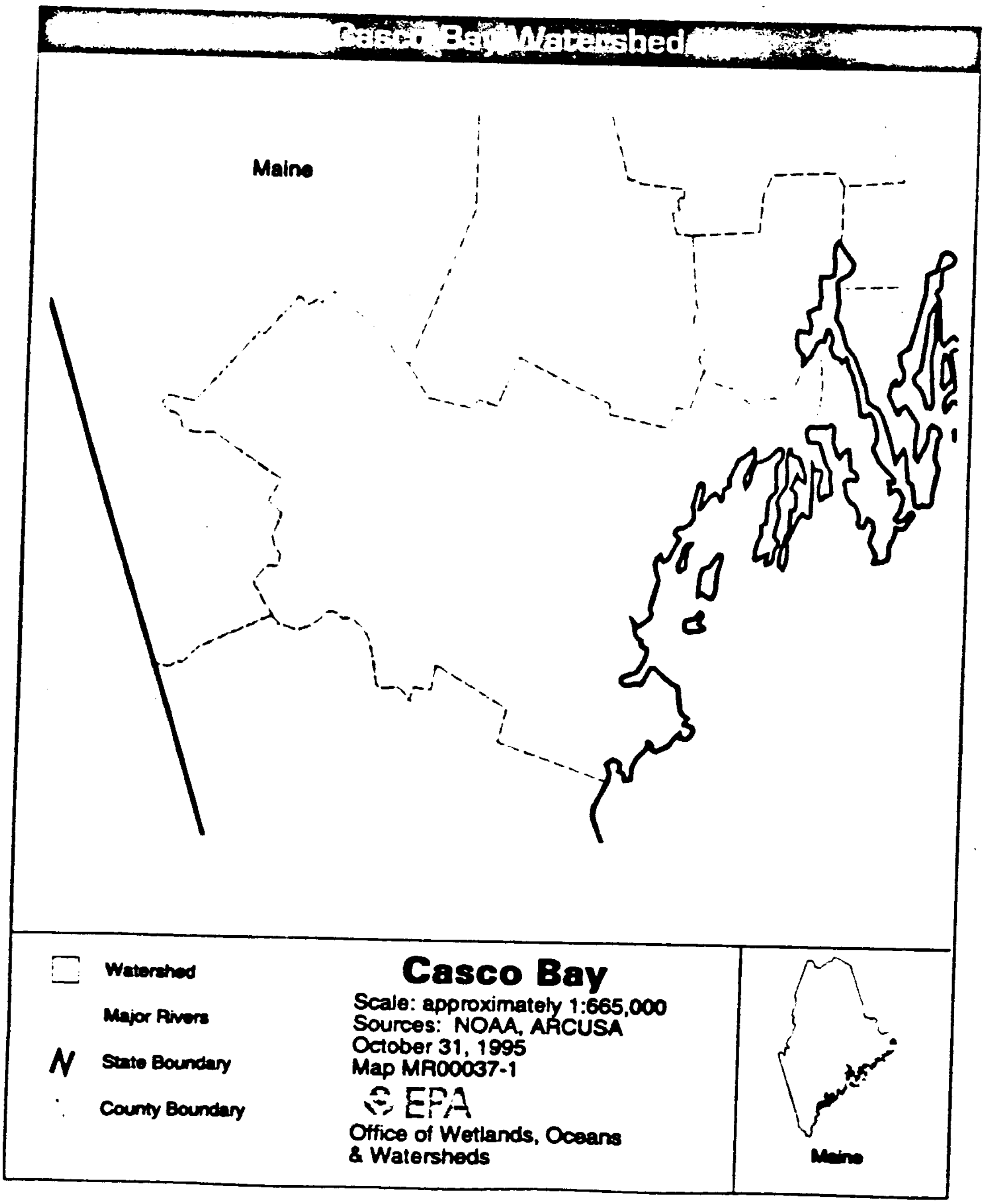
Casco Bay Watershed
Maine
Watershed
Major Rivers
State Boundary
County Boundary
Casco Bay
Scale: approximately 1:665,000
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-1
EPA
Office of Wetlands, Oceans
& Watersheds
Maine

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Freshwater is delivered to the Bay by the Fore, Presumpscot, Stroudwater, and Royal rivers and a number of smaller rivers and streams. In addition, waters from Sebago Lake feed the estuary.[8] However, compared to the nation's other estuaries, the amount of freshwater inflow to Casco Bay is less than average.

The Bay's rocky coastline and more than 750 islands, provide unique habitats for invertebrates and nesting areas for waterbirds.[9] Other common types of habitat include sand and mud flats, eelgrass beds, mussel bars, salt marshes, and freshwater wetlands.[10] Geographic Information System (GIS) mapping in 14 coastal communities of the Casco Bay area has measured approximately 12,100 acres of flats; 1,355 acres of eelgrass beds; 4,100 acres of salt marsh; and 15,200 acres of freshwater wetlands.[11]

Values of the Bay

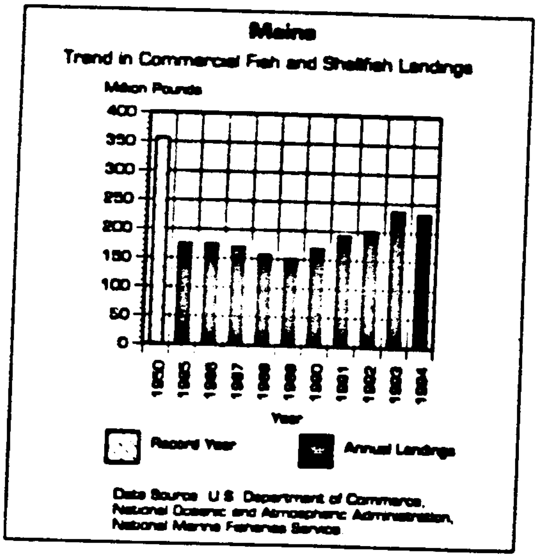
Casco Bay and its living resources attract both in-state and out-of-state residents. The Bay's intrinsic beauty and its popularity as a hub for recreational boating and fishing add significant revenue to the local and regional economies. The variety of productive habitats within the Casco Bay watershed also support a number of invertebrate, fish, and bird species.

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the New England region totaled approximately $583 million. Many of the commercially valuable species in the New England region depend upon the health of Casco Bay for survival. In 1994, the State of Maine's commercial finfish and shellfish landings totaled approximately 231 million pounds, valued at $243 million.[12]

Lobster is one of Maine's most commercially valuable fisheries. Twenty percent of Maine's lobster landings occur in Cumberland County, which borders the Bay.[13] The Bay's ledges, rocky bottoms, and high salinity levels provide ideal habitat for lobster. In addition, soft-shell clams and crabs caught from Casco Bay account for a large portion of Maine's total landings. Mussels and scallops are also caught in Casco Bay.

At least 36 finfish species inhabit the Bay.[14] Herring and menhaden are two chief commercial finfisheries of Casco Bay. Other fish species which inhabit the Bay include winter flounder, pollock, sculpin, rock gunnel, Atlantic shad, and skate.[15] Striped bass, alewife, rainbow smelt, and shad are anadromous fish which pass through Casco Bay to reach freshwater spawning grounds. Bluefin tuna also use the Bay.[16]



Recreation/Tourism

Maine's coasts provide a popular vacation spot for visitors, recreational boaters, and sport fishermen. Although the figures date back to the late 1980s, the data in the Estuary Project's preliminary plan for Casco Bay indicate that the annual revenue generated from tourist and recreational activities in the Casco Bay area was over $250 million.[17] Clearly, those values have increased today. The growing recreational use of the Bay and the resulting revenue, have raised public awareness about the potential adverse effects — such as reductions in water quality — that personal actions can have on the Bay.

The islands and coves of Casco Bay draw many sail and power boats to the area. There are at least 19 marinas in the Bay, with an average of 100 slips per marina, and about 3,400 moorings.[18] In 1989, the towns of the Casco Bay region had more than 12,000 boats registered, which generated over $328,000 from excise taxes and registration fees.[19] Figures for 1990 reveal that the State of Maine registered 112,559 boats, generating $85.2 million in boating equipment, sales and rentals for that year.[20]

Recreational fishing is another common activity for residents and visitors. In 1991, fresh- and saltwater recreational fishing in Maine generated $340 million and employed nearly 6,500 people.[21] Mackerel, pollock, flounder, haddock, cod, bluefish, bluefin tuna, and striped bass are the most sought-after sport fish in the Bay.[22] In 1991, approximately 143,000 saltwater anglers spent 843,000 fishing days off the coast of Maine. Fifty-four percent of these anglers were non-residents of the State.[23]

Other popular recreational activities around Casco Bay include sea kayaking, birdwatching, hiking, and camping. Three state parks — Two Lights in Cape Elizabeth, Wolf Neck Woods in Freeport, and Andrews Beach on Long Island — are situated in the Casco Bay region. In 1988, attendance records for these three parks indicated that there were 129,736 visitors. Of these three parks, Wolf Neck Woods is the only one that charges visitor parking fees. In 1988, the revenue generated from these parking fees at Wolf Neck Woods was almost $46,000.[24]

Wildlife

In the late nineteenth century, marine biologists began seriously studying Casco Bay and its wildlife diversity. The Bay has a range of habitat which supports species native to both northern and southern ecoregions.[25] Therefore, this estuarine transition zone hosts an abundance of life. For example, a 1983 study of the Bay revealed that the mean density of organisms inhabiting the Bay was 8,743 organisms per square meter; in contrast, Delaware Bay's mean density was 722 organisms per square meter.[26]

Over 150 waterbird species inhabit the coastal areas of Maine. About 164 seabird colonies of double-crested cormorants, eiders, black guillemots, and others are found on the unpopulated islands of Casco Bay.[27] Loons, grebes, and snow geese use the Casco Bay area for wintering habitat. Other common wildlife species observed around the Bay include harbor seals, whales, porpoises, and dolphins.

Federally-listed endangered and threatened species also depend on the Bay habitats for survival. The endangered bald eagle feeds in areas along the Bay, and the endangered roseate tern nests on two islands of the Bay.[28] In addition, the threatened piping plover depends on Maine's estuarine wetlands.[29]

Threats to the Bay

During the past twenty years, the amount of developed area in the lower Casco Bay watershed doubled because of the growth in Portland, South Portland, and Westbrook.[30] This urban sprawl has resulted in the construction of more impervious surface areas, such as roofs and pavements, within the watershed. The loss of natural areas that absorb and filter contaminants, such as wetlands and vegetated lands, has significantly contributed to water quality declines throughout the region.

Polluted urban stormwater is one of the leading sources of pollution in Casco Bay.[31] Stormwater delivers a substantial amount of heavy metals, nutrients, pathogens, organic chemicals, sediments, and floatable debris to Casco Bay during snow melts and heavy storms. This source of pollution accounts for 50 percent of the hydrocarbons and over 80 percent of the lead entering the Bay.[32] In the Portland region of Casco Bay, water quality standards are regularly exceeded during storm events. To better manage this problem, the municipalities of Portland, South Portland, and Westbrook are planning stormwater infrastructure upgrades.[33]

Evidence of Casco Bay's pollution problems has been mounting since the early 1980s. Due to past industrial activities within the region, toxic contaminants have accumulated in Casco Bay's sediments and waterways. However, most of the build-up is concentrated in Portland Harbor. In addition to toxic pollution, excess nutrients and pathogens contribute to the Bay's water quality problems and adversely affect the aquatic life. Finally, because Portland is an active shipping port, potential threats from shipping traffic and accidental vessel and tanker spills are of great concern.[34]

Through the Casco Bay National Estuary Program, the priority problems afflicting Casco Bay are being identified, and actions to restore the Bay are being developed. To date, priority problems of the Bay include pathogen contamination and increased nutrient loadings resulting from polluted urban stormwater, combined sewer overflows, and failed septic systems. In addition, toxics, contaminated sediments, poor land use planning, population growth, and floatable debris pose threats to the vitality of the Bay system.[35]

Pathogen Contamination

Pathogens are disease-causing microorganisms often found in human and animal wastes. Pathogens enter Casco Bay through several sources including combined sewer overflows (CSOs), polluted urban stormwater, direct boater discharge, and septic system failures. CSOs occur when the volume of water collected during rainstorms exceeds the holding capacity of combined sewer and stormwater conveyance lines. The result is the discharge of raw sewage and industrial wastewater into the Bay. There are approximately 75 CSO outfall pipes along Casco Bay and its tributaries.[36]

Overboard discharge systems are a type of septic system prevalent in the Casco Bay region. They were installed to replace straight pipes that discharged raw waste into the Bay. However, because these systems were deemed ineffective due to the high level of maintenance required, the Federal Food and Drug Administration determined that overboard discharge systems are a potential source of pathogens and their mere presence warrants the closure of nearby shellfish beds.[37] Although 355 systems are licensed within the Bay area to discharge up to 300 gallons of treated effluent each day, the State legislature has prohibited the issuance of new overboard discharge permits and has initiated a grant program to encourage their removal or replacement.[38]

Pathogens in coastal waters pose health risks to humans who eat contaminated shellfish or ingest polluted beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated water. For this reason, beaches and shellfish harvest areas are closed or restricted when water monitoring indicates that high levels of enterococcus or fecal coliform bacteria (indicators of pathogens) are present in Maine's coastal waters.

Three beaches on Peaks Islands have been permanently closed since 1991 because of high levels of pathogens. Portland's East End Beach was closed for approximately two weeks during the summer of 1994 for the same reason.[39] Clam beds are also affected by pathogen contamination in the Bay. In 1990, 43 percent of the Bay's 11,112 acres of clam flats were closed — up from 38 percent in 1989.[40]

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, reach the estuary in a path similar to pathogens. Leading sources of nutrients into the Bay include polluted urban stormwater, CSOs, sewage treatment plants, failed septic systems, boater discharges, agricultural runoff, and atmospheric deposition. More than 25 percent of the total input of nitrogen and phosphorus to the Bay originates from fertilizer runoff from agricultural land.[41]

Individual septic and overboard discharge systems, which are not designed to remove nitrogen, are a major source of nutrient contamination in the Bay. There are 230,000 septic systems in the State of Maine, many of which are situated within the Bay's watershed.[42]

Excessive levels of these nutrients stimulate the growth of algae, which can lead to oxygen depletion in the Bay. The over-enrichment of nutrients is called eutrophication. As algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but they also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the level of oxygen available for other aquatic life. Oxygen-deficient conditions (called hypoxia) can result in large fish kills. During the summer of 1992, approximately one million menhaden suffocated because of oxygen depletion in the New Meadows River.[43]

Toxics/Contaminated Sediments

Toxic metals, organic chemicals, and other pollutants settle and accumulate on the bottom of the Bay and its tributaries. Tides, erosion, dredging, and the movement of aquatic life can agitate the

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sediments and free contaminants to float through the aquatic system. Organisms eat and absorb toxins, passing these contaminants to higher levels of the food chain, such as fish, birds, and humans.

Until 1983, Casco Bay was believed to be pristine. Yet, later that year several assessments of the Bay's sediments revealed the presence of polychlorinated biphenyls (PCBs), hydrocarbons (PAHs), lead, cadmium, silver, mercury, chromium, zinc, chlordane, and dioxin.[44] These toxic metals and organic chemicals can accumulate in the tissues of worms, clams, fish, and birds. Lead, cadmium, mercury and silver are found in "high" levels in Casco Bay compared to other estuaries in the United States.[45] As more toxins are released in the environment, wildlife are increasingly threatened by the possibility of diminished reproductive and developmental abilities, increased rates of cancer, and early mortality.[46]

High levels of sediment contamination, found in the Fore River, Back Cove, and Presumpscot River, are responsible for declines in populations of fish and shellfish species.[47] Blue mussels with elevated levels of lead and mercury have been harvested in these areas.[48] In addition, studies of flounder indicate high levels of toxic contaminants in their livers.[49] Dioxin contamination contributed to the East Coast-wide consumption restrictions for lobster tomalley (liver) in 1994. The tomalley were found to have dioxin levels 20 to 30 times greater than other lobster meat.[50]

Most of the heavy metals found in the Bay originate from vehicular discharges and industrial waste, and are concentrated near Portland Harbor in the Inner Bay.[51] Petroleum and petroleum byproducts are the most widespread contaminants of the Bay.[52] Therefore, hydrocarbons, chemicals resulting from petroleum combustion, are the most common toxins found in the Bay. Historically, a major source of hydrocarbons in the Fore River was coal tar from the gasworks near the Million Dollar Bridge. Oils still ooze from this site on hot summer days. Chlordane, a dangerous pesticide that is currently banned, is another chemical that can be found in the Bay, particularly in the Inner Bay and the Back Cove areas.[53] The levels of hydrocarbons and chlordane found in Casco Bay are "high" relative to other estuaries in the nation.[54] Chlorine, an unmonitored disinfectant used in overboard discharge sewage systems and sewage treatment plants, poses other serious ecological consequences for the Bay and its living inhabitants.[55]

Floatable Debris

Trash accumulated on estuarine beaches also threatens the ecosystem. During the week of October 8, 1994, volunteers cleared 18,800 pounds of marine debris from 172 miles of Maine's beaches. Of the total amount of marine debris collected, 59.2 percent was plastic, 12.4 percent was glass, 9.8 percent was metal, and 18.6 percent was from other materials.[56]

The Casco Bay Estuary Project

Casco Bay was designated under the National Estuary Program as an estuary of "national significance" in 1990.[57] The Preliminary Comprehensive Conservation and Management Plan (CCMP) was completed in 1992. The draft CCMP was completed in 1995. The Preliminary CCMP for the Casco Bay Estuary Project (CBEP) followed an action-oriented agenda focusing on immediate steps to reduce pollutants and improve the Bay. The Plan emphasizes habitat protection, ecological research, public education to encourage stewardship, pollution prevention, and management techniques to ensure the future health of the Bay.[58]

To assist in determining how best to proceed, the CBEP conducted an assessment of existing and past water quality planning programs for their effectiveness and applicability to the CBEP. An assessment of the effectiveness and transferability of actions taken in other estuary programs was also conducted. To help identify the key problems and likely sources of pollution to the Bay a "dirty history" was conducted in South Portland, Portland and the Stroudwater River area. The study involved identifying sites of former tanneries, dumps, foundries, machine shops, gas works, and shipyards to determine the types of pollutants that may have been associated with these industries or businesses. The

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final lesson learned from this history is that pollution endures for centuries. Activities from 150 years ago are still polluting the estuary today.

Watershed management planning, emphasizing best management practices, and wetlands restoration have been the focus of many of the interim actions adopted by the Preliminary CCMP. The CBEP realizes that long-term protection of the Bay will depend on the participation of local communities. Therefore, the Project has given local governments the tools they need to make good environmental decisions. For instance, Geographic Information System (GIS) mapping is being used to store and map information about shellfish beds, wetlands, combined sewer overflows, and point-source pollution. GIS also maps things such as roads, drainage ways and existing development sites. This information provides an invaluable service for community leaders for the wise management of environmental resources. It gives the local officials the opportunity to see the effect of decisions before they are made. This type of informed decision-making is instrumental in preventing pollution in Casco Bay.

Additional CBEP projects have provided more tangible results, such as restoration of some commercial shellfish harvests. In the fall of 1994, the Town of Harpswell reopened 20 acres of clam flats in Doughty Cove which had been closed for seven years. With the assistance of NEP funding and the efforts of citizens, the flats were restored after pollution in the area was reduced.[31] An education campaign was also initiated to teach homeowners about cleaner waste disposal techniques, such as maintaining septic systems.[32]

The CBEP is also working with the U.S. Fish and Wildlife Service's Gulf of Maine Project on two studies, the Casco Bay Critical Habitats and Development Study and the Casco Bay/Sheepscot Bay Habitat Modeling Study. These studies attempt to look ahead at the impact of development on fish and wildlife habitat if current trends are allowed to continue. The CBEP is also developing models to identify critical habitat for eight estuarine and nearshore species. These species include American lobster, softshell clam, alewife, tomcod, mummichog, winter flounder, sand lance, and Atlantic salmon.

Although many of the CBEP's efforts to date have been successful, a few obstacles continue to interfere with the ultimate goal of implementing the CCMP. Most importantly, the lack of a federal commitment to funding, as well as a shortage of political will, has raised concerns about how the plan will be implemented once the CCMP has been approved.

There are also concerns over whether or not the most critical ecological problems will be addressed. Due to the fact that the Management Conference that developed the CCMP includes certain stakeholders that have tremendous political influence, problems that are of priority to the environmental community and other citizens organizations may go unaddressed. This is especially likely, since the amount and quality of public involvement in the NEP process has been inadequate. Public involvement in the restoration of Casco Bay would be enhanced if the CBEP geared budget and staff toward developing an effective public relations campaign. In some circumstances it has also been noted that the process used to identify leaders for the different committees has not always produced those with the greatest expertise and experience.

National Coastal Caucus

Friends of Casco Bay and the Conservation Law Foundation have been actively involved in the protection and restoration of Casco Bay. These organizations continue to work towards strengthening support for interim implementation projects under the CCMP. The staff, Board of Directors, and members of Friends of Casco Bay (FOCB) and the Conservation Law Foundation (CLF) have been involved in the Casco Bay Estuary Project in numerous capacities. In particular, FOCB and CLF have played key roles on the Citizens Advisory Committee. In addition, FOCB has served on the Management Committee, Technical Advisory Committee, and Implementation Committee.

Since 1989, Friends of Casco Bay has been a lead organization working to improve and protect the environmental health of Maine's beautiful Casco Bay. As professional steward for the Bay, the BayKeeper

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works with concerned citizens and businesses to cooperatively solve pollution problems, and educate people on the importance of caring about the Bay.

FOCB programs actively address broad problems affecting the Bay — pollution discharges, clam flat closures, pogy die-offs, dredging, oil spill management, and sewage pollution. By advocating for sustainable management of the Bay's resources, FOCB combines environmental protection with economic opportunities. They continue to build coalitions among diverse groups, to monitor water quality and critical habitats, to promote stewardship, and to respond daily to concerns of citizens and marine communities.

The Estuary Project has provided a grant to FOCB to organize and run a volunteer monitoring program. The BayKeeper has trained approximately 200 volunteers who regularly monitor the Bay at 104 stations. The data gathered from the monitoring program will serve to develop baseline information for Casco Bay, to identify problem areas, to help determine whether closed clam flats could be reopened, and to involve citizens in the protection of the Bay.

The Conservation Law Foundation is a non-profit public interest and environmental law organization founded in 1966. CLF's lawyers and scientists work to improve resource management, environmental protection, and public health throughout New England. CLF currently has projects in energy conservation, marine resources protection, transportation planning, land protection, and environmental health. Its marine resources project has focused on preventing oil and gas development on Georges Bank, reducing pollution from municipal sewage treatment plants, ending overfishing of New England groundfish, and protecting marine habitat. CLF has offices in Boston, MA; Rockland, ME; and Montpelier, VT.

CLF and the Island Institute of Rockland, ME, focused attention on Casco Bay in 1988 with the release of *Troubled Waters: Report on the Environmental Health of Casco Bay*. The report detailed early warning signals of degradation in the Bay and recommended, among other actions, that Casco Bay be included in the National Estuary Program. In 1989, CLF filed a lawsuit against the Portland Water District for repeated violations of the federal Clean Water Act due to inadequate sewage treatment. The suit was settled with the court ordering the District to upgrade its Portland plant in order to reduce the discharge of pollutants to Casco Bay.

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Charlotte Harbor
in Florida

Portrait of the Estuary

The Charlotte Harbor National Estuary Program is beginning to examine the water quality and habitat problems of the Charlotte Harbor estuarine system and the impact that the larger watershed area has on the estuary. Charlotte Harbor, located in southwest Florida, is the ninth largest estuary in the Gulf of Mexico.[1] The water surface area of the Harbor is about 270 square miles[2] and the average depth is eight feet.[3]

Stretching from the headwaters of the Peace River in Polk County southward to Estero Bay, the greater watershed of Charlotte Harbor covers 4,360 square miles.[4] Portions or all of Sarasota, Lee, Charlotte, DeSoto, Hardee, and Polk Counties are in the watershed. Cape Coral, Fort Myers, Port Charlotte, Punta Gorda and Fort Myers Beach are some of the larger residential communities located in the watershed.

A number of lagoons and embayments, including Lemon Bay, Bull Bay, Turtle Bay, San Carlos Bay, and Estero Bay, are located within the Charlotte Harbor system.[5] Gasparilla Sound is a large, open body of water which is also situated in this estuarine system.[6] Several barrier islands are situated off the coastline in this section of Florida.

Freshwater flows into the Charlotte Harbor estuarine system through three large rivers (the Myakka, Peace, and Caloosahatchee Rivers), navigational and drainage canals, and a number of smaller creeks.[7] Over the years, sections of the Peace River have been drained and diverted to support farming, mining and increasing municipal demands.[8] The section of the Myakka River which runs through Sarasota County has been designated as a wild and scenic river by the State of Florida. This portion of the River also supports many of the freshwater and tidal wetlands of the Charlotte Harbor area.[9] The southern portion of the Harbor system receives its freshwater from the Caloosahatchee River, which is managed by federal and State officials as part of the Lake Okeechobee management project and the Everglades restoration program.[10]

Charlotte Harbor	
Area of watershed	4,360 square miles
Area of surface water	270 square miles
Average depth	8 feet
Values	• Tourists spend more than $1 billion • Recreational fishing generates $3.5 billion in economic output* • 5 National Wildlife Refuges and 8 Florida State Aquatic Preserves
Threats	• Hydrologic alterations • Nutrient loadings • Habitat loss and degradation
CCMP status	Expected in 1998

Designated as a "Nationally Significant" Estuary in 1995.
*State figure

Values of the Harbor

Tourism and commercial fishing are integral to the economy of the Charlotte Harbor area and the State of Florida. Local communities recognize the critical link between economic stability and the protection of diverse habitat and wildlife populations. For this reason, estuary protection and restoration plans are being developed in areas along Florida's coastline. Estuaries of Florida are critical to commercial and recreational fish and shellfish.

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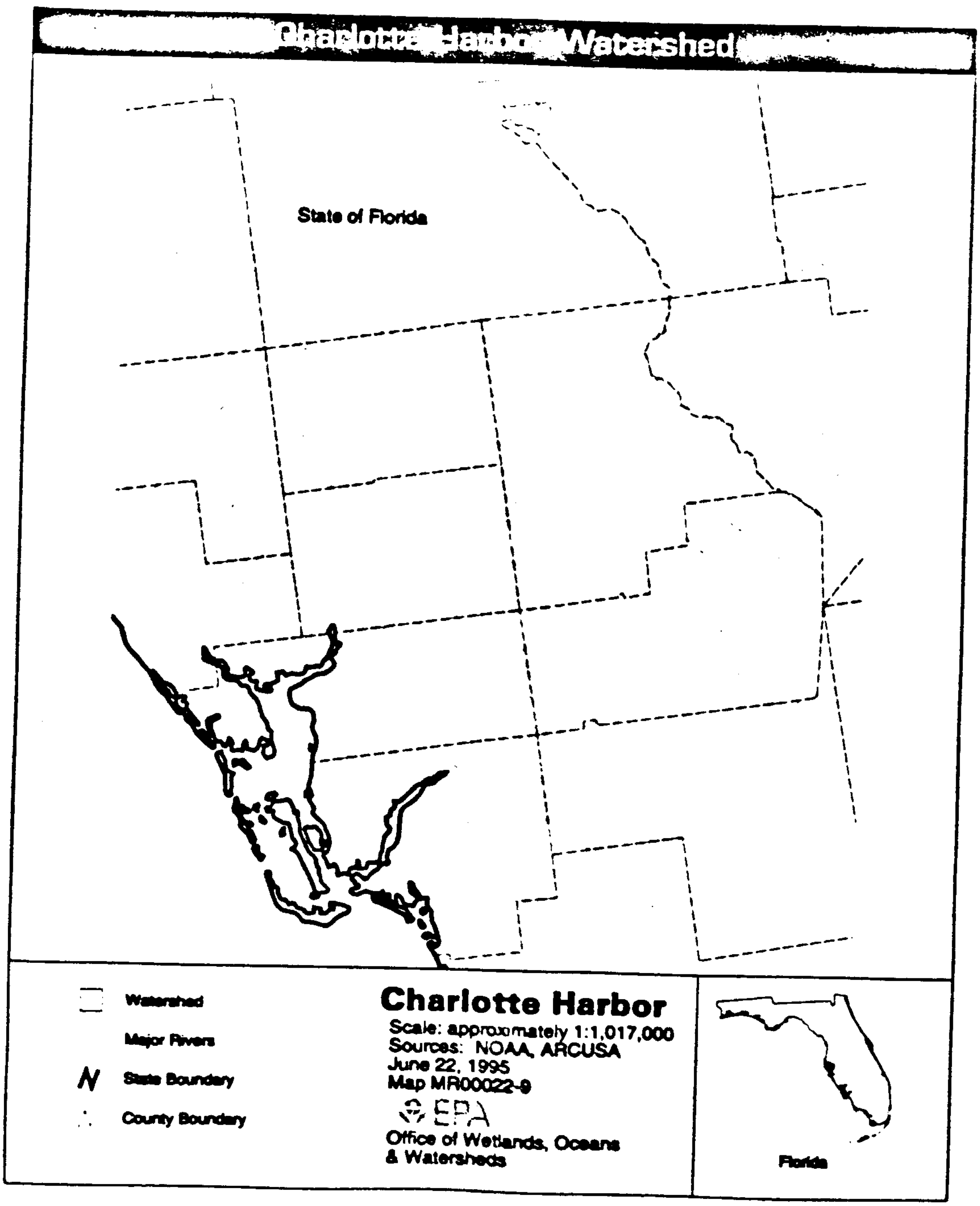
Charlotte Harbor Watershed
State of Florida
Watershed
Major Rivers
N State Boundary
County Boundary
Charlotte Harbor
Scale: approximately 1:1,017,000
Sources: NOAA, ARCUSA
June 22, 1995
Map MR00022-9
EPA
Office of Wetlands, Oceans
& Watersheds
Florida

Almost 90 percent of the commercial fish and 70 percent of the recreational fish species caught in the State use estuaries for all or part of their lives.[11]

Fisheries/Seafood

In 1994, the combined market value of commercial fish and shellfish landings in the Gulf Coast region of the United States was approximately $806 million. Many of the valuable fish species in the region depend on Charlotte Harbor and other Gulf of Mexico estuaries. In fact, 90 percent of the combined recreational and commerical fish catch in the Gulf of Mexico use estuaries and coastal wetlands during their life cycles.[12] Also in 1994, the State of Florida's commercial finfish and shellfish landings totaled approximately 177 million pounds, valued at $239 million.[13]

Commercial and recreational fisheries found in the Charlotte Harbor estuary system include black mullet, spotted sea trout, king whiting, flounder, bluefish, grouper, king mackerel, and several species of sharks.[14] The Charlotte Harbor also supports blue crab, pink shrimp, stone crab, hard clam, and scallop populations. Since 1945, tidal flats, salt marshes and oyster reefs have declined, as have landings of pink shrimp, blue crab, and scallops.[15]

Recreation/Tourism

In 1993, over 1.6 million tourists visited three coastal counties of the Charlotte Harbor estuary system (Charlotte, Lee, and Sarasota) and spent over $1.1 billion.[16] The natural beauty and resources of the Charlotte Harbor entice tourists to the beaches and barrier islands of the area. Favorite recreational activities within the Charlotte Harbor area include sport fishing, swimming, and sunbathing. Another popular activity in the Harbor is boating; over 100 recreational marinas are situated in Charlotte, Lee and Sarasota Counties.[17]

In 1991, recreational fishing in Florida generated approximately $3.5 billion in economic output and employed approximately 58,000 people.[18] In the same year, approximately 2 million saltwater anglers spent over 22 million days fishing off the coast of Florida. Thirty-four percent of the anglers were non-residents of the State.[19] It has been estimated that saltwater fishing in the Charlotte Harbor generates nearly $37 million from angler expenditures annually.[20] Part of this revenue originates from the nation's largest sustainable tarpon tournament, which is held in the Charlotte Harbor.[21]

Wildlife

The Charlotte Harbor area supports a great diversity of wildlife. Approximately 316 bird, 44 mammal, 591 invertebrate, 55 reptile, and 273 marine fish species are found throughout the Charlotte Harbor watershed.[22] Two of the most recognized inhabitants are bottlenose dolphins and West Indian manatees. Both manatees and dolphins use the Harbor for calving grounds. In addition, sawfish, a State-protected species, can be found near the mouth of the Myakka River.[23]

The Charlotte Harbor area provides important habitat for rare, threatened and endangered species. In 1990, 86 federal- and State-protected species were found in the Charlotte Harbor area.[24] Currently, the State of Florida has 97 federally-protected endangered and threatened species.[25] Of these, the endangered bald eagle, West Indian manatee, shortnose sturgeon, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, wood stork, American crocodile, Cape Sable seaside sparrow, Florida salt marsh vole, and Lower Keys rabbit, plus the threatened piping plover, Florida scrub jay, Atlantic saltmarsh snake, and loggerhead sea turtle depend upon Florida's estuarine wetlands.[26] Many of these protected species use the Charlotte Harbor estuarine system.

The abundance of wildlife can be attributed to the diversity of habitat types in the area. Habitats include freshwater wooded wetlands, tidal wetlands, tidal mud flats, submerged aquatic vegetation (58,495 acres), and mangroves (56,631 acres).[27] Five National Wildlife Refuges and eight Florida State Aquatic Preserves are situated within the Charlotte Harbor watershed.

Threats to the Harbor

The Charlotte Harbor estuary system has been the subject of numerous inter-governmental and independent studies during the past few decades.

Based on that data, the issues prioritized for action include changes in freshwater flow, nutrient loadings, and habitat loss. It is likely that the Harbor Estuary Program will address these and other issues.

Hydrologic Alterations

Human activities have significantly altered the level of freshwater flowing into the Charlotte Harbor system. The upper Peace River's flow of freshwater is one-third less than its historic levels.[28] In this portion of the watershed, freshwater is being diverted for farming, mining, aquifer supplies and other projects. At the same time that diminished flows of freshwater have been reaching the Harbor via the Peace River, the lower portion of the Harbor has been deluged with excess levels of freshwater from the Caloosahatchee River. The significant inputs of freshwater from this river are the result of the management of Lake Okeechobee's lock system. Although management practices have improved, submerged aquatic vegetation, oyster reef coverage, and bay scallop populations have been drastically harmed by the sudden, large freshwater infusions.[29]

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by urban stormwater, sewage treatment plants, malfunctioning individual septic systems, atmospheric deposition, agricultural runoff, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Harbor. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Harbor, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills.

The loadings of nutrients into Charlotte Harbor are increasing. As forests and pasture lands are being converted to agricultural lands, more pesticides and fertilizers run off into the Harbor's tributaries, especially the Peace River. Increasing population growth within the watershed is leading to more wastewater discharges from sewage treatment plants. Projections are showing that the volume of wastewater discharge will likely increase by 26 million gallons per day by 2000.[30] Population growth and development are also causing natural lands to be replaced with more impervious surface areas, such as pavement and roofs. By losing the natural filtering and absorbing qualities of natural lands, the effects of storm events are intensified as increased flows of stormwater carrying greater concentrations of nutrients and other contaminants reach estuarine waters.

Habitat Loss and Degradation

Development activities of the past have destroyed a significant portion of the habitat in the Charlotte Harbor area. Between 1945 and 1982, approximately 51 percent of the area's salt marsh and 29 percent of the seagrass acreage was lost.[31] Since 1945, 76 percent of the non-vegetated tidal flats have been destroyed.[32]

The remaining salt marshes and mangrove forests provide substantial benefits for the wildlife and the coastal communities of the Charlotte Harbor area. These wetland areas provide important spawning, nursing and feeding grounds for fish and shellfish and nesting areas for birds. In addition, coastal wetlands filter pollutants carried by stormwater and surface runoff before they flow into the estuary or its tributaries. As a result, these areas are important for maintaining the water quality along the coasts. They also absorb excess flood waters and protect upland areas from coastal storms. Among their other functions, coastal wetlands also provide places for recreation, such as canoeing and bird watching.

Seagrass habitat has greatly declined in San Carlos Bay. This decline is attributed to the sudden alterations in water salinity levels caused by the release of freshwater from Lake Okeechobee via the Caloosahatchee River.[33]

The Gulf Coast of Florida is one of the nation's fastest growing areas. Two counties within the Charlotte Harbor watershed, Charlotte and Lee Counties, are projected to be among the nation's leading coastal counties in terms of the percentage of population change between 1988 and 2010. Charlotte and Lee County expect a 62 percent and 52 percent increase in population between 1988 and 2010, respectively.[34]

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Additional Concerns

Trash accumulated on estuarine beaches also poses a threat to the ecosystem. The amount found in just one day was staggering — on September 17, 1994, volunteers cleared over 368,000 pounds of marine debris from 1,267 miles of Florida beaches. Of the total amount of marine debris collected, 61.4 percent was plastic, 12.5 percent was metal, 11 percent was glass, and 15.1 percent was from other materials.[19]

Charlotte Harbor National Estuary Program

With the Environmental Protection Agency's acceptance of Charlotte Harbor into the National Estuary Program, it became one of the most recent group of seven estuaries added to the Program. Of the four estuaries nominated by Governor Chiles on March 7, 1995 — Charlotte Harbor, the Lower St. Johns River, St. Andrew Bay, and Lake Worth Lagoon — only the Charlotte Harbor estuary was accepted. On July 6, 1995 Charlotte Harbor was officially designated an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Shortly thereafter, the EPA convened a Management Conference responsible for coordinating the development of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect Charlotte Harbor. Due to the large amount of information already available about the problems facing the Harbor, the Program has proposed a three-year process rather than the customary four-to-five year timeframe. As a result, the CCMP is scheduled for completion in 1998.

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Columbia River
in Oregon and Washington

The Lower Columbia River Estuary is unique — with aspects of both a classic estuary and a wild river. It may be the most neglected estuary in the country; even evidence of toxic contamination manifested in bald eagle reproductive failure has been widely ignored. While we (Northwest Environmental Advocates) will continue to enforce the Clean Water Act at the courthouse, we think the National Estuary Program offers the opportunity to do what the law cannot do, such as restore some of the wetlands that have been destroyed.

— Nina Bell, Executive Director
Northwest Environmental Advocates

Columbia River	
Area of watershed	259,000 square miles
Population	1.36 million people
Values	• Sport fishing generates $1.9 billion (WA) and $941 million (OR) in economic output* • Fisheries generate $175 million (WA) $66 million (OR)* • Most valuable waterway for salmon in U.S.
Threats	• Toxic contamination • Habitat loss and modification • Pathogen contamination • Fishery declines
CCMP status	Final expected in 1998

Designated as a "Nationally Significant" Estuary in 1995

* State figures

Portrait of the Estuary

The Columbia River's waterfalls, forested cliffs, and miles of tidelands distinguish it as one of the most scenic areas in the nation. Based on volume of water flow, the Columbia River is the second largest river in the United States.[1] From its headwaters in Canada, the Columbia River flows 1,214 miles before reaching the Pacific Ocean, and forms 300 miles of the border between Washington and Oregon.[2] The Lower Columbia River Estuary Program will study the tidally-influenced portions of the Columbia River and its tributaries. This area includes the Lower Columbia River from the Bonneville Dam at River Mile (RM) 146 down to the River's mouth and through the near-coastal waters to the 3-mile limit of the Pacific Ocean. The tidally-influenced areas include the urbanized portions of the Willamette River at Portland, Oregon. Some of the larger tributaries within the tidally-influenced zone of the Estuary include the Willamette, Lewis and Clark, Kalama, Lewis, Sandy, Washougal, and Cowlitz Rivers. Throughout this report, the study area will be referred to as the Lower Columbia River Estuary.

The entire Columbia River has the fourth largest watershed in the United States,[3] measuring a total of 259,000 square miles.[4] Waters originating in seven States (Washington, Oregon, Idaho, Montana, Wyoming, Utah, and Nevada) and British Columbia drain into the Columbia River and ultimately into the Estuary. Due to its enormous size, the entire watershed area of the Columbia River is not included in the study area. However, the States of Oregon and Washington have agreed not to limit the Comprehensive Conservation and Management Plan (CCMP) solely to the study area if actions can be taken in the greater watershed to improve the water quality and habitat of the Lower Columbia River Estuary. The watershed area of the entire Columbia River system is divided by the Cascade Mountain range. The eastern range of the Cascades, which

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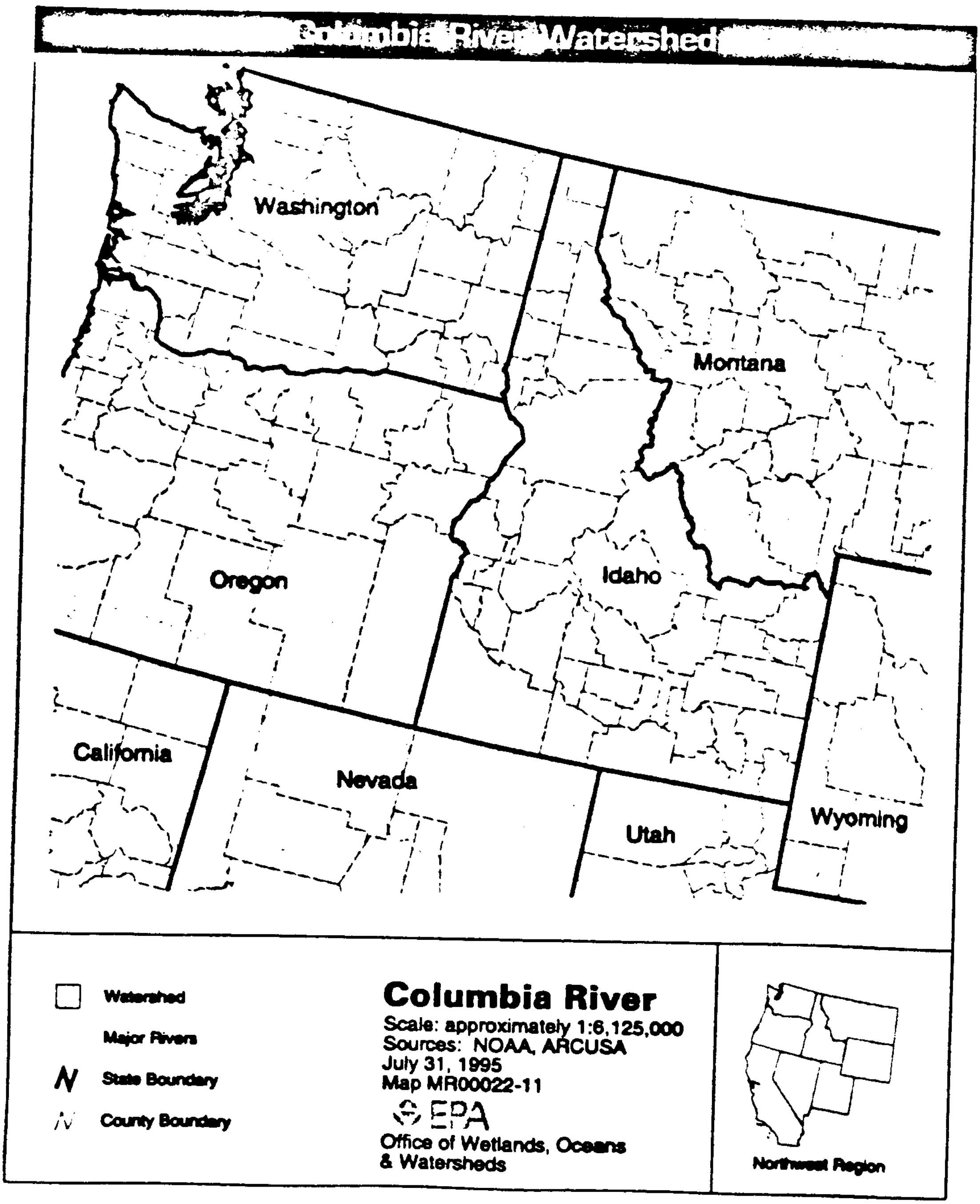

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receives about eight inches of rain per year, is characterized by dry conditions.[5] Much of the drainage from the eastern section of the Cascades occurs during the snow melts of spring and early summer. In great contrast, the western range of the Cascades receives up to 200 inches of rain per year.[6]

The Lower Columbia River Estuary includes portions of five Washington counties (Pacific, Wahkiakum, Cowlitz, Clark and Skamania) and portions of four Oregon counties (Clatsop, Columbia, Washington, and Multnomah). In 1993, the combined population of these nine counties totaled approximately 1.36 million people.[7]

A unique feature of this region is its cultural composition. Several Native American tribes have treaty rights to cultural and natural resources within the Columbia River system. They are particularly concerned about the need to restore the anadromous salmon runs of the Columbia River.

Values of the Estuary

The Lower Columbia River Estuary is ecologically and economically critical to the Pacific Northwest. The area hosts a diversity of wildlife; provides nursery habitat for anadromous, resident, and ocean-dwelling fish and shellfish; attracts millions of outdoor enthusiasts; and is important for fishing, forestry, agriculture and maritime trade.

Tourism/Recreation

Numerous recreational and tourist opportunities attract millions of individuals to the Lower Columbia River Estuary (including the lower Willamette River) each year. Boating is a popular activity in the Columbia River, supporting over 644,000 use days by registered boaters in Oregon during 1993.[8]

Sport fishing is another lure of the Estuary. In 1993, recreational anglers made approximately 332,000 trips to the area to fish for salmon, sturgeon, and shad.[9] In 1991, recreational fishing in Oregon generated approximately $941 million in economic output and employed nearly 16,000 people. In Washington, recreational fishing generated approximately $1.9 billion in economic output and employed nearly 27,000 people.[10] Also in 1991, approximately 225,000 saltwater anglers spent over one million days fishing off the coast of Oregon. Over 500,000 saltwater anglers spent over 3.5 million days fishing off the coast of Washington in that year.[11]

The Lower Columbia River Estuary includes several national and State parks which offer hiking, fishing, crabbing, boating, and swimming opportunities. In 1989, 1.4 million people visited the four Washington State parks which border the Columbia River Estuary.[12] Since its creation in 1986, the downstream portion of the Columbia River Gorge National Scenic Area has been an attractive destination for visitors of the Pacific Northwest. This area is a popular destination for windsurfers.

Fisheries/Seafood

Several species of fish depend on the Lower Columbia River Estuary during their life cycles. Numerous stocks of salmon and steelhead use the Lower Columbia River Estuary to make the transition from fresh to salt water and back again as they migrate to and from the sea. In fact, the Columbia River is recognized as the most valuable salmonid waterway in the continental United States.[13] For a number of other fish species, the Estuary provides essential spawning and nursery habitat. A few of the species which use the Estuary include longfin smelt, American shad, sturgeon, sockeye salmon, Pacific herring, chinook salmon, and steelhead.

The Columbia River Estuary contributes valuable fishery resources to the Pacific Coast of the United States. In 1994, the combined value of the Pacific Coast's commercial finfish and shellfish industries (excluding Alaska) totaled approximately $401 million. In 1994, Oregon's commercial finfish and shellfish landings totaled approximately 246 million pounds, valued at $66 million. In 1994, Washington's commercial finfish and shellfish landings totaled approximately 528 million pounds, valued at $175 million.[14]

The Columbia River contains the world's largest runs of chinook salmon and steelhead.[15] However, these legendary runs have declined substantially due to habitat losses, the overappropriation of water, changes in water flow, and poor water quality throughout the greater watershed and in the Estuary. In particular, hydroprojects along the entire Columbia River system have taken a huge toll on salmon runs. Many stocks have gone extinct, and many

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others are threatened by extinction. Still, an estimated 220 million juvenile salmon use the Lower Columbia River Estuary each year.[16] The declines in salmon and steelhead populations have prompted authorities to reduce allowable fishing days for these fish. Since 1980, an average of 39 days per year have been open to fishing; fifty years ago, anglers could fish for salmon and steelhead an average of 270 days per year.[17] In 1993, the commercial mainstem fishery below Bonneville Dam had 23 allowable fishing days. The 1993 catch was a record low — 559,500 pounds with a landing value of approximately $966,000.[18]

Wildlife

The Lower Columbia River Estuary includes tracts of publicly-owned parkland and reserves that support an abundance of wildlife. The Julia Butler Hansen Columbia White-tailed Deer National Wildlife Refuge and the Lewis and Clark National Wildlife Refuge both support wildlife in the area. The Lower Columbia River also includes Oregon's Lower Sauvie Island which provides feeding and wintering habitat for endangered wildlife and thousands of migratory birds.[19]

The Estuary provides important habitat for about 175 different migratory and resident bird species.[20] Bald eagles, peregrine falcons, Aleutian Canada geese, marbled murrelets, terns, great blue herons, mallards, and trumpeter swans are a few of the migratory and resident species which can be found in the Estuary.

The State of Oregon has 32 federally-listed threatened or endangered species, and the State of Washington has 22 listed species.[21] A number of these listed species depend upon the estuarine wetlands of the Columbia River system for survival. The threatened bald eagle, for instance, relies on the wetlands of the Lower Columbia River Estuary to support its populations, which are suffering from reproductive failure due to toxic contamination.[22]

Pacific harbor seals use the Estuary for breeding grounds. Other mammals which inhabit the Estuary area include sea lions, elk, fox, mink, river otters, and Columbia white-tailed deer.

Threats to the Estuary

Water quality assessments of the Lower Columbia River Estuary have already been conducted by the Lower Columbia River Bi-State Water Quality Program. The Bi-State Program was established in 1990 as a joint project of the Washington Department of Ecology and the Oregon Department of Environmental Quality, funded in part by public ports and pulp mills. The Lower Columbia River Estuary Program will build on the work produced by the Bi-State Program. Toxic contamination, habitat loss and modification, pathogen contamination, and fishery declines have been identified as the most significant threats to the health of the Lower Columbia River Estuary.

Toxic Contamination

Toxic contamination in the Lower Columbia River Estuary is a serious concern for the health and continued survival of wildlife populations. This is due to pollution sources throughout the enormous Columbia River watershed and an abundance of industrial polluters in the study area. Active industrial polluters in the Lower Columbia River Estuary include pulp and paper mills, lumber and plywood mills, metals production facilities, chemical industry facilities, and power generating plants.[23] These polluting industries have contributed to the fact that the Lower Columbia River Estuary contains seven Superfund sites. In addition to industrial pollution, the entire Columbia River system and Estuary have been afflicted with a toxic legacy owing to the proximity of the Hanford Nuclear Reservation. Between 1941 and 1977, the waters of the Columbia River were used to cool eight military nuclear reactors at the Hanford Reservation, where waters passing over radioactive fuels were discharged directly back into the Columbia River. Consequently, the Columbia River has earned the distinction of "the most radioactive river in the world."[24]

Examples of toxic contaminants (including heavy metals and radioactive wastes) which persist in the Lower Columbia River Estuary include polychlorinated biphenyls (PCBs), dioxin, DDT, plutonium, cesium, and strontium-90.[25] The State of Oregon recently concluded that a total of 26 toxic pollutants, including trichlorobenzene, arsenic, and chromium, were found at levels in violation of State water quality standards in the Lower Columbia River.[26]

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Toxic contaminants reach the Estuary and its tributaries in a variety of ways, including point source discharges, polluted stormwater, dredging operations, farming, mining, logging, toxic sites, and atmospheric fallout.

The damaging effects of toxic contaminants on the living resources of the Columbia River system are far-reaching. For instance, resident fish of the Lower Columbia River Estuary contain levels of PCBs, dioxin, and DDT in their tissues which affect animals at higher levels of the food chain. PCBs are found at levels that can cause complete reproductive failure in mink, which rely on fish from the Estuary and its tributaries as a food source. DDE, a breakdown product of the banned pesticide DDT, is causing egg shell-thinning in threatened bald eagle populations, which are currently suffering reproductive failure in the Lower Columbia River Estuary. Studies have also revealed high levels of toxic contamination in otters and harbor seals.[27] The reproductive processes in otter populations have also been threatened, as male otters have been found with significantly altered reproductive organs.

Recent studies have revealed that the ingestion of contaminated fish caught from the Estuary poses a higher risk of cancer and reproductive failure in humans.[28] Researchers are studying the consumption patterns of the Native American populations in the area (typically, fish consumption is nine times greater for tribal members) and the increased risk to subsistence fishers.[29]

Habitat Loss and Modification

Over the years, much of the estuarine habitat of the Columbia River has been altered by building upriver dams, diking, dredging, and converting natural lands to urban or agricultural uses. Today, the Columbia River system is controlled almost entirely for human uses, such as hydropower, irrigation, flood control, and navigation.[30] The construction of these water-related projects has claimed an enormous amount of valuable natural habitat in the entire Columbia River system. Approximately 86 percent of the original 722,000 acres of historic wetlands in the Lower Columbia River Estuary have been destroyed.[31] In addition, up to 77 percent of the Estuary's original tidal wetlands and 65 percent of its original marsh swamps have been destroyed.[32] Most of the remaining wetlands are located in the protected National Wildlife Refuges. The Bi-State Program intends to create a wetlands Geographic Information Systems (GIS) map which will assist in locating areas that need stronger protections.[33]

Estuarine and freshwater wetlands provide critical breeding, spawning, nursery, and sheltering areas for many fish, birds and other wildlife. In addition to the benefits they provide for wildlife, wetlands serve numerous functions for communities. Wetlands provide buffers for inland areas during storms, preventing shoreline erosion and absorbing excess flood waters. Wetlands filter pollutants which are carried by stormwater and runoff from agricultural and urban areas, thereby protecting water quality in other receiving surface waters and groundwater.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, industrial point sources, combined and sanitary sewer overflows (CSOs and SSOs), polluted urban stormwater, agricultural runoff, boating wastes, and septic systems. Pathogens pose risks to humans who eat contaminated shellfish or who are exposed to pathogen-contaminated waters through recreation. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of contaminated shellfish or water. For this reason, shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination). However, swimming areas are not regularly monitored, and therefore are not closed on a regular basis.[34]

Monitoring has indicated that bacterial levels exceed safe standards for shellfish harvesting in certain areas of the Lower Columbia River Estuary. In 1990, all of the Estuary's 2,000 acres of shellfish beds were closed to commercial harvest.[35] Bacterial levels also pose threats to recreational users of the Lower Columbia River — of particular concern is the stretch along the River between Portland, Oregon and Longview, Washington.[36]

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Fishery Declines

In the early 1800s, the Columbia River supported runs of 16 million salmon per year. Due to the large number of hydroprojects along the River, and the accompanying habitat loss and water quality declines, present-day runs only support 2.5 million salmon annually.[37] Dam construction and operations are among the primary reasons for today's crippled salmon populations. Currently, 211 major dams are situated in the entire Columbia River watershed.[38] As part of their natural life cycles, salmon migrate from fresh to salt water and back to freshwater for spawning purposes. However, dams pose physical obstacles along their spectacular migration routes, often blocking access to their original spawning grounds. It is estimated that up to 30 percent of young salmon are killed at each dam they encounter as they try to make their way to the ocean.[39]

The lack of instream flow and impaired water quality in spawning and migration waters throughout the watershed pose equally serious risks to already-struggling salmon populations. The disappearance of estuarine wetlands, which provide critical nursery habitat, restricts the Estuary's carrying capacity for salmon. In addition, during the spring, water flows in the Columbia River are held back for summer irrigation projects. Thus, salmon smolts, which require large volumes of water to flow seaward in a physiologically-set time period, often die before reaching ocean waters. Currently, 67 Columbia River salmon stocks are extinct and 72 are at risk.[40]

The Lower Columbia River Estuary Program

With the Environmental Protection agency's acceptance of the Lower Columbia River Estuary into the National Estuary Program (NEP), it was included among the most recent group of seven estuaries added to the Program. In July, 1995, the Lower Columbia River Estuary was officially designated as an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Representatives from both Washington and Oregon will participate in the Management Conference.

The Lower Columbia River Estuary Program includes a streamliped NEP since it builds on the Bi-State Water Quality Program. Although much of the initial planning required to begin a local estuary program has already been conducted by the Bi-State Program, serious concerns remain about whether the NEP will follow the Bi-State Program with respect to decision-making and management structure. Specifically, there is much concern over the lack of inclusion of all stakeholders in the decision-making process involved in the management conference of the local NEP. Currently, the role of industry and States far exceeds that of citizens and the environmental community. Therefore, it is imperative that the Lower Columbia River Estuary Program do a better job than the Bi-State program to include citizens in the local NEP.

National Coastal Caucus

Northwest Environmental Advocates (NWEA) is a 27-year old membership organization focused on water quality and wetlands protection in Oregon and Washington. Northwest Environmental Advocates was the first to publicly raise the issue of Columbia River water quality in 1988. In seeking to obtain the support of the Oregon and Washington governors for National Estuary Program nomination in 1989, NWEA helped to establish the Bi-State Program on Lower Columbia River Water Quality. NWEA's Executive Director co-chaired the Steering Committee for this program for two and one-half years. In 1992, NWEA again spearheaded an unsuccessful drive to obtain NEP status for the Columbia, a move which eventually led to its designation in 1995.

NWEA works on the full range of issues related to implementation of the Clean Water Act's water quality-based approach in Oregon and Washington, serving on advisory committees, educating the public, and bringing lawsuits to force the development of Total Maximum Daily Loads (TMDLs) on polluted waters throughout the two States. NWEA's educational program is called Columbia/Willamette RiverWatch. RiverWatch has taken thousands of people to see first-hand the wonder and problems of the Columbia River Estuary and its tributaries. The program also produced the nationally-acclaimed environmental maps *Columbia River: Troubled Waters* and *Portland/Vancouver: Toxic Waters*, as well as cross-discipline environmental curricula.

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Corpus Christi Bay
in Texas

Our bays and estuaries are our most precious resources. In the Corpus Christi area, we have an opportunity to avoid many of the problems that have damaged natural resources elsewhere. By implementing an effective Bay management plan now, we can assure healthy and productive Bays for the future.

— Ray Allen, Chairman
Coastal Bend Bays Foundation

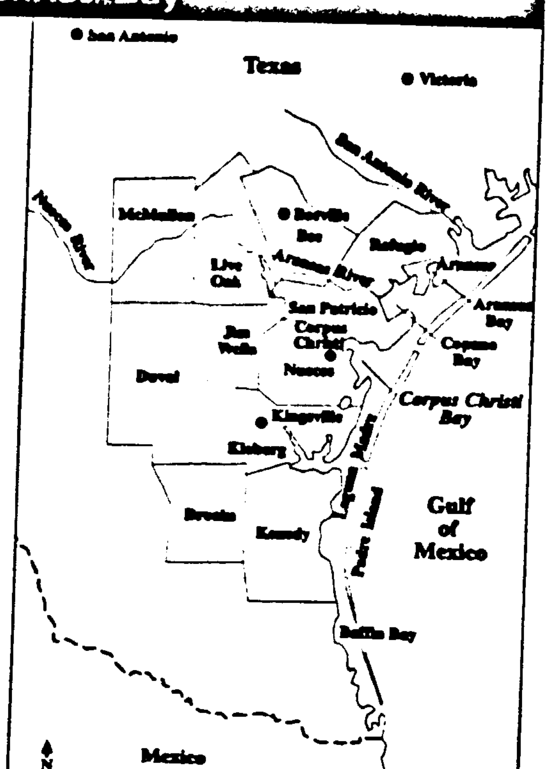
Portrait of the Bay

The Corpus Christi Bay Estuary Program is examining the water quality and habitat problems of the Bay and the impact that the greater watershed area has on the estuarine system. Corpus Christi Bay is located along the south central Texas coast. The study area of the Corpus Christi Bay system extends from the brackish Aransas and Copano Bays at its northern boundary to Baffin Bay and the hypersaline Upper Laguna Madre at its southern boundary.[1] In sum, the estuarine system comprises over 25 bays

Corpus Christi Bay

Area of surface water	600 square miles
Area of watershed	11,000 square miles
Length	75 miles
Average depth	3 to 8 feet
Population	500,000 people
Value	• Commercial and recreational fisheries generate $364 million • Tourism generates $1.3 billion in economic output • Home to Padre Island, the world's longest barrier island
hreats	• Freshwater inflow • Habitat loss • Water quality degradation • Brown tide • Floatable debris
CCMP Status	Final expected in 1998

Designated as a "Nationally Significant" Estuary in 1992.



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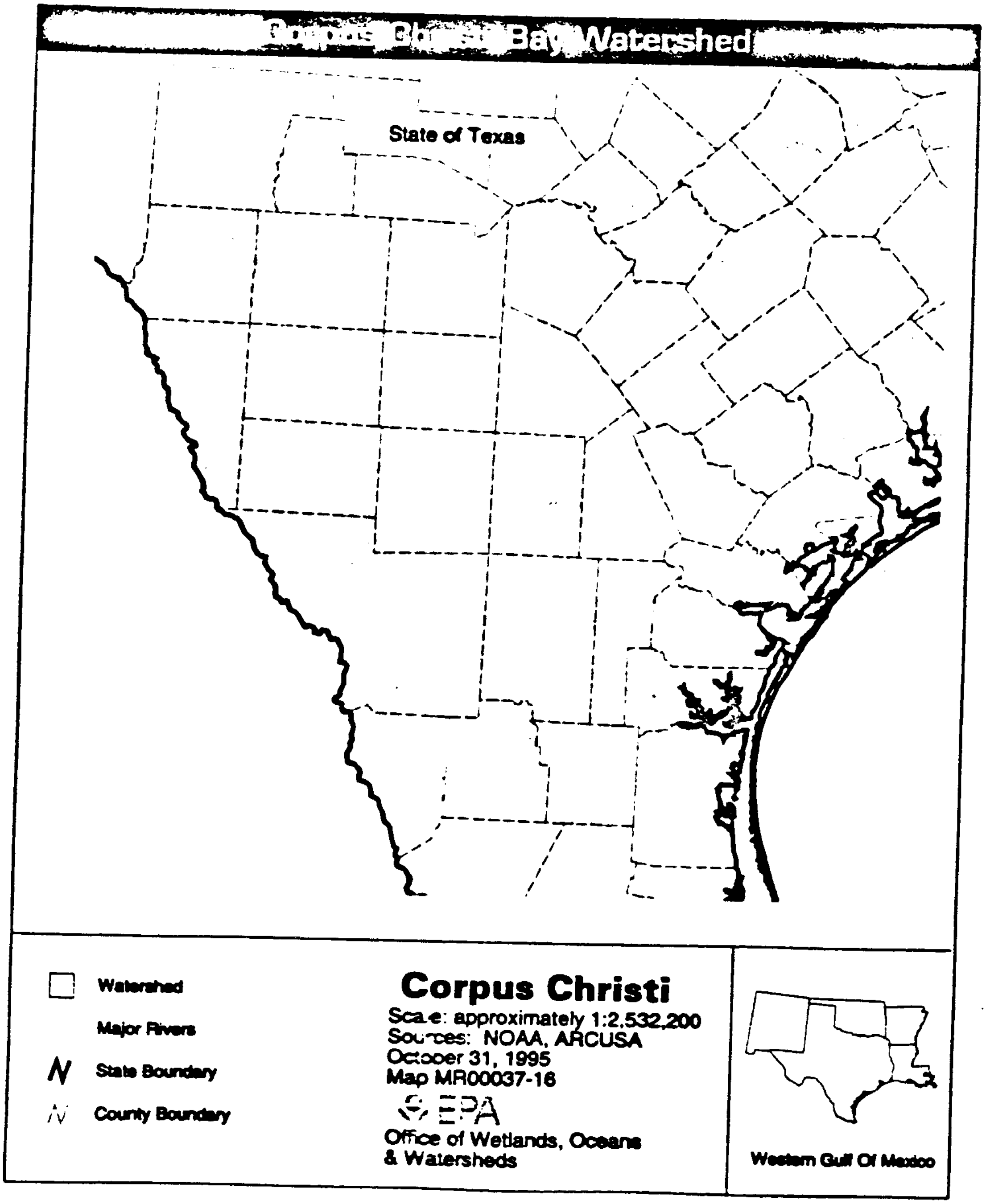

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and saltwater bayous.[2] The estuarine area of the Corpus Christi Bay system measures 600 square miles.[3] Barrier islands — including Padre Island, the world's largest barrier island — separate the estuary from the Gulf of Mexico.

The greater watershed area of the Corpus Christi Bay system extends into the south-central portion of Texas. The watershed study area of the Corpus Christi Bay National Estuary Program covers approximately 11,000 square miles.[4] The Bay system stretches along 75 miles of Texas coast and includes portions or all of twelve counties — Nueces, Kleberg, Kenedy, San Patricio, Aransas, Refugio, McMullen, Live Oak, Bee, Jim Wells, Duval, and Brooks counties.[5] This region of Texas is often called the Coastal Bend.

The Corpus Christi Bay system is the second most populated estuary in Texas.[6] The current watershed population of approximately 500,000 people is expected to increase by 20 percent between 1990 and 2000,[7] and double by the year 2040.[8] Corpus Christi, the seventh largest city in Texas, is home to over one-half of the watershed's population.[9]

The Bays in the system are relatively shallow compared to other estuaries along the Gulf of Mexico and in other parts of the nation. Corpus Christi Bay's average depth is eight feet; Aransas Bay's is five feet; and the Upper Laguna Madre's is three feet. For comparison, the average depth of Gulf of Mexico estuaries is eight feet and the national average is 23 feet.[10]

The inland areas of the Corpus Christi watershed are semi-arid. The Bay area's average annual rainfall is 24 to 36 inches; however, its annual surface evaporation rate is 60 inches.[11] The system's primary sources of freshwater are the San Antonio, Mission, Aransas, and Nueces rivers. In recent years, the freshwater inflows have declined due to increasing diversions and demands by municipalities, industries, farmers, and other residents. The resulting change in water salinity levels in the Bay is having serious impacts on fishery and other aquatic resources.

Values of the Bay

Corpus Christi Bay provides many economic and recreational benefits to visitors and residents of the area. In addition, the Bay system provides critical habitat for a great diversity of animal and plant species. The economic impact of the area's commercial and recreational fisheries is calculated to be $364 million per year.[12] The Port of Corpus Christi, the deepest port in the Gulf of Mexico, is used to support many commercial activities in the area. Minor oil spills and bilge discharges are a frequent by-product of this Port activity. Since the natural environment of Corpus Christi Bay is greatly tied to the economic successes of this region, restoring and protecting the Bay is imperative.

Recreation/Tourism

The Corpus Christi Bay system is a well known and very popular tourist destination which contributes significantly to the local and State economies. Approximately 2.8 million people visit the city of Corpus Christi each year. The tourist industry alone in this region employs 10,600 persons.[13] In 1991, tourist expenditures were $530 million — a $180 million increase from 1989.[14] The average, total economic output from tourism in the city is $1.3 billion per year.[15]

A few of the popular activities which attract visitors and residents to the area include sport fishing, sunbathing at beaches, swimming, camping, bird watching, hiking, and wind surfing. Padre Island (the world's longest barrier island), Padre Island National Seashore, Aransas National Wildlife Refuge, and many State parks are some of the favorite sites which highlight the ecological richness of Texas' Gulf coast. Padre Island National Seashore alone caters to between 750,000 and one million visitors annually.[16]

In 1991, recreational fishing in Texas generated $2.8 billion in economic output and employed nearly 40,000 people.[17] In the same year, over 828,000 saltwater anglers spent over 6.8 million days fishing off the coast of Texas.[18] In 1986, the most recent year for which data is available, sport fishing in just the Corpus Christi and Aransas bays contributed a total of $246 million to the region. During the same year, the total output of other water-related activities in Corpus Christi and Aransas bays was $133.6 million.[19]

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the Gulf region

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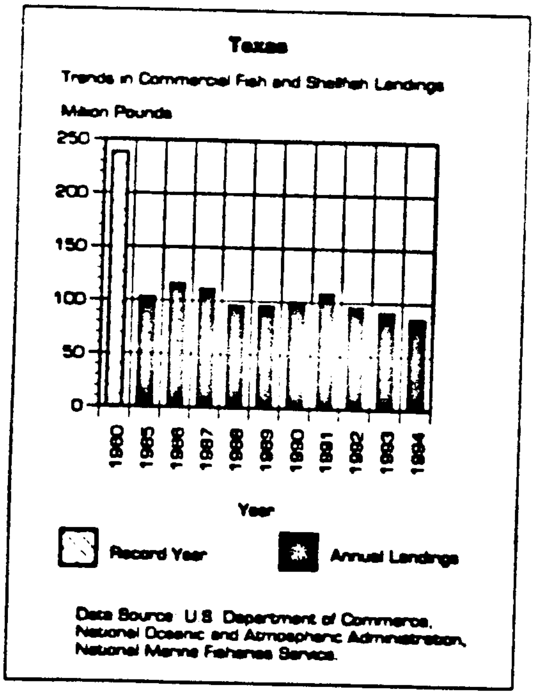

totaled approximately $806 million.[20] Many of the commercially valuable species in the Gulf region depend upon the health of Corpus Christi Bay for survival. In 1994, Texas' commercial finfish and shellfish landings totaled approximately 85 million pounds, valued at $207 million in dockside revenues.[21]

The Corpus Christi Bay system provides critical spawning and nursery habitat for the Gulf of Mexico's shrimp and finfish species. Important commercial and recreational fisheries of the area include redfish, spotted sea trout, shrimp, black drum, Atlantic croaker, blue crab, and flounder.[22] Approximately 136 fish species live in the upper Laguna Madre estuary and 213 species live in Aransas Bay.[23]

Wildlife

The coastal areas around Corpus Christi Bay provide important habitat for a diversity of wildlife. The most popular wildlife inhabitants are whooping cranes. These endangered birds, which can grow to a height of five feet, use the Aransas National Wildlife Refuge and nearby areas as wintering grounds. White-tailed deer, American alligators, armadillos, bobcats, brown pelicans, sandhill cranes, and other waterfowl also inhabit the Refuge.[24] In sum, 389 bird species, 64 amphibian and reptile, 46 mammal, and 213 fish species are found in the Refuge.[25] Seventy-five percent of the bird species in North America use Corpus Christi Bay to establish permanent nests or to rest along migratory routes.[26]

Many federally-protected threatened and endangered species rely upon Corpus Christi Bay and other estuaries of Texas. Specifically, the Kemp's ridley sea turtle, piping plover, and whooping crane are endangered species which depend upon estuarine wetlands in Texas. The threatened loggerhead sea turtle also depends upon these areas for habitat.[27]

Threats to the Bay

Public concern about the health and future of the Corpus Christi Bay system started mounting when shrimp landings began declining significantly and large algal blooms began appearing in the coastal waters a few years ago. Since then, the Corpus Christi Bay National Estuary Program (CCBNEP) has compiled a list of priority issues of concern that affect the Bay. The seven priority issues of concern are reduced freshwater inflow, wildlife population declines, habitat loss, water quality impairment, altered circulation, floatable debris,[28] and public health.[29] A mysterious and prolonged brown tide has invaded portions of the Bay system and will also be studied. As the population in the region continues to grow, these problems will likely escalate.

Freshwater Inflow

The alteration of freshwater flow into the Bay is probably the most controversial management issue within the estuarine system. As communities surrounding Corpus Christi Bay grow, more freshwater is required to meet the demands of residents. In addition, industrial operations and agricultural producers need freshwater to conduct their businesses. Yet, adequate amounts of freshwater must also be delivered to the Bay system so that the

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aquatic life found in these productive waters is sustained. Without healthy populations of fish, shellfish and other wildlife, many jobs within the fishing and tourism industries would be jeopardized. Unfortunately, this policy delute has, on occasion, digressed into a "people versus fish" controversy, instead of examining how the entire ecosystem can balance its freshwater needs.

Diverting freshwater from the Bay can disrupt the delicate ecological balance of the estuary. Low-salinity waters are required to maintain vital nursery habitats for the Bay's juvenile fish and shellfish. Declining freshwater inflows, in combination with water quality impairments and changes in circulation patterns, are suspected causes of decreasing shrimp and fish populations.[30] Lack of freshwater inflow, and the resulting decrease in flushing capacity in the system, may also be responsible for pollutant and sediment concentrations in the Bay region.[31]

The Choke Canyon Dam and Lake Corpus Christi reservoir operate to ensure a steady flow of freshwater distribution to users within the watershed and an adequate release of freshwater for Nueces Bay. Following concerns that freshwater releases were inadequate to support aquatic life in the Bay, an Order by the Texas Water Commission establishing monthly inflow requirements was issued and a freshwater advisory council was established.[32] Since then, an alternative freshwater inflow plan, which attempts to balance human needs with needs of the Bay and the estuaries, has been approved by the State.

As more people move to the region and the tourism appeal of the area grows, freshwater will be in even greater demand to sustain the diverse needs of humans and natural resources in the watershed. Examining the full effects of diminished freshwater flow to the estuaries will be a part of the planning process; and hopefully innovative measures to solve the problem will result.

Habitat Loss

The coastal wetlands and submerged aquatic vegetation of the Corpus Christi Bay system provide important nursery, spawning, and feeding grounds for an abundance of fish, shellfish, and wildlife. Coastal development, dredging activities, pollution, and other factors can damage and destroy these vital habitats and thereby reduce populations of estuarine wildlife.

Besides providing spawning and nursery grounds for aquatic life, wetlands benefit the Corpus Christi Bay system by filtering nutrients and toxic pollutants. Contaminants running off agricultural and urban lands can enter coastal waters unless they are trapped by wetlands bordering the aquatic system. Wetlands located above drinking water aquifers will filter these contaminants before they reach the groundwater. In addition, wetlands protect inland areas from coastal storms and flooding by absorbing much of the excess water and reducing the impact of storm tides and waves.

Seagrass is another essential aquatic resource of the Corpus Christi Bay system. Seagrass meadows provide valuable habitat for fish and shellfish in the Bay. Shoal grass is the prevalent seagrass of the system. Most of the seagrass cover is found in the Upper Laguna Madre. In fact, over 75 percent of this lagoon's bottom is vegetated with seagrass, while twelve percent of Corpus Christi Bay's bottom is covered by seagrass.[33] The shoal grass of the Upper Laguna Madre attracts 75 percent of the world's red duck population to the Upper and Lower Laguna Madre and the Laguna Madre de Tamaulipas in Mexico during the winters.[34] However, the brown tide which has been in the Upper Laguna Madre since 1989, is growing so densely that it is blocking sunlight needed by the shoal grass, causing losses among this habitat.[35]

Approximately 35 percent of Texas' coastal marshes were destroyed between the mid-1950s and 1979.[36] The Corpus Christi Bay area includes over 20,000 acres of emergent wetlands and 46,000 acres of seagrasses.[37]

Water Quality Degradation

Nutrients, chemicals, metals, sediments, and oil enter the Corpus Christi Bay system, impairing the water quality. Pesticides, nutrients from animal waste, and fertilizers that run off agricultural lands, present pollution problems for the Bay. Ranching and agricultural production are important land uses

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throughout the watershed; however, there is a concern that these activities may be contributing significant amounts of pesticides and nutrients to the Bay. The Corpus Christi Bay system has the fourth highest agricultural acreage of the nation's 92 estuaries.[38]

Heavy metals which have been found in the Bays include cadmium, selenium, zinc and silver.[39] Accidental oil spills that occur in the harbor channel occasionally reach other portions of the Bays and threaten habitat and wildlife populations. Because the watershed area hosts the nation's third largest petro-chemical complex, and shipping traffic in the Bays is heavy, the threat of major oil spills and barge collisions is a concern in the area.

Brown Tide

Since 1989, the system has been plagued by a brown tide which began in Baffin Bay and then spread northward. The brown tide alga, *Aureococcus anophagefferens*, is microscopic, yet it grows very quickly. It impairs the system because it is harmful to other aquatic organisms. In the Laguna Madre, the shallow water has been infested by thick, sunlight-blocking algae. Except for a similar problem in the Peconic Bays, this situation is virtually unheard of any where else in the world.[40]

Brown tide algae block sunlight from seagrass beds thereby destroying submerged habitat which provides important nursery areas for juvenile aquatic animals. Another problem with the takeover of the brown tide in the system is that it is not as palatable to zooplankton and fish larvae as is regular phytoplankton. Thus, it disrupts the basis of the food chain.

Floatable Debris

Trash floating in waters and accumulating on estuarine and ocean beaches threatens the ecosystem and its wildlife inhabitants. The amount found in just one day can be staggering — on September 17, 1994, volunteers cleared 334,200 pounds of marine debris from 167.8 miles of beach area in Texas. Of the total amount of marine debris collected, 70.7 percent consisted of plastics, 8.4 percent was metals, 8.2 percent was glass, 12.7 percent was from other materials. One of the heaviest pieces of garbage collected was a submerged Pontiac Fiero that was hauled in on North Padre Island.[41]

Padre Island National Seashore is the longest undeveloped beach in the United States. Due to the convergent currents occurring off the coasts, it has more accumulated marine debris than any other shoreline. Ninety percent of the trash that plagues its shores consists of plastics.[42] In a study conducted between March 1994 and February 1995, the National Park Service collected 40,580 debris items. The sources of these items were then identified and percentages were allocated based on this data. The study found that the shrimping industry was directly responsible for generating 30 percent of the debris and "suspected" of contributing an additional 35 percent. The offshore oil and gas industry was responsible for 13 percent and the remaining 22 percent of the debris consisted of items from an unknown source.[43] Continuing efforts are needed to stem the amount of marine debris found along Gulf shores in order to protect visitors and wildlife from potentially harmful materials. It is believed that sea turtle populations are most threatened by the ingestion of floatable debris.[44]

The Corpus Christi Bay National Estuary Program

With its inclusion into the National Estuary Program in 1992, Corpus Christi Bay was designated an estuary of "national significance." The NEP agreement between the EPA and the Texas Natural Resources Conservation Commission includes a plan for conducting a four-year study to develop a Comprehensive Conservation and Management Plan, referred to as the Coastal Bend Bay Plan (CBBP). The Corpus Christi Bay National Estuary Program (CCBNEP) is overseen by a Management Conference which consists of the following five committees: Policy Committee, Management Committee, Local Governments Advisory Committee, Citizens Advisory Committee, and Scientific-Technical Advisory Committee. The structure is designed to solicit input and participation from all

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users of the estuary system — industry, farmers, ranchers, small business owners, the military, bird watchers, boaters, windsurfers, local and State officials and resource managers, citizens, scientists, and environmental advocates. These committees are responsible for assisting in the development of the CBBP, which will serve as the basis for the implementation of management actions. The first Draft CBBP was released in March, 1996. The goal for completion of the CBBP is September 1998.

The CCBNEP had its first public activity, a conference, in the fall of 1994. The primary focus of many of the 130 participants was concern over freshwater releases to Nueces Bay. Another workshop was held in February of 1995 which focused on educating local communities and creating a vision for the future of the Bay. This meeting marked the first time all members of the CCBNEP were able to work together as a group.

The Corpus Christi NEP has focused its initial efforts on developing water conservation and reuse strategies, as well as, using freshwater releases from reservoirs during high salinity periods. These efforts are ultimately intended to lead to improved water quality for the surrounding human population, and the endangered marine life. After conducting a series of 13 public workshops to solicit comments on the list of priorities, the following seven issues of concern were identified: altered freshwater inflow to bays and estuaries; condition of living resources; loss of wetlands and estuarine habitats; degradation of water quality; altered estuarine circulation; bay debris; and selected public health issues. This list will continue to evolve and be prioritized as more information becomes available.

"Best Management Practices for Sediment, Nutrients, and Chemicals from Agricultural Croplands" is what the CCBNEP labeled its first Action Plan Demonstration Project. Since the CCBNEP study area includes so much agricultural land, implementation of agricultural best management practices (BMPs) is key to addressing the problem of polluted runoff. The project monitors runoff for sediments, nutrients and commonly-used agricultural chemicals over at least 10 rainfall events. The area being monitored covers 2,700 acres of cropland in San Patricio County that drain into Nueces Bay. The data are then analyzed and used to assess local agricultural practices and their contribution to the polluted runoff problems in the Bay. The Project then evaluates current BMPs and recommends actions to enhance their effectiveness. The results are also expected to provide an opportunity for farmers to increase economic profitability.

The second year of the CCBNEP is focused on eight major studies. Three of these will address aquatic vegetation and bay bottom habitats and will be completed by August, 1996. The first will analyze the impact of human activities — such as shrimping, commercial tug and barge operations, construction, oil and gas operations, recreational boating, historic shell and maintenance channel dredging, and the placement of maintenance dredge materials — on bay habitat. It will describe the extent, magnitude, and periodicity of effects of these activities on the physical, chemical and biological characteristics of bay habitat. The second study will undertake a major initiative to map the seagrass beds; conduct a trends analysis to determine if the beds are expanding or shrinking; and determine the cause of any losses. The final habitat study will use existing data to assess the status and trends of freshwater and saltwater wetlands and other aquatic habitats, natural and dredged material islands, natural and artificial hardened shorelines, and riparian woodlands within the CCBNEP study area.

One of the biggest and most important challenges of the CCBNEP will be to help residents of the Coastal Bend understand the interdependence of the environment and the economy and the necessity of striking a complementary balance between the two.

Local Grassroots Efforts

The Coastal Bend Bays Foundation (CBBF) is a non-profit organization dedicated to the conservation and responsible use of our natural resources. Representatives of environmental groups, industry, commercial and recreational fishing, tourism, resource agencies, shipping and developmental interests have joined together to identify problems

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and seek solutions to issues involving South Texas bays and estuaries.

To accomplish its mission, the CBBF has established five goals: Facilitation, Conservation, Education, Advocacy, and Research. Each of these goals corresponds quite well with the goals of the CCBNEP. CBBF intends to provide a forum for dialogue among the diverse users of the Corpus Christi Bay system. It develops projects for the purpose of preserving and enhancing the natural resources of the bays, estuaries and freshwater wetlands of south Texas. CBBF acts as a "land trust" for the purpose of acquiring, preserving, and enhancing wetlands and other ecologically important areas.

Education is another important element of the organization. CBBF provides resources and guidance for education projects with the purpose of developing a motivated constituency to protect the Bay. The organization works to empower educated citizens to become strong advocates of the natural resources of the Coastal Bend area. Finally, CBBF supports and encourages the allocation of public and private resources for research into the resources of the bays, estuaries, and wetlands of South Texas.

The philosophy of the organization, as articulated in each of its goals, has helped CBBF become a key voice on behalf of the environment and the citizens of the Coastal Bend Bays during the development of its Plan. Members, Board of Directors and staff of CBBF have served in numerous capacities in the development of the CBBP and in monitoring the interim actions and other steps taken in the Plan. Specifically, they serve on the Management Conference, as well as the Policy Committee and the Scientific Advisory Committee. CBBF has been involved in the CCBNEP since its inception and was instrumental in promoting the designation of Corpus Christi Bay as an estuary of "national significance".

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Delaware Estuary
in Delaware, New Jersey and Pennsylvania

The key to protecting the Delaware River and Estuary is to listen to the River and what it has to say. The River communicates in sign language—the signs it uses are water quality, fish and wildlife populations, and the abundance or absence of habitat and plant species. It is up to us to learn the River's language, to read its signs, and to take its message to heart in our daily lives.

—Maya K. van Rossum, Executive Director
Delaware Riverkeeper Network

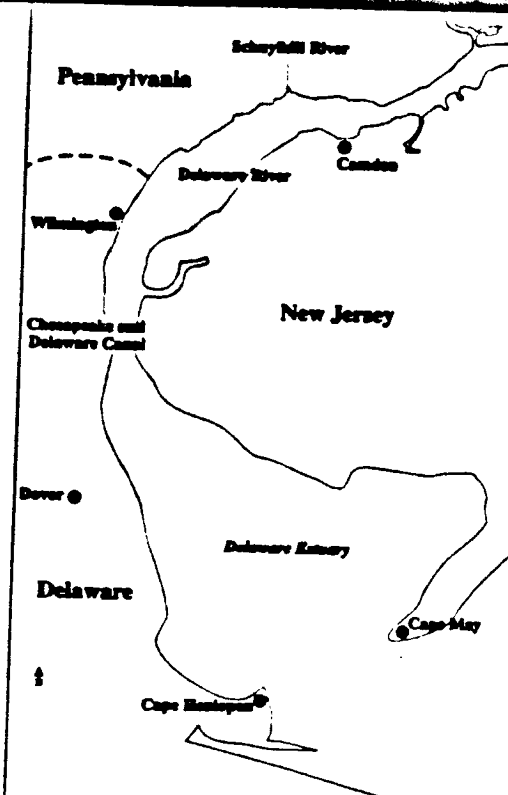
Portrait of the Estuary

The Delaware Estuary Program is examining the water quality and habitat problems of the Delaware Estuary and the impact that the greater watershed area has on the estuarine system. The Delaware Estuary extends 134 miles from its mouth between Cape May, New Jersey and Cape Henlopen, Delaware, northward to Trenton Falls, New Jersey.[1] With a water surface area of 768 square miles, the

Delaware Estuary

Area of surface water	768 square miles
Area of watershed	13,500 square miles
Average depth	21 feet
Population	• 8 million people
Values	• Sport fishing generates $25 million in economic output • The Estuary generates $28.7 billion in sales and wages • Home to the world's largest horseshoe crab population
Threats	• Habitat loss and degradation • Water diversion • Population growth and land use • Toxic pollution • Pathogen contamination • Nutrient loadings
CCMP status	Draft completed in 1995 Final approval expected in 1996

Designated as a "Nationally Significant" Estuary in 1988.



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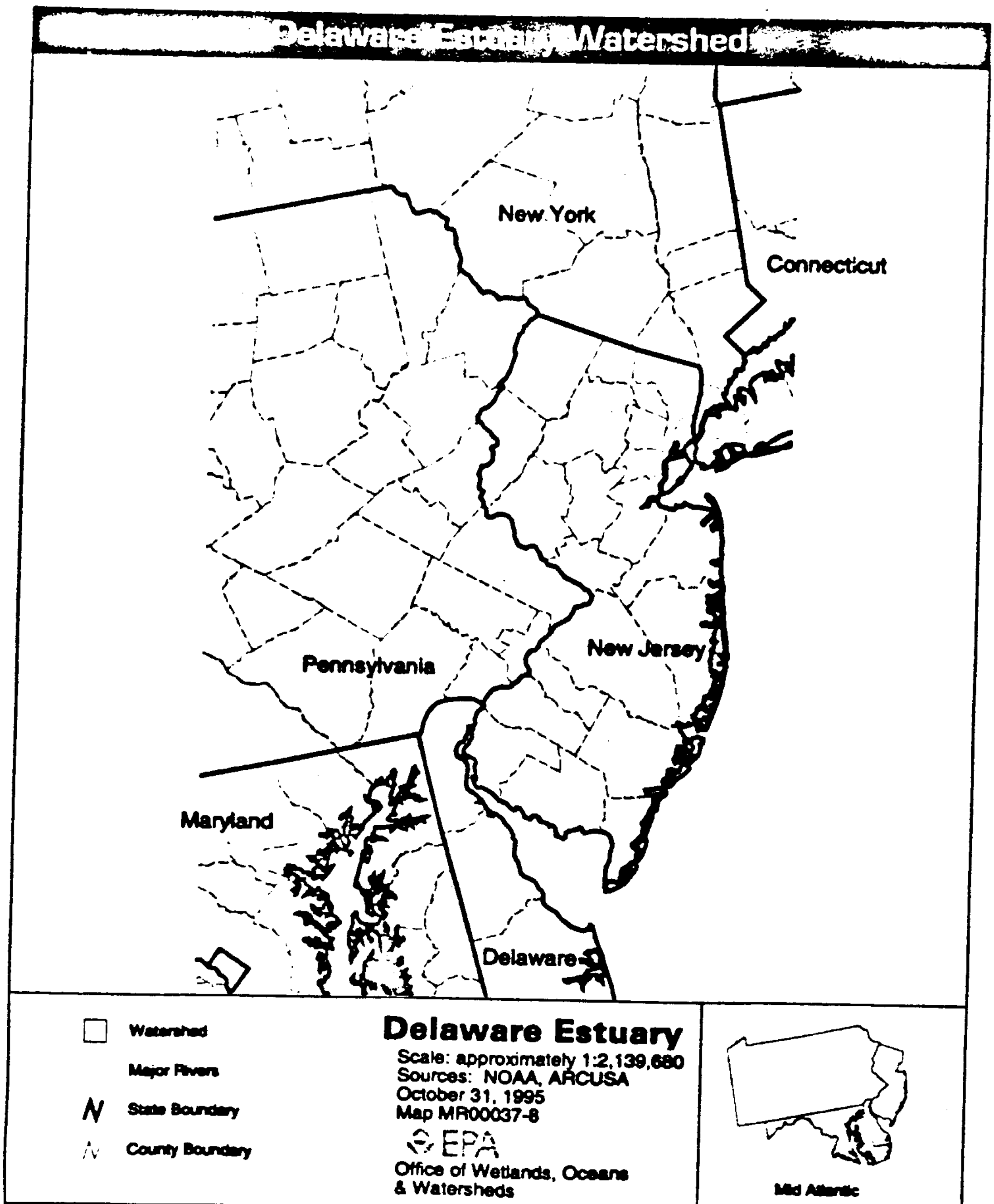
Delaware Estuary Watershed
New York
Connecticut
New Jersey
Pennsylvania
Maryland
Delaware
Watershed
Major Rivers
State Boundary
County Boundary
Delaware Estuary
Scale: approximately 1:2,139,680
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-8
EPA
Office of Wetlands, Oceans
& Watersheds
Mid Atlantic

Delaware Estuary is one of the largest estuaries along the Atlantic coast.[2] The average depth of the Estuary is 21 feet.[3]

The Delaware Estuary is one of the most relied-upon estuaries in the world. The watershed area of the Delaware Estuary includes portions of Pennsylvania, New Jersey, Delaware and New York. The Delaware River drainage basin, also referred to as the watershed, measures 13,500 square miles.[4] The watershed contains the population centers of Philadelphia, Pennsylvania; Trenton and Camden, New Jersey; and Wilmington, Delaware. In total, it includes 22 counties and 500 municipalities.[5]

An estimated 8 million people live within the watershed,[6] creating a density of 942 persons per square mile.[7] Six million people live in the portion of the watershed south of Trenton.[8] Projections indicate population growth rates of 52 percent for the State of New Jersey, 32 percent for Pennsylvania and 16 percent for Delaware by the year 2020.[9] The Delaware River provides the source of drinking water for over 20 million persons.[10] New York City, for example, diverts water from the upper Delaware River for its drinking water. To ensure that this critical service continues, maintaining the health of this system is crucial.

Most of the freshwater which enters the Delaware Estuary is carried by the Delaware and Schuylkill Rivers.[11] The remainder of the freshwater inflow originates from the Chesapeake and Delaware Canal and smaller tributaries.[12]

The Delaware Estuary system contains three ecologically defined zones — the upper zone, the transition zone, and the lower zone. The upper zone, consisting of tidal freshwater, is the most developed, and therefore, the most polluted part of the Estuary. The transition zone is characterized by high turbidity, low biological productivity, and a wide salinity range (0 to 15 parts per thousand).[13] The lower zone, with its shallow waters and high salinity, is considered the most biologically productive area.[14] The Delaware Estuary has an unusually strong tidal flow, one of the reasons for its naturally high dissolved oxygen levels. In addition, it only takes the whole system approximately 90 days to flush, or replace, all of its water content.[15]

Various habitat types can be found within the Delaware Estuary's watershed. Some of the more prominent habitats include coastal marshes, intertidal mudflats, beaches, and upland forests.

Values of the Estuary

The Delaware Estuary is a valuable resource for the many residents and visitors of the mid-Atlantic area. The Estuary supports large populations of birds, shellfish, and other wildlife which attract numerous bird-watchers, recreational fishermen, hikers, and photographers. The Delaware Estuary includes over 1.1 million acres of wetlands and subtidal habitats that support numerous animal and plant species and provide a buffer zone from residential areas. In addition, wetlands of the Delaware Estuary provide critical habitat for 35 percent of the region's threatened and endangered species.[16]

Population centers throughout the mid-Atlantic region depend upon the health and vitality of this natural resource. The Delaware Estuary watershed provides a source of drinking water for almost ten percent of the nation's population.[17] In addition, regional towns depend upon fishery and tourist industries supported by the Delaware Estuary to keep their economies afloat.

Recreation/Tourism

The Estuary provides a wealth of recreational opportunities — from swimming and nature watching to sport fishing — for millions of individuals each year. The economic benefits derived from these recreational activities are great. In addition to the resources it offers visitors, the Delaware Bay provides a solid base of employment opportunities for its surrounding residents. A Department of Commerce analysis approximates that the Delaware Estuary supported 123,000 jobs, and generated $4.3 billion in wages and $24.4 billion in sales in 1990.[18]

Sport fishing is a popular and valuable activity in the Delaware Estuary. In 1990, the value of sport fishing in the Estuary was estimated at $25 million.[19] State-specific numbers are available for as recent as 1991. Recreational fishing in the State of Delaware

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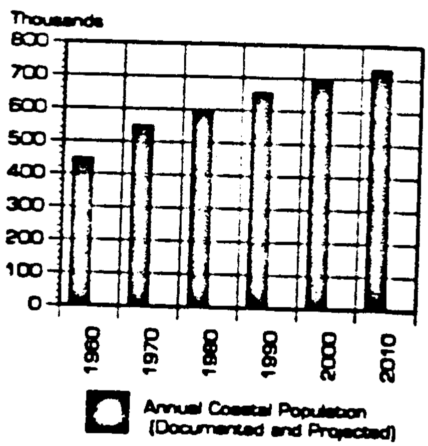
Delaware Coastal Population



Data Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service

generated approximately $110 million and employed nearly 2,000 people in 1991. In the same year recreational fishing in New Jersey generated approximately $1.3 billion in economic output and employed nearly 16,800 people; and in Pennsylvania it generated approximately $1 billion and employed nearly 16,000 people.[20]

For the States of New Jersey and Delaware, saltwater fishing accounts for a large portion of the revenue derived from recreation. In 1991, 130,000 saltwater anglers fished off the Delaware coast, spending a total of 759,000 fishing days.[21] Over 66 percent of the fishermen were nonresidents of Delaware.[22] During the same year, 746,000 individuals spent a total of over 6 million days fishing off the coast of New Jersey.[23] The Delaware Estuary is important for many of the saltwater species caught off the mid-Atlantic coast since it provides feeding, spawning, and nursery grounds for the aquatic life which make up the intricate food web.

In 1988, birdwatchers contributed $5.5 million to the local economy of Cape May, New Jersey.[24] A number of state parks and national wildlife refuges provide great vantage points to observe birds and other wildlife.

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the Middle Atlantic region totaled approximately $149 million.[25] Many of the commercially valuable species in the Middle Atlantic region depend upon the health of the Delaware Estuary for survival.

In 1994, the State of Delaware's commercial finfish and shellfish landings totaled approximately seven million pounds, valued at $6 million.[26] In the same year, New Jersey's commercial finfish and shellfish landings totaled approximately 202 million pounds, valued at $100 million.[27] Pennsylvania's 1994 commercial finfish and shellfish landings totaled 371,000 pounds, and were valued at $292,000.[28]

The American oyster and the blue crab have historically been among the most economically valuable species in the Delaware Estuary. However, the economic contributions of the Estuary's oyster population have declined steadily since the early 1950s, primarily due to disease. As recently as 1980, over 640,000 pounds of oysters were commercially landed in the Estuary; in 1985 the landings had dropped to 39,000 pounds.[29] By 1989, there was no significant oyster harvest remaining.[30]

Landings of clam in the Estuary also dropped significantly — from 500,000 pounds in 1985 to 37,000 pounds in 1989.[31] The blue crab population, however, has remained viable in the face of human-induced environmental pressures, due to its rapid rate of reproduction and short life span.[32] In 1989, the blue crab fishery alone generated over $2 million for the local economy.[33]

Over 200 migrant and resident finfish species use the Delaware Estuary. Some of the more prevalent species include sharks, skates, sturgeon, American eel, blueback herring, Atlantic menhaden, alewife, American shad, striped bass, bluefish, weakfish and flounder. Overall finfish populations in the Delaware Estuary have been declining since the early 1900s due to overfishing, habitat loss, and water quality declines. Over the same period, commercial harvesting has shifted to the lower portions of the Estuary.[34] Currently, 31 finfish species are caught commercially in the Delaware Estuary.[35] In 1990, commercial finfish of the Delaware Estuary generated approximately $1.4 million.[36]

Wildlife

The Delaware Estuary supports a wide range of plants and wildlife, including oysters, crabs, sturgeon, pheasants, diamondback terrapins, ducks, and humpback whales. The Estuary has achieved a phenomenal reputation for the abundance of migratory birds which use the area as wintering and resting habitat. Over 70,000 greater snow geese use the Bombay Hook National Wildlife Refuge in Delaware in the early fall.[37] Canada geese, pintail ducks, green-winged teal ducks, black ducks, and wood ducks use the rich wetlands of this Refuge. Seventy percent of the North American red knot population has been found using the Estuary at one time.[38]

The Estuary is home to the world's largest horseshoe crab population.[39] Recent medical research has been conducted on the blood of the horseshoe crab. It is being used to help detect minute amounts of bacterial toxins associated with bacterial diseases, fever, shock and death in humans.[40] The annual, late-spring mating and nesting of the horseshoe crab is an inspiring spectacle for avid bird-watchers who travel to the bay shore to gaze at hundreds of thousands of red knots, ruddy turnstones, sanderlings, semipalmated sandpipers, and other migratory birds feasting on horseshoe crab eggs. Some migratory birds can gain as much as 50 percent of their body weight from the crab eggs.[41]

The Delaware Estuary also contains the largest heron, ibis, and egret rookeries on the east coast.[42] Humpback whales can be observed in the estuarine area.[43] Several estuarine-and wetlands-dependent federally threatened and endangered species can be found in Delaware, New Jersey, and Pennsylvania. The endangered roseate tern, and the threatened bald eagle and piping plover live in the Delaware Estuary.[44]

Threats to the Estuary

The Delaware Estuary includes the world's largest freshwater port (Port of Philadelphia), the nation's second largest petrochemical center, and several major population centers. For these and other reasons, the Estuary is vulnerable to human disturbance. Approximately 70 percent of the oil arriving on the Atlantic Coast is transported through the Estuary, placing the region at great risk from harmful oil spills.[45] The Trenton-Wilmington area has the world's greatest concentration of heavy industry.[46] Thus, the Estuary suffers from both historic and current effects of industrial pollution and oil spills as well as the continued pressures to convert natural areas into residential and commercial areas.

In order for the Estuary to continue to sustain the needs and activities of such an overwhelming population, measures must be taken to keep the quality of its aquatic and living resources intact. The Comprehensive Conservation and Management Plan (CCMP) of the Delaware Estuary Program identifies the priority threats to the Estuary system as habitat loss, water diversion, population growth, pathogen contamination, nutrient loading, and toxic pollution.[47]

Habitat Loss and Degradation

The Delaware Estuary includes approximately 405,000 acres of wetlands.[48] It is estimated that up to 24 percent of the Estuary's original wetlands have been destroyed.[49] Over the last 50 years, more than 39,000 acres of mostly freshwater and forested wetlands have been lost due to draining, filling, and other activities.[50]

The loss of wetlands habitat impairs the Estuary system in a variety of ways. Without wetlands to filter and absorb contaminants washed from urban streets, shoreline dredging, and agricultural lands, greater numbers of pollutants in higher concentrations reach the water and degrade the water quality. Secondly, without wetlands, the effects of storms are heightened due to the system's lack of protection from erosion and reduced ability to absorb tides and storm waters. Because many fish species rely on wetlands for nursery grounds, the loss of wetlands results in declines among fish populations. Finally, the ability of wetlands to retain and recharge groundwater is hampered by their decline. All of these factors affect the communities which are situated near the Delaware Estuary. In fact, it was calculated that wetlands conversions resulted in costs of about $166 million from lost flood controls, wildlife habitats, recreational uses, and waste treatment processes.[51]

The introduction of non-native species into the system is another cause of natural habitat loss.

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Phragmites, a common reed, has strangled out native vegetation, destroying valuable habitat and eliminating species diversity in the Estuary. It is estimated that one-third of the tidal wetlands in the Estuary are infested with *Phragmites*.[12] Wetlands of the Delaware Estuary are found in the jurisdictions of three States and hundreds of municipalities and counties. Efforts to protect these vital resources must be better coordinated in order to be successful.

Water Diversion

The diversion of surface water and groundwater supplies for human uses is seriously harming the Estuary's living resources by increasing the salinity levels of the Estuary system. Used to generate power and provide drinking water, combined water withdrawals from the Delaware River Basin are estimated at 7.3 billion gallons per day. New York City, the largest user of the Estuary's water supply, is licensed to take 800 million gallons per day for its public drinking water system. Power generation accounts for 68 percent of the total water withdrawals.[13] Water withdrawals threaten the integrity of the ecosystem by altering the balance between freshwater and saltwater, thereby threatening the biological productivity of the ecosystem.

Population Growth and Land Use

The biological integrity of the Delaware Estuary is threatened by the fact that it is used by such a wide number of municipalities and industries for transporting goods and commerce and for receiving wastewater discharges. The Trenton-Wilmington corridor of the Estuary is considered to be the most heavily industrialized region per square mile in the world.[14] In 1990, the Estuary contained 181 industrial and 153 municipal point sources of pollution.[15]

Due to the area's large population size, a substantial amount of land within the region surrounding the Estuary continues to be developed for residential and commercial uses. Populations in the region are expected to increase during the next few decades. By 2020, an overall population increase of 1.1 million individuals (14 percent) is anticipated in this region.[16] Individual State populations are expected to grow by the following percentages: 52 percent in New Jersey; 32 percent in Pennsylvania; and 16 percent in Delaware. Population growth in the region will increase freshwater consumption by an anticipated 28 percent (up from 344 million gallons per day to 440 million gallons per day).[17]

In addition to increased water usage, population growth encourages more development activities, thus, infringing upon valuable wildlife habitat and creating more water quality problems for the Estuary. The replacement of natural lands by impervious surfaces, such as pavement and roofs, harms the water quality of the system. For instance, during heavy rain events, contaminants carried by urban stormwater are more likely to reach the Estuary without the filtration provided by soils and other natural areas. Thus, the ever-growing population within the Estuary, and the subsequent impact of human activities, present enormous obstacles to estuarine health and stability.

Toxic Pollution

Heavy metals and organic contaminants are a serious problem in the Delaware Estuary. High levels of toxic contamination can be found in sediments, the water column, and in the tissues of aquatic animals. Due to its extensive history as an industrial center, the Estuary is affected by high concentrations of toxins, particularly in urbanized areas. Not only do these contaminants persist in the estuarine environment for up to decades, but also many "bioaccumulate" and are carried to higher levels of the food chain, harming shellfish, fish, birds, and even humans. Reproductive rates for peregrine falcons, osprey, and bald eagles are lower for those nesting along the Estuary than they are for nesting populations in other areas of the mid-Atlantic due to their exposure to toxins.[18] In addition, there are growing concerns that subsistence fishers in urban and rural areas are increasing their risks of developing cancer by consuming higher than usual amounts of contaminated seafood.

Zinc, copper, nickel, chromium, silver, arsenic and lead are common contaminants of the Estuary which enter the system through point source discharges, urban stormwater, atmospheric deposition, agricultural runoff and groundwater. Approximately 110 tons of arsenic, chromium, copper and

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lead are loaded into the Estuary each year.[59] Copper, lead, and zinc are entering the Estuary through over 50 possible point source discharges and numerous nonpoint sources.[60] In addition, nearly 11 tons of mercury enter the Estuary each year. The concentrations of polychlorinated biphenyls (PCBs) are increasing in all three zones of the Estuary.[61]

PCBs, chlordane and DDT have been found in fish tissue and have led to fish consumption advisories throughout the Delaware Estuary. Specifically, Pennsylvania and New Jersey have issued fish consumption advisories for channel catfish caught from the upper Delaware River; and Delaware has issued a statewide advisory for striped bass during the past few years. Other fish species which have been subject to recent fish consumption advisories in portions of the Estuary include white perch, American eel, bluefish, and white catfish.[62] Finally, all fishing in Camden, New Jersey has been shut down due to the presence of chlordane, a pesticide which is officially banned due to its destructive human health effects.[63] Currently, there are no uniform standards for sampling potential sites of contamination and issuing advisories in the three States.[64] The lack of coordination of fish monitoring and public notification is recognized as a critical defect in efforts to protect and inform the public about the safety and quality of the Estuary's resources.

The Delaware Estuary is consistently one of the most widely-used shipping ports in the eastern United States. In 1993, the Delaware River had the second highest tonnage of maritime imports of all United States' rivers — second only to the Mississippi River.[65] Over one billion barrels of oil are transported via the Ports of Camden, Philadelphia, Gloucester City, Salem and Wilmington, placing the area at great risk from the effects of a damaging oil spill.[66]

Pathogen Contamination

Pathogen contamination, as measured by fecal coliform levels, does not seem to be as pervasive a problem in the Delaware Estuary compared to other coastal waters. However, pathogens (disease-causing microorganisms found in human and animal wastes) enter the Estuary system from over 300 combined sewer overflow outlets and the large number of municipal wastewater treatment plants.[67] Due to high levels of bacteria, "fishable and swimmable" standards for water quality are not often met in the Estuary between Camden, NJ and Philadelphia, PA.[68]

Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated waters. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria are present in coastal waters.

Between 1985 and 1990, the number of shellfish beds approved for harvesting decreased from 351,000 acres to 311,000 acres, a reduction of nine percent.[69] In both New Jersey and Delaware, sewage treatment plants were identified as significant pollution sources, contributing to the restriction of harvest areas.[70] Delaware, Pennsylvania, and New Jersey have all issued fish consumption advisories due to public health concerns about pathogen contamination.[71]

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus are dumped into estuaries by urban stormwater, sewage treatment plants, atmospheric deposition, agricultural runoff, combined sewer overflows, and boater discharges. Due to the large number of urban wastewater plants in the Delaware Estuary, sewage discharges are considered to be the principal source of nitrogen and phosphorus in the Estuary.[72]

Excessive levels of these nutrients stimulate the growth of algae in the Estuary. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Estuary, but also require a great amount of dissolved oxygen as they decompose. The decomposition process depletes the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. Wastewater upgrades in communities throughout the watershed since the 1970s have diminished the levels of harmful contaminants reaching the Estuary through wastewater.[73]

In some portions of the Estuary, polluted runoff from farmland is a major source of phosphorus entering the Estuary. A study of the Upper Perkiomen watershed indicated that agricultural runoff contributes 80 percent of the nonpoint source pollution in the sub-watershed.[74]

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The amount found in just a few days is staggering — on September 17, 1994, volunteers cleared 46,000 pounds of marine debris from 115 miles of Delaware's beaches. Of the total amount of marine debris collected, 60.4 percent was plastic, 10.7 percent was metal, 14.2 percent was paper, and 14.7 percent was from other materials.[75] In the same year, on October 15th and 27th volunteers cleared 73,782 pounds marine debris from 171 miles of New Jersey's beaches. Of the total amount of marine debris collected, 66.3 percent was plastic, 10.4 percent was paper, 8.2 percent was metal, and 15.1 percent was from other materials.[76] On September 17, 1994 in Pennsylvania, volunteers cleared 2,600 pounds of marine debris from 12.38 miles of the state's beaches. Of the total amount of marine debris collected, 69.1 percent was plastic, 8.8 percent was metal, 13.9 percent was paper, and 8.2 percent was from other materials.[77]

The Delaware Estuary Program

In 1988, the Delaware Estuary was nominated by the States of Delaware, Pennsylvania, and New Jersey for inclusion in the National Estuary Program. Later that year, it was officially designated an estuary of "national significance." Delaware, New Jersey and Pennsylvania, as well as Regions II and III of the EPA were jointly tasked with administering the Delaware Estuary Program (DELEP). The DELEP was given the responsibility of developing a Comprehensive Conservation and Management Plan (CCMP) to address the problems facing the Estuary and to recommend solutions to those problems. The framework of the DELEP consisted of a Management Committee, Policy Committee, Scientific and Technical Advisory Committee, Local Government Committee, Financial Planning Committee and Citizens Advisory Committee.

Recognizing that the DELEP is in a unique position as the only tri-state estuary program, the lack of a central staff focus made coordination among agencies particularly challenging. The level of outreach needed to communicate with the wide array of other non-governmental stakeholders in the DELEP adds additional responsibilities. These interests include representatives from recreational groups, business, industry, ports, watermen, scientists, educators and environmentalists. Communication was also problematic because Program Directors were spread out over such a wide geographic territory.

By August of 1992, the Management Committee decided to hire a Program Coordinator to assist in both the coordination and communication among the stakeholders. This significantly helped move the Program toward completing its Draft CCMP which was released for public review and comment in January of 1995. However, several critical issues must be resolved before the final plan is approved. Most of the issues involve mechanisms for implementing the CCMP once it is approved.

It has taken the DELEP six years to develop the CCMP. The complexities involved in negotiating a plan with so many key stakeholders can not be understated. Maintaining a high degree of participation among all stakeholders, especially citizens, both in the planning and the implementation phase is critical to the success of the program. For instance, without the financial commitments of the States, the CCMP is unlikely to be implemented. Similarly without full participation of citizens, community support would be difficult to attain. Experience has shown that the lack of community "buy-in" to the Plan could also lead to resentment and potential opposition. Those NEPs that have the highest degree of citizen involvement have proven to be the most successful.

The three States involved in the DELEP have expressed varying degrees of commitment to implementing the CCMP. The biggest points of contention seem to involve the level of citizen participation, financial contribution and cash match, and early implementation actions. The communication and coordination problems experi-

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enced during the first three years of the planning phase of the DELEP should be a reminder that all stakeholders, including citizens, need to remain involved throughout the life of the process. It should also be clear that a central office with authority to encourage implementation actions is critical to the success of the Program.

The draft CCMP recommends 77 actions to address problems and threats standing in the way of a healthy Estuary. These actions are divided into the following seven issue areas: monitoring; Regional Information Management Services; water use management; land management; toxics; habitat and living resources; and education and involvement. The Delaware Estuary Program provides mini-grants to grassroots organizations in the watershed. One project identified in the CCMP and funded by the DELEP is the restoration of the heavily contaminated Alcyon Lake in Gloucester County, New Jersey. Another project developed a method to filter out pollutants in the runoff by using terraces and grassy channels along streambanks. Due to the success of these programs and the commitment of the agricultural community, these methods have been used by local farmers and gardeners throughout the watershed.

The DELEP's ultimate goal for the Delaware Estuary is to implement specific measures which will ensure sustainable development within the system. In a watershed subject to explosive population bursts such as the Delaware Estuary, balancing development initiatives with the laws of nature is vital to the future of the Estuary

National Coastal Caucus

The Delaware Riverkeeper Network, an affiliate of the American Littoral Society, is a non-profit membership organization that has been working since 1988 to promote public education and action, and to protect, restore, and enhance the Delaware River environment. Riverkeeper works throughout 12,765 square miles and portions of four states (New York, New Jersey, Pennsylvania and Delaware) of the Delaware Watershed. Riverkeeper serves watershed residents, volunteers, schools, fishermen, service organizations, citizens groups, scouts, farm organizations and environmental groups. Since its creation, Riverkeeper has significantly improved stewardship on the Delaware River.

The Delaware River is one of about ten waterbodies nationwide that has a Keeper Program. The Keeper approach emphasizes the ecological functions of watersheds, the hydrologic cycle and nature's food web. It also emphasizes local action and enforcement of the Clean Water Act and other environmental laws. As a citizens organization, it accomplishes its mission by patrolling, investigating, intervening and raising public awareness of the problems of the River and its Estuary.

Members, staff and volunteers of the Delaware Riverkeeper Network have served in numerous capacities in the development of the CCMP and in the monitoring of the interim actions and other steps necessary to encourage implementation of the CCMP for the DELEP. Specifically, they have served on the Citizens Advisory Committee and Public Participation Subcommittee.

The Riverkeeper works to strengthen citizen protection of the Delaware River, its habitats and tributary watersheds. Volunteer efforts are the core of Riverkeeper's programs. Citizen monitoring of streams in the watershed helps agencies and private citizens enforce environmental laws and provides information for managing human impacts on the ecosystem. Riverkeeper's citizen monitoring program, which includes sites from Handcock, NY to Delaware Bay, is a comprehensive program involving streamwatch programs, chemical water quality tests, and macroinvertebrate testing. A related program includes the Home Waters program which establishes task forces in tributary watersheds and helps citizens learn to make full use of the public processes available to them.

Riverkeeper also maintains a pollution hotline, an enforcement program that spots and reports violations of environmental regulations; helps organize and implement stream bank restoration projects; and patrols the Delaware Estuary (in a recently donated boat) to find threats to water quality and to follow up on pollution reports.

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Delaware Inland Bays
in Delaware

Every newspaper has headlines that scream warnings to Delaware. 'Crab Populations Down,' 'Poor Trout Season,' 'Fish Stocks Endangered,' 'Clam Harvest Down 90 percent since 1990,' 'Black Ducks Scarce,' and so on.... Yet, Delaware's Inland Bays' nursery and larval areas continue to be polluted and over-exploited. The contribution these Bays make financially to the State and local area is enormous, both from tourism and fishing supplies; yet the valuable, irreplaceable resource has almost no protection except that provided by the Clean Water Act.

—Til Purnell, Executive Secretary
Save Wetlands and Bays

Portrait of the Bays

The Delaware Inland Bays Estuary Program is examining the water quality and habitat problems of the Delaware Inland Bays and the impact that the greater watershed area has on the estuarine system. The Delaware Inland Bays are actually three bays — Rehoboth, Indian River, and Little Assawoman bays — located along the southern Delaware coast. The surface water of the Bays covers 32 square miles.[1] The average depth of the Delaware Inland Bays is a shallow four feet.[2]

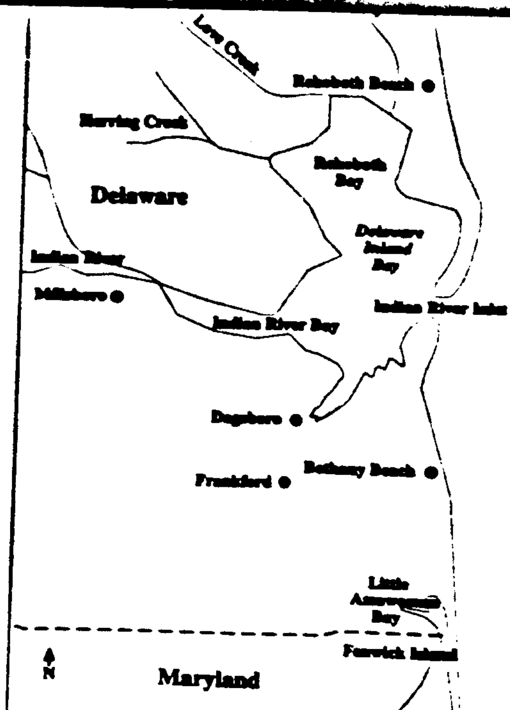
The watershed area of the Bays measures 300 square miles and extends to include portions of

Delaware Inland Bays

Area of surface water	32 square miles
Area of watershed	300 square miles
Average depth	4 feet
Population	120,000 people
Values	• The hard clam fishery generates $48,000 • Sport fishing generates $110 million in economic output* • Recreational boating generates $14.7 million
Threats	• Nutrient loadings • Habitat loss and degradation
CCMP status	Approved in 1995

Designated as a "Nationally Significant" Estuary in 1988.

*State figure



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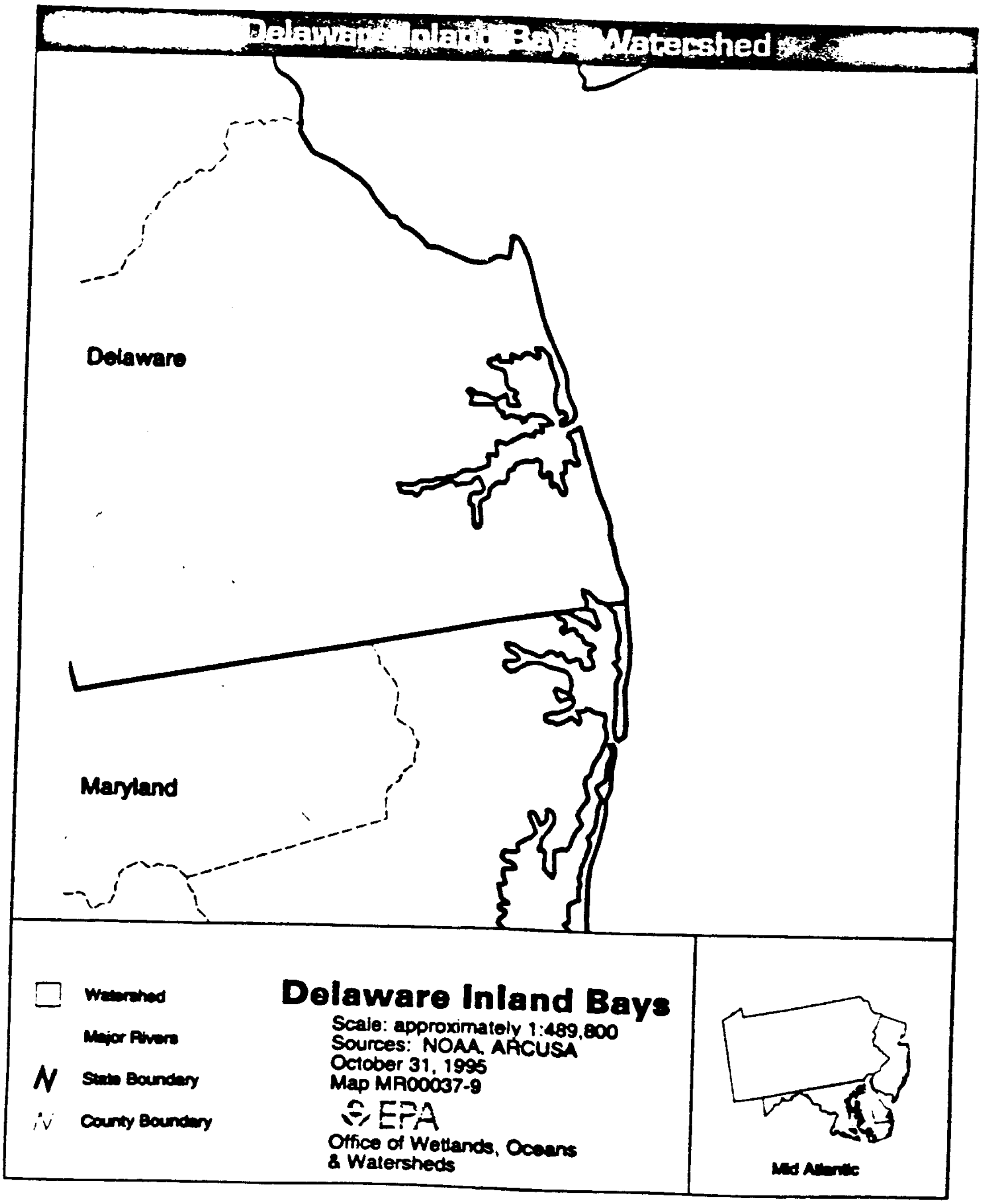
Delaware Inland Bays Watershed
Delaware
Maryland
Watershed
Major Rivers
State Boundary
County Boundary
Delaware Inland Bays
Scale: approximately 1:489,800
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-9
EPA
Office of Wetlands, Oceans
& Watersheds
Mid Atlantic

northern Maryland. Approximately 120,000 persons live within the watershed.[3] Portions of Sussex County, including the communities of Millsboro, Rehoboth Beach, and Bethany Beach, are situated within the watershed. The area is experiencing sizable population increases. The population of Sussex County grew from 80,356 in 1970 to 113,225 in 1990 and is expected to increase to approximately 150,000 by 2011.[4] During the summer months, the resort communities along bay and ocean shores in the region host hundreds of thousands of visitors.

The Bays have a number of features which distinguish them from other estuaries in the United States. First, physical connections with the Atlantic Ocean are limited. Saltwater reaches the Bays via the Indian River Inlet, Lewes and Rehoboth Canal, Roosevelt Inlet, and the Assawoman Canal.[5] Projects to deepen the Indian River Inlet have significantly altered the Inland Bays. During the past 60 years, the Bays have changed from a predominantly fresh water estuary to a marine-dominated one.[6] Barrier islands separate each of the Bays from the Atlantic Ocean. Second, unlike most estuaries which receive the bulk of their freshwater inflow from rivers, the Delaware Inland Bays receive as much as 80 percent of their freshwater, six to nine million gallons a day,[7] from groundwater sources.[8] The main tributaries that carry freshwater to the Bays are Indian River, Love Creek, and Herring Creek. Overall, the freshwater inflow, calculated to be 300 cubic feet per second,[9] is relatively low compared to other estuaries in the nation.[10] Finally, the shallowness of the Bays, coupled with limited freshwater inflow and flushing capacity make them particularly vulnerable to harmful contaminants.

Various types of habitat can be found within the watershed. These habitats include approximately nine square miles of salt marshes and wetlands, which provide critically productive buffer zones between the Bays and uplands.[11] Forested wetlands and sand dunes are other habitat types which support wildlife in the Bays.[12] The Inland Bays are stressed by 495 acres of "dead-end," unflushable lagoons in developments.[13] Many of these are anoxic and thus devoid of life.

Agriculture is the primary industry and the predominant land use in the watershed. Forty-seven percent of the land surrounding the Bays is used for agriculture.[14] Within the entire watershed, urbanized and publicly-owned lands comprise less than 25 percent of the land.[15]

Values of the Bays

The values of the Delaware Inland Bays system are inestimable. Numerous beaches, commercial and recreational fishing grounds, and abundant natural resources are found within this estuary system. Approximately 5,000 acres of public lands exist within the watershed area,[16] including Fenwick Island, Cape Henlopen, Holts Landing, and Delaware Seashore State Parks. These areas provide outdoor enthusiasts with a variety of recreational opportunities. According to a 1995 study, more than five million people visit Delaware every year.[17] Not surprisingly, 78 percent of those surveyed said visiting the beach and partaking in outdoor recreation activities were the primary purposes of their visit.[18] In 1992, domestic travellers spent $813.3 million and international visitors spent an additional $62 million in the State.[19]

Fisheries/Seafood

The Delaware Inland Bays provide important spawning and nursery grounds for commercially valuable fish and shellfish caught in the mid-Atlantic region of the United States. Of the approximately 30 square miles of classified shellfish harvesting areas within the Delaware Inland Bays, nineteen square miles are approved for harvesting.[20] Blue crab and hard clam form the basis of the Inland Bays' commercial and recreational fishing industries.[21] In 1990, the commercial landings for hard clam in the Delaware Inland Bays totaled 45,700 pounds, valued at $46,000.[22] Weakfish, spot, bluefish, and Atlantic menhaden represent the majority of the commercial finfish catch in the Delaware Inland Bays.[23] In 1994, commercial finfish landings for these four fish species in the Delaware Inland Bays totaled 23,166 pounds, valued at $10,900.[24]

In the past, the Bays supported bay scallop, oyster, and other shellfish fisheries as well as runs of anadromous fish such as alewife, herring, shad, and striped bass.[25] However, pollution, habitat alterations, channeling projects, and overfishing have resulted in declining populations of these fish and shellfish. The clam population has been depleted to less than 10 percent of its former size, and sport fishing stocks are also declining.[26] The loss of these resources has a deleterious effect not only on the livelihoods of local fishermen, but also on the economy of the area.

Recreation/Tourism

The shores of the Inland Bays and the Atlantic Ocean attract millions of tourists and outdoor enthusiasts each year. In 1985, approximately three million persons visited the Delaware Inland Bays.[27] In 1986, over 750,000 people visited the state parks near the Bays.[28] In 1987, Rehoboth beach was designated one of the top ten beaches in the U.S. The present-day number of visitors to the Bays and parks has grown exponentially since the late 1980s. Rehoboth Beach, although on the ocean and not the Bays, is a very popular vacation area in the Inland Bays region. The Bays provide an ideal spot for residents of Washington, D.C. and other major cities to spend a relaxing weekend. Sailing, swimming, sport fishing, water skiing, and hiking are a few of the popular activities which can be pursued in and near the Bays.

Economies of the local communities benefit from the recreational activities which lure visitors to the area. A 1984 study estimated that the recreation industry was responsible for 12.3 percent of the employment in Sussex County. In the same year, tourism and recreation generated visitor expenditures of $140 million and provided $4 million in taxes to state and local governments.[29]

Recreational fishing and boating help to support the coastal communities of Delaware. In the Delaware Inland Bays, recreational boating expenses alone account for an estimated $14.7 million per year.[30] Bluefish is the most commonly-caught recreational fish in the Bays. In 1991, recreational fishing in Delaware generated $110 million in economic output and employed nearly 2,000 people.[31] In that year, 45,000 freshwater and 130,000 saltwater anglers spent a total of 1.2 million days fishing in the waters of Delaware.[32] Two-thirds of the saltwater anglers were nonresidents of the State.[33]

Wildlife

The Delaware Inland Bays support and maintain a plentitude of plant and animal life. Migratory birds use the Delaware Inland Bays and its wetlands as wintering habitat and resting areas along the Atlantic Flyway. These migratory birds supplement the year-round waterbird populations which inhabit the Bays. A few of the many bird species which rely on the Bays include hooded mergansers, canvasback ducks, eagles, cormorants, ospreys, Arctic brant, snow geese, blue herons, glossy ibises, and oyster catchers.[34]

Delaware has 17 animal species on the federal threatened and endangered species list.[35] The endangered bald eagle and the threatened piping plover are protected species which rely on estuarine wetlands and beach habitats.[36]

Threats to the Bays

A full range of environmental stresses threaten the natural environment of the Delaware Inland Bays. Agricultural runoff, urban stormwater, wastewater outfalls, septic system discharges, recreational activities, dredging and coastal development all burden the estuary by destroying pristine habitat and degrading water quality.[37]

The Comprehensive Conservation and Management Plan of the Delaware Inland Bays Estuary Program has highlighted nutrient over-enrichment and habitat degradation as the primary threats to the system's water quality and natural resources. Other areas of concern are circulation patterns, pathogen contamination, and sea level rise.[38]

Nutrient Loadings

Sussex County's landscape and economy is dominated by agricultural production. Throughout the Bays, agricultural operations are the leading source of nitrogen and phosphorus inputs to the Bays.[39] Other nutrient sources include septic systems, sewage treatment plants, urban stormwater, atmospheric deposition, and forested areas.

Excessive levels of these nutrients stimulate the growth of algae in the Bays. As the algae grow and thicken, they not only block essential sunlight from bottom-dwelling plant communities, but also deplete aquatic systems of dissolved oxygen. The process of algal decomposition requires a large amount of oxygen and thereby, levels of oxygen for other aquatic life are reduced. Low oxygen conditions (called hypoxia) can result in large fish kills. Compared to other middle-Atlantic estuaries, the Delaware Inland Bays, are highly eutrophic.[40] Massive fish kills plagued the Indian River in the late spring of 1987 and 1988.[41]

The application of fertilizer on agricultural lands and residential lawns is a significant source of the nitrogen and phosphorus loadings which enter the Indian River and Little Assawoman Bays. In these areas, the nutrients leach through the sandy, porous soil and eventually permeate the groundwater aquifers in the watershed. The quality of groundwater aquifers is of grave concern, not only from an ecological perspective but also because the population of Sussex County depends on groundwater as the source of its drinking water supply.[42] Groundwater flow within the watershed is extremely slow. It is reported that nitrogen currently being discharged to the Bays was initially applied to lands 20 to 40 years ago.[43] Therefore, fertilizers being used today are likely to be a persistent problem for the Bays for the next several decades. As a result, the problems associated with nitrogen loadings will continue to reappear and present ongoing challenges to efforts to restore the Bays.

Poultry production is a growing industry in Sussex County and Delaware. It is estimated that Delaware produces 18 percent of the nation's broilers.[44] In Sussex County, 83 million chickens, creating over 95,000 tons of manure, are produced each year.[45] Chicken manure and by-products derived from chicken production are spread on agricultural lands in the watershed as fertilizer and are major sources of nutrients which enter the Bays.

Habitat Loss and Degradation

The wetlands and submerged aquatic vegetation that are part of the Delaware Inland Bays ecosystem are threatened and destroyed by eutrophication, high turbidity, sedimentation, natural events, and human activities. Examples of human activities which have modified and destroyed habitat in the estuary include dredging, filling, channelization, inlet stabilization, and construction.[46] Developing lands close to the Bays and its wetlands typically results in increased sedimentation due to land erosion; toxic and organic pollution due to more impervious surface areas — such as pavement and roofs; increased sewage discharges; and changes in water flow patterns and volume.

Eelgrass and widgeongrass are believed to be the only species of submerged aquatic vegetation that were historically found in the Bays.[47] During the past few decades, these grasses have disappeared as a result of the over-enrichment of nutrients and the resulting high turbidity.[48] In 1990, an unsuccessful attempt was made at re-planting eelgrass in the Bays; these beds later died.[49] Since seagrasses provide rich habitat for fish and shellfish, their loss has had an adverse affect on the populations of desirable estuarine resources.

Not only are the Bays losing seagrass habitat, but important wetlands acreage is also disappearing. Between 1938 and 1973, 24 percent of the area's tidal wetland acreage was destroyed,[50] primarily as a result of dredging and filling of the habitat.[51] Tidal wetlands provide important habitat for spawning, nursing, migration, and feeding for a variety of fish, shellfish, insects, birds, amphibians, and mammals. It is estimated that more than 60 percent of the area's freshwater wetlands have been destroyed since 1950 because of channelization and ditching.[52] The freshwater wetlands of the Bays provide critical habitat for anadromous fish, waterfowl, and mammals and filter nutrients, pollutants and sediments. Loss of habitat within the Inland Bays, increased human disturbance, and poor water quality have devastated many plant and animal populations. In addition, economic benefits of wetlands, such as flood control and water quality enhancement, are jeopardized by losses of wetlands in the Delaware Inland Bays area.

Projects to stabilize the Indian River Inlet, conducted in the late nineteenth and early twentieth centuries, have seriously altered the estuarine habitat. The Inlet provided the historical connection between the Atlantic Ocean and the Bays. Originally a freshwater, landlocked system, the Bays have been converted to a marine-dominated estuary. The almost total loss of the tidal freshwater portion of the Inland Bays has virtually eliminated nursery habitat for once-common fish such as striped bass, shad, and herring.[53] The objectives of these stabilization projects were to provide a commercial navigational route; to increase salinity and to decrease stagnation

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of the Bays; and to allow more tidal activities in order to control mosquitos. However, the effects on the Bays have been widespread and far worse than anticipated. Shoreline accretion and beach erosion have occurred on nearby coasts. Erosion of the channel banks and channel bottom have widened and deepened the Inlet.[55] These changes have seriously altered the habitats and living resources of the Bays.

Additional Concerns

Pathogen contamination poses another threat to the health of Delaware Inland Bays. Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated waters. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of enterococcus or fecal coliform bacteria (indicators of pathogen contamination) are present in coastal waters. In the Delaware Inland Bays, the number of closed shellfish beds increased by 75 percent over the past two decades.[56]

The trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The amount found in just one day can be staggering — on September 17, 1994 volunteers cleared 46,000 pounds of marine debris from 115 miles of Delaware's beaches. Of the total amount of marine debris collected, 60.4 percent was plastic, 10.7 percent was metal, 14.2 percent was paper, and 14.7 percent was from other materials.[57]

The Delaware Inland Bays Estuary Program

In June, 1987 Delaware Inland Bays was nominated for inclusion in the National Estuary Program. It was accepted and officially designated an estuary of "national significance" in 1988. The Delaware Department of Natural Resources and Environmental Control, the Department of Health and Social Services, Sussex County and the EPA are coordinating the administration of the Delaware Inland Bays Estuary Program (DIBEP). The DIBEP was created to assess water quality in the Inland Bays; to make recommendations to address problems; and to bring together federal, state and local initiatives to ensure coordination of efforts to solve problems.

After significant public comment, much negotiating, and revisions to four different drafts, the plan to restore the Bays was finally approved. The EPA and the Governor of Delaware approved the final Comprehensive Conservation and Management Plan (CCMP) for Delaware Inland Bays in June, 1995. The Center for the Inland Bays (Center), a nonprofit organization, was established at the recommendation of the DIBEP's Citizens Advisory Committee to oversee and facilitate the implementation of the CCMP. Other post-CCMP activities of the Center include developing a strategic implementation plan, revising the monitoring plan and conducting public education and outreach projects. The Center has stated that it is a neutral arbiter. Unfortunately, the center has decided not to take any action on activities such as protecting eelgrass replanting areas.

From April 1991 through June 1993 the DIBEP convened a series of five "vision" workshops which were used to develop a framework for the CCMP. These workshops proved to be quite instrumental in jump-starting the process to move the CCMP development forward. Throughout the process the DIBEP has emphasized the use of regulatory and non-regulatory tools, ranging from erosion control requirements to landowner stewardship, as mechanisms to encourage wise management of the Bays system. Although the Center does not plan to use regulatory measures in its efforts to facilitate the implementation of the CCMP, some believe that this entity needs to consider both regulatory and non-regulatory mechanisms in order to achieve the community's goals most effectively.

The DIBEP has already made some progress in restoring the Bay. Stormwater management and sediment controls have been implemented for new development projects with the assistance of the DIBEP funding. Conservation plans, which outline ways to

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prevent soil erosion and agricultural runoff, have also been developed through the DIBEP for 49,274 out of 60,000 acres of cropland. In addition, the DIBEP is implementing two monitoring programs, one involving grassroots citizen participation as well as a more comprehensive scientific program. Additional educational efforts have focused on proper maintenance of septic tanks by homeowners in the watershed, including the replacement of 4,600 septic systems.

There have, however, been some weaknesses in the program that need to be addressed. Five Action Plans are outlined in the CCMP including an Education and Outreach Plan; Agricultural Source Action Plan; Industrial, Municipal, and Septic System Action Plan; Land-Use Action Plan; and Habitat Protection Action Plan. However, there is no water use plan included in the CCMP. This is particularly troubling since the Inland Bays are already enormously overburdened with boats and the recreational use of the estuary is only expected to increase. The CCMP references "A Water-Use Activity Impacts Report" that was prepared in 1989 which is supposed to serve as a basis for developing a Water-Use Plan for managing use of the Bays' waters. Yet no indication of movement in this direction has been seen.

In addition, although a Land-Use Action Plan exists in the CCMP, there is little mention made in the Plan for ways to control poor development, which is the primary cause of habitat destruction. Many believe that this issue should have been addressed more thoroughly by the DIBEP rather than relying on the Coastal Sussex Land-Use Plan. Although Sussex County is currently reviewing its land-use goals, the State is also developing a new transportation plan which is expected to cause further delays for the Land-Use Plan.

National Coastal Caucus

Save Wetlands and Bays (SWAB) is a nonprofit organization founded in 1980, with its established headquarters in Millsboro, Delaware. Devoted to protecting and restoring the Delaware Inland Bays, SWAB involves itself in issues that threaten the vitality of the water quality and living resources of the Bays.

SWAB has been involved in the NEP since its earliest days. Members, Board of Directors, and volunteers of SWAB have served in numerous capacities in the development of the CCMP and in monitoring of the interim actions and other steps taken to implement the plan. SWAB has played a key role in raising the voice of the citizens and ensuring that public participation remain an important part of the process. Specifically, SWAB has served on the Citizens Advisory Committee, the Scientific and Technical Advisory Committee as the Citizens Advisory Committee liaison, and the Monitoring Committee.

SWAB is an activist organization and its philosophy is one of cooperation and inclusion. Therefore, it works in coalition with a full range of local, state and national organizations, including such groups as the Conservation Network of Delaware, the Audubon Society, The Groundwater Foundation, League of Women Voters, Common Cause, Sierra Club, The Nature Conservancy, and the Chesapeake Bay Foundation. SWAB coordinates and submits public comments on regulatory and legislative proposals affecting the Bays. SWAB works to ensure citizens concerns are raised during public hearings and supports efforts by other local organizations to implement actions identified in the CCMP guidelines.

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Galveston Bay
in Texas

Galveston Bay is the most productive estuary in Texas. Thanks to the successes of regulations under the Clean Water Act, one of its major tributaries has been brought back from a dead body of water (and one of the most polluted in the country) to one with a surprising diversity of aquatic life. The challenge ahead for the Bay is to continue balancing all of its diverse uses while maintaining and restoring its health. Implementation of the Galveston Bay Plan is integral to that effort.

—Linda Shead, Executive Director
Galveston Bay Foundation

Portrait of the Bay

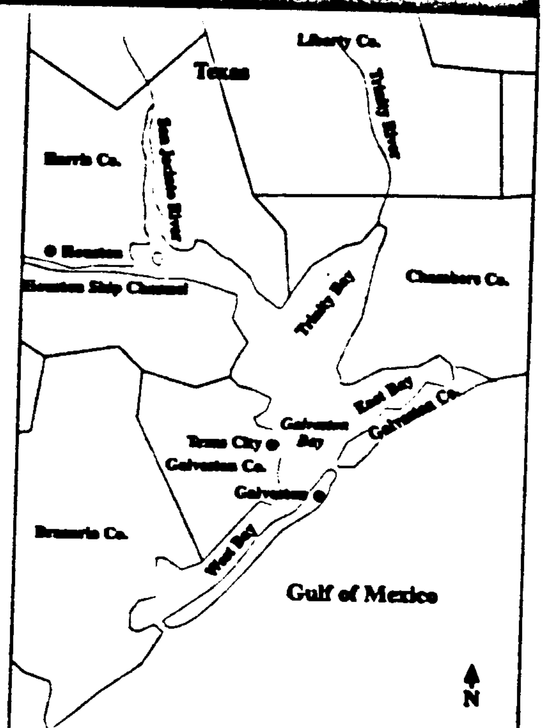
The Galveston Bay National Estuary Program is examining the water quality and habitat problems of Galveston Bay and the impact of the greater watershed on the estuarine system. Galveston Bay, located to the east and south of Houston, is one of the largest estuaries in Texas. The Galveston Bay system is composed of four large and two small bays — Galveston, Trinity, West, East, Bastrop and Christmas bays. It has a water surface area of 600 square miles.[1] Compared to other estuaries, Galveston Bay, with an average depth of six feet, is a

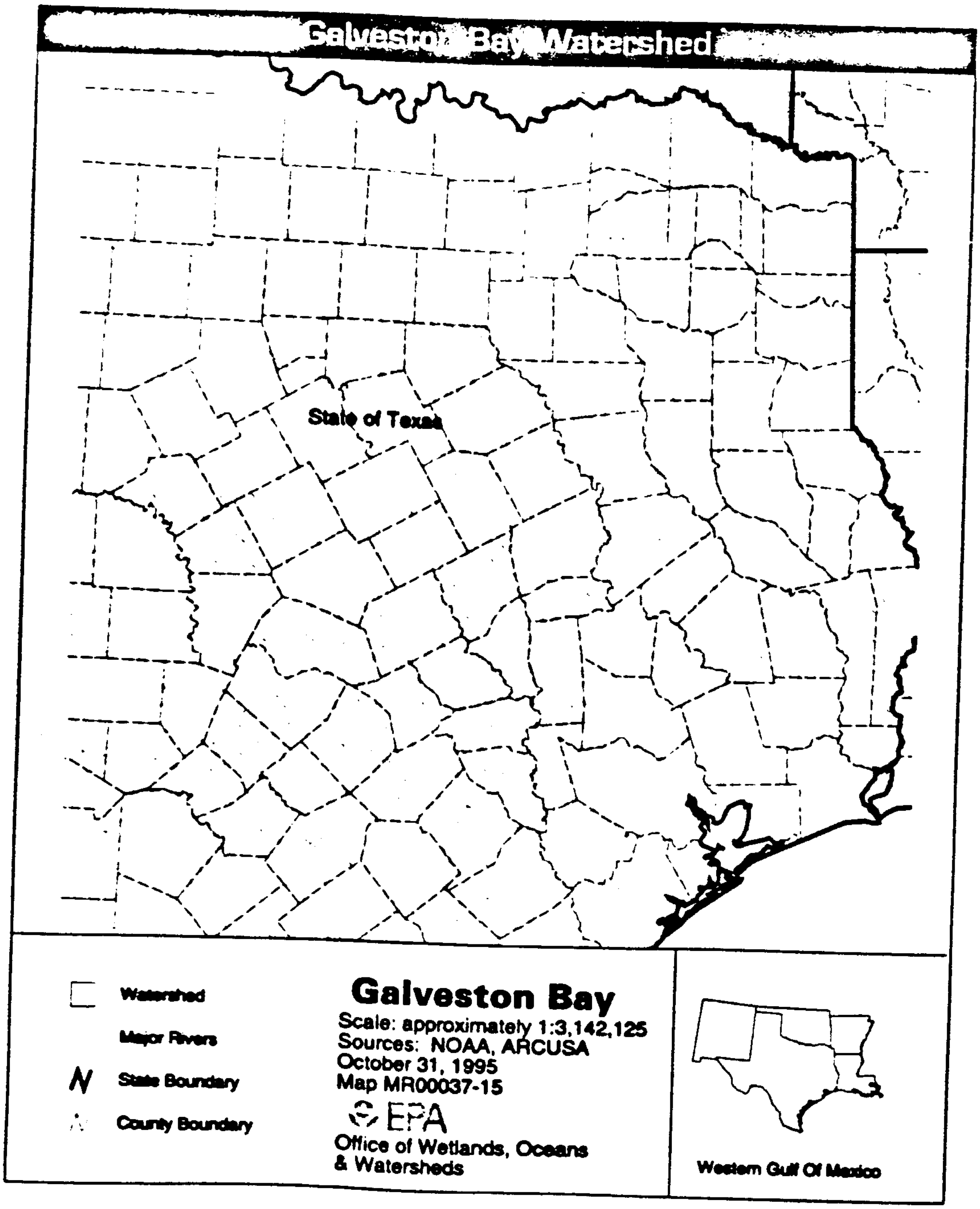
Galveston Bay

Area of surface water	600 square miles
Area of watershed	22,000 square miles
Average depth	6 feet
Population	6.7 million people
Values	• Tourism generates $7.5 billion • Sport fishing generates $2.8 billion in economic output* • The second most productive U.S. Estuary for seafood
Threats	• Habitat loss and degradation • Freshwater diversion • Toxic pollution • Pathogen contamination • Floatable Debris
CCMP status	Approved in 1995

Designated as a "Nationally Significant" Estuary in 1988.

*State figure





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shallow estuary.[2] Not including dredged channels, the maximum depth of the Bay is ten feet.[3]

The Galveston Bay watershed area measures 22,000 square miles and includes the large metropolitan areas of Houston, Dallas, and Fort Worth. Over 6.7 million persons live in this watershed.[4] Four populous counties — Brazoria, Galveston, Chambers, and Harris — border the Galveston Bay shoreline. The combined population of these four counties totaled 3.2 million in 1990, comprising 73 percent of Texas' coastal population.[5] Projections indicate that the population in this area will continue to grow steadily over the next fifteen years. It is estimated that Harris County's population alone will increase by over 900,000 persons between 1988 and 2010; and the county's population density will surpass 2,100 persons per square mile by 2010.[6]

Galveston Bay has the largest volume of freshwater inflow of any estuary in Texas.[7] The principal source of freshwater into the Bay is the Trinity River.[8] The abundance of freshwater in the Bay mixes with saltwater from the Gulf of Mexico and creates ideal living conditions for finfish, shrimp, crabs, and oysters. As a result, it is the second most productive estuary in the United States for seafood.[9]

Distinctive types of habitat which can be found around Galveston Bay include river delta, marshes, mudflats, seagrass beds, oyster reefs, and open bay waters. Within the local watershed there are 183 square miles of salt marsh that border the Bay, 14 square miles of forested wetlands, and 35 square miles of freshwater ponds and lakes.[10]

Galveston Bay supports the sixth largest port in the world, used by ships servicing the petroleum and petrochemical industries.[11] The Houston Ship Channel, which cuts through Galveston Bay, is a major cargo route which connects the port of Houston with the Gulf of Mexico. Maintaining a proper balance between the health of the Bay's natural resources and the heavy industrial use of this waterbody has proven to be a tremendous challenge.

Values of the Bay

Commercial fishing, recreational activities and tourism provide the people of the Galveston Bay area with significant revenue and enjoyment. Maintaining healthy and productive coastal waters is important for continuing these desirable uses. Area residents have shown that they are willing to contribute financially to protect these waters. According to a 1994 survey, the average household in the Greater Houston-Galveston area is willing to add an additional $7 per month to its utility bills to clean up and restore the Bay. Over 90 percent of the respondents to the survey believed that reducing water pollution in the Bay was important, and a majority indicated that their primary motive in decreasing water pollution was to leave a healthy Bay to future generations.[12]

Recreation/Tourism

Sport fishing is an expanding industry in Texas. In 1991, recreational fishing in Texas generated approximately $2.8 billion in economic output and employed nearly 40,000 people.[13] Fifty percent of sport fishing activity and expenditures in all of Texas occur in Galveston Bay.[14] Saltwater fishing drew approximately 828,000 saltwater anglers to fish for a total of 6.8 million days in coastal and ocean waters off Texas during 1991.[15] Some of the most popular sport fish caught in the Bay area include red fish, red drum, sea trout, sea bass, and blue marlin. The third largest recreational boating fleet in the U.S. can be found in the Bay.

Tourism in the Bay area supported 80,000 jobs and generated $7.5 billion in travel and payroll dollars in 1992. Ecotourism is the fastest growing segment of the tourism industry.[16] Nature-related activities, such as bird watching at High Island, lure people from all over the world. Galveston Bay is home to 139 colonial, colonial inland, and open water bird species.[17] The coastal woodlands of the Bay are an important resting place for migrating neotropical birds.

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the Gulf region totaled approximately $806 million.[18] Over 90 percent of the commercially and recreationally important fish and shellfish species in the entire Gulf region use the coastal wetlands of estuaries of the Gulf, like Galveston Bay, during their life cycles.[19]

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Galveston Bay is the most productive bay fishery in Texas, generating over 11 million pounds of fish and shellfish, a total economic impact to the state of up to $358 million each year.[20] At least 162 species of finfish inhabit the estuary.[21] Some of the most commercially valuable species include white shrimp, pink shrimp, brown shrimp, oysters, blue crabs, and Gulf menhaden. Annual shrimp harvests from Galveston Bay are valued at $46 million.[22] Oysters represent the cornerstone of the Galveston Bay fishery, yielding 60 to 70 percent of the total oyster production in Texas.[23]

Wildlife

Galveston Bay is home to a great diversity of wildlife. Two National Wildlife Refuges, the Anahuac and Brazoria, are located in the Bay system. The Bay provides a congregating point for the largest number of waterfowl along the Central Flyway.[24] In addition, the American alligator, spotted seatrout, Atlantic croaker, sanderling, and brown pelican have experienced significant population increases in the Bay. However, due to habitat destruction in the region, several other species, such as the diamondback terrapin and striped bass, have suffered long-term population declines. More recent declines have been noted for white shrimp, blue crab, mottled ducks, and other species of near-shore feeding colonial waterbirds.[25]

Several of the 71 federally threatened and endangered species in Texas are present in Galveston Bay. Some of these species include the brown pelican, piping plover, whooping crane, American alligator, and Kemp's ridley, leatherback, loggerhead, and green sea turtles.[26] In addition, the bald eagle and Attwater prairie chicken are coastal prairie species that use estuaries.

Threats to the Bay

The urbanization of the Galveston Bay area has contributed to the estuary's past and present water pollution problems. Over time, however, the primary sources of pollution have changed. Decades ago, industrial and municipal discharges were considered the main sources of water quality impairment in Galveston Bay. Galveston Bay still has the greatest concentration of point sources among Gulf Coast estuaries — 747 industrial sources and 566 municipal wastewater treatment plants in 1990. However, polluted runoff and stormwater carrying pollutants from streets, lawns, development sites, and farmland in the watershed are currently responsible for a large portion of the area's water pollution problems.

The problems that the Galveston Bay Plan identifies as priority threats to the health of the Bay system include habitat loss, freshwater diversion, toxic contamination, and pathogen contamination.[27] In order to solve many of these problems, efforts to combat polluted runoff and stormwater discharges must be addressed. In addition, floatable debris found along coastal areas harms the integrity of the ecosystem and repels tourists from shoreline areas.

Habitat Loss and Degradation

Loss of valuable wetlands and seagrasses is the most critical problem facing the health of Galveston Bay.[28] The loss of habitat is the primary cause of species declines in the region. It not only displaces species from their homes, but also disrupts the food chain since the decline of one species impacts others. In addition, because wetlands filter contaminants before they reach waters, the loss of habitat has severely negative consequences for water quality. Thus, habitat protection is critical to the ecological health of Galveston Bay.

Between the 1950s and 1989, over 32,000 acres of Galveston Bay wetlands were destroyed. During this time, a 21 percent net loss of area fresh- and saltwater marshes occurred.[29] The conversion of wetlands to open water and upland areas for urban, agricultural, and oil and gas development is the leading cause of wetlands losses in the Galveston Bay system.[30]

In addition to the tremendous loss of wetlands, seagrass acreage declined from 5,000 acres in the mid-1950s to only 700 acres in 1989 — a loss of 85 percent. Reasons for the destruction of seagrasses in the Galveston Bay system range from chemical spills to coastal development, dredging, trawling, and wastewater discharges.[31] Only five percent of the Bay has any seagrass beds, most of which can be found in Christmas

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Bay.[32] Efforts to restore seagrasses in Christmas Bay are proving successful. Between 1987 and 1989, seagrass acreage in this area increased by 185 acres.[33]

Coastal wetlands and seagrass meadows are critical nursery grounds for fish and shellfish, and provide habitat for a variety of shorebirds and migratory birds. The loss of coastal wetlands and seagrass meadows jeopardizes aquatic wildlife, and furthermore, threatens jobs which are connected to the natural resources of the Bay system.

Freshwater Diversion

The population of the Galveston Bay watershed has experienced steady growth. Almost 650,000 persons live within two miles of the Bay.[34] As population growth continues to occur, competition over limited Bay resources, such as freshwater for drinking water supplies, irrigation and municipal purposes, will intensify. Among the top issues governing the health of the Bay are the volume, timing, and quality of freshwater inflows, and the resulting water circulation patterns.[35]

The productivity of estuaries is dependent on the delicate balance between fresh- and saltwater. In order to sustain its valuable resources, the Galveston Bay system relies upon the continual inflow of freshwater from rivers and tributaries. Precipitation also plays an important role in providing freshwater to the system. However, freshwater diversions may alter salinity levels of the Bay, and thereby threaten organisms that depend on freshwater availability.[36] Oysters are one such species that relies on a stable balance of fresh- and saltwater. Balancing the diversion of freshwater to meet both the demands of humans and of nature is one of the many difficult issues under consideration in the Galveston Bay Program.

Toxic Pollution

Although shipping and industrial activities in Galveston Bay contribute trillions of dollars in revenue to the State, such revenue does not come without costs. In the 1960s, toxic pollutants plagued Galveston Bay and the upper Houston Ship Channel to the extent that massive fish kills occurred, and many feared the Bay's potential flammability. During this time, a calculated 500,000 pounds of biochemical oxygen demand (a measure of oxygen-robbing pollutants) entered the system each day primarily from industrial and municipal wastewater treatment facilities.[37] Today, despite efforts to control these activities, certain segments of the Houston Ship Channel still exceed water quality standards for toxic contaminants, such as polychlorinated biphenyls (PCBs), DDT, and heavy metals.[38] In fact, six of the top ten problems affecting Galveston Bay are related to toxic contaminants derived from petroleum compounds.[39]

Even though large amounts of toxic waste have been reduced by point source permitting controls, Galveston Bay still suffers from toxic contamination caused by polluted runoff. For instance, the amount of oil deposited into Galveston Bay yearly from urban polluted runoff is equivalent to 40 percent of the amount of the Alaskan oil spill of 1989. Between November 1993 and January 1994, a recreational area on Clear Creek (a tributary of Galveston Bay), was closed for several weeks due to the presence of toxic materials that originated from a Superfund site.[40] In addition, residues from the banned pesticides, DDT and dieldrin, have been found in the tissues of oysters caught in Galveston Bay.[41] Other types of seafood caught in the upper areas of the Bay pose public health risks for recreational and subsistence consumers because of their unacceptably high levels of toxic contamination.[42]

Pathogen Contamination

Harmful pathogens (disease-causing bacteria and viruses found in animal and human wastes) originating from wastewater discharges and polluted runoff from farmland, urban streets and lawns, also enter Galveston Bay. Galveston Bay receives about 60 percent of the total permitted wastewater discharged in all of Texas.[43] With such a heavy volume of wastewater being received in one bay, the threats associated with pathogenic contamination are extreme. Pathogens also have the potential to severely stress the aquatic life of the system. Fecal coliform contamination, from polluted runoff delivered to the Bay, has resulted in the permanent closure of 50 percent of the Bay to shellfish harvesting.[44]

In addition, bacterial contamination of beach waters

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poses health concerns for swimmers, divers, and other users. Throughout the nation, beaches are frequently closed because of unhealthy levels of bacterial contamination in bay and ocean waters. Galveston County monitors ten rotating sites along the Gulf of Mexico on a quarterly basis.[45] The Bay beaches are not generally used for swimming, and therefore, are not monitored.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. On September 17, 1994, volunteers cleared 334,200 pounds of marine debris from 167.8 miles of Texas beaches. Of the total amount of marine debris collected, 70.7 percent was plastics, 8.4 percent was metal, 8.2 percent was glass, and 12.7 percent was from other materials.[46]

Galveston Bay National Estuary Program

Galveston Bay joined the National Estuary Program in 1988. In 1994, the Galveston Bay National Estuary Program (GBNEP) released the Galveston Bay Plan for public comment. The plan outlines actions to improve the future health and sustainability of the Bay and its valuable resources. Based on scientific data and community input, the Comprehensive Conservation and Management Plan (CCMP) contains strategies to remedy the problems caused by pollution, development, and resource overuse. Included in the CCMP are 17 priority problems and 82 suggested management and restoration initiatives. In April 1995, the CCMP for Galveston Bay was the seventh such project of the NEP to gain approval by the EPA.

In developing the plan, the first step was to reach consensus among the stakeholders on the Bay's problems. The CCMP was developed as part of a highly collaborative process among government agencies, business interests, environmental organizations and the general public. The fact that all levels of the community were truly involved in developing the plan, and not just those with special interests, may be the greatest strength of the Program. This high level of participation by the community during the planning phase created the momentum necessary to ensure support for the implementation of the restoration plan.

After bringing all the interested parties together, the next stage was to conduct scientific research to more specifically define the problems and to determine the source of these problems. After reviewing these results and gaining public comment, the outlines of the CCMP had fallen into place. The planning process was balanced with on-the-ground demonstration projects. These activities included establishing two new coastal preserves, sponsoring the restoration of oyster reefs and salt marshes, and working with the ship channel industries to implement a pollution prevention program. Other objectives include reducing polluted runoff by ten percent, reducing the amount of marine debris and illegal dumping by 50 percent, and establishing a seafood advisory program.

The implementation of the Galveston Bay Plan is being carried out jointly by the Galveston Bay Estuary Program of the Texas Natural Resource Conservation Commission (TNRCC) and the Texas General Lands Office (GLO). From the CCMP emerged four management initiatives to address habitat loss: wetlands management and protection, erosion mitigation, beneficial use of dredged materials, and subsidence reduction. The loss of habitat in Texas is particularly troubling because of the direct financial impact on the fisheries economy. Coastal salt marshes serve as a nursery for over 90 percent of coastal marine organisms and they produce far more vegetation than any intensive agricultural crop.[47]

Although these and other elements of the Plan have a tremendously high likelihood of success, there were a few stumbling blocks experienced along the way. For example, governance of the implementation effort was highly debated. Initially, a regional authority with taxing power was suggested. Some particular local governments did not want to create a new entity or allow additional taxing authority in their areas. The Galveston Bay Plan ultimately suggested implementation by the TNRCC. The State legislation decreed joint administration by the TNRCC and GLO (with base funding through the Coastal Protection Fund which is administered by GLO). The GBEP is now a program within the TNRCC.

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National Coastal Caucus

The Galveston Bay Foundation (GBF) has been intimately involved in the GBNEP since its inception. In most cases, a former or the current Chair of the GBF Executive Committee served as the official representative on the main committees, including the Policy Committee and Management Committee. Several other GBF trustees, sometimes representing other entities with a common interest, also served on the Scientific/Technical Advisory Committee, Citizens Advisory Steering Committee, and Public Forum to help develop the plan to restore the Bay. In addition to the committees, GBF trustees and members served on a variety of task forces for the GBNEP. GBF entered into a number of contracts from GBNEP for programs of shared interest: the Bay Day festival, citizens water quality monitoring, environmental inventories of coastal preserves, citizen pollution reporting hotline, boater education (marine sanitation), and Bay Ambassadors (speaker's bureau).

Three key GBF programs that are in keeping with the goals of the Galveston Bay Plan are habitat restoration, volunteer water quality monitoring, and the Bay Day educational festival.

Acknowledging that habitat loss was identified early on by the GBNEP as the number one priority problem, GBF began marsh restoration in 1989 with twenty volunteers creating a few hundred square feet of smooth cordgrass (*Spartina alterniflora*) marsh in the Galveston Bay System. By 1994, the program had grown to involve over 200 volunteers, and over 150,000 square feet of marsh were created. Cordgrass stabilizes the Bay's shoreline, preventing further erosion and creating buffers to filter pollution. Today the seeds from these matured plants have naturally reseeded themselves on the opposite shore with seeds carried across the bayou's waters.

Currently, GBF is in the middle of a two year project to restore nine acres of marsh in the Clear Lake watershed (a subwatershed of Galveston Bay). During the marsh restoration activities, over 500 volunteers have been educated in the values of coastal wetlands.

GBF has an extensive program of volunteer water quality monitoring, with over 35 sites in the base program. An additional dozen volunteers are participating in an NEP demonstration project to show the value of citizen monitoring in watershed management. GBF's program has been recognized by the Texas Natural Resource Conservation Commission as one of the premier programs in the State.

In 1991, in order to maintain the high level of buy-in and public support for protecting and restoring the Bay, GBF and GBNEP began an annual family festival to celebrate the resources and uses of Galveston Bay. The festival brings together all of the users of the Bay system and gives them an opportunity to tell the story of their relationship to Galveston Bay.

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Indian River Lagoon
in Florida

Indian River Lagoon is the most diverse estuary in North America and is home to many endangered species. The Lagoon area also includes two of the fastest growing cities of the United States. This estuary deserves the dedication and commitment of local citizens who love the place.

—Diane Barile, Executive Director
Marine Resources Council of East Florida

Portrait of the Lagoon

The Indian River Lagoon National Estuary Program is examining the water quality and habitat problems of the Indian River Lagoon and the impact that the greater watershed area has on the estuarine system. The system includes the Indian River Lagoon, Mosquito Lagoon, and the Banana River. The Lagoon is a long, narrow estuarine system which forms 40 percent of Florida's east coast.[1] It extends from the Ponce de Leon Inlet near New Smyrna Beach southward to the Jupiter Inlet near Palm Beach—a total of 155 miles. The Lagoon's water surface area is 353 square miles.[2] The Lagoon's average depth is a shallow three feet; the depth extends to 12 feet along the Intracoastal Waterway.[3]

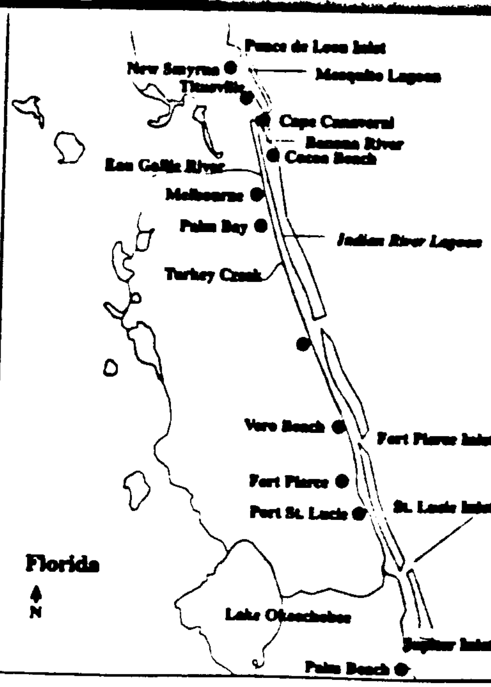
The Indian River Lagoon watershed measures approximately 2,300 square miles and includes portions of Volusia, Brevard, Indian River, Saint

Indian River Lagoon

Area of surface water	353 square miles
Area of watershed	2,300 square miles
Average depth	3 feet
Population	678,000 people
Values	• Fisheries generate $239 million* • Tourism generates $33.4 billion* • One-third of U.S. manatee population uses the Lagoon
Threats	• Habitat loss and degradation • Nutrient loadings • Stormwater • Pathogen contamination
CCMP status	Final expected in 1996

Designated as a "Nationally Significant" Estuary in 1990.

*State figure



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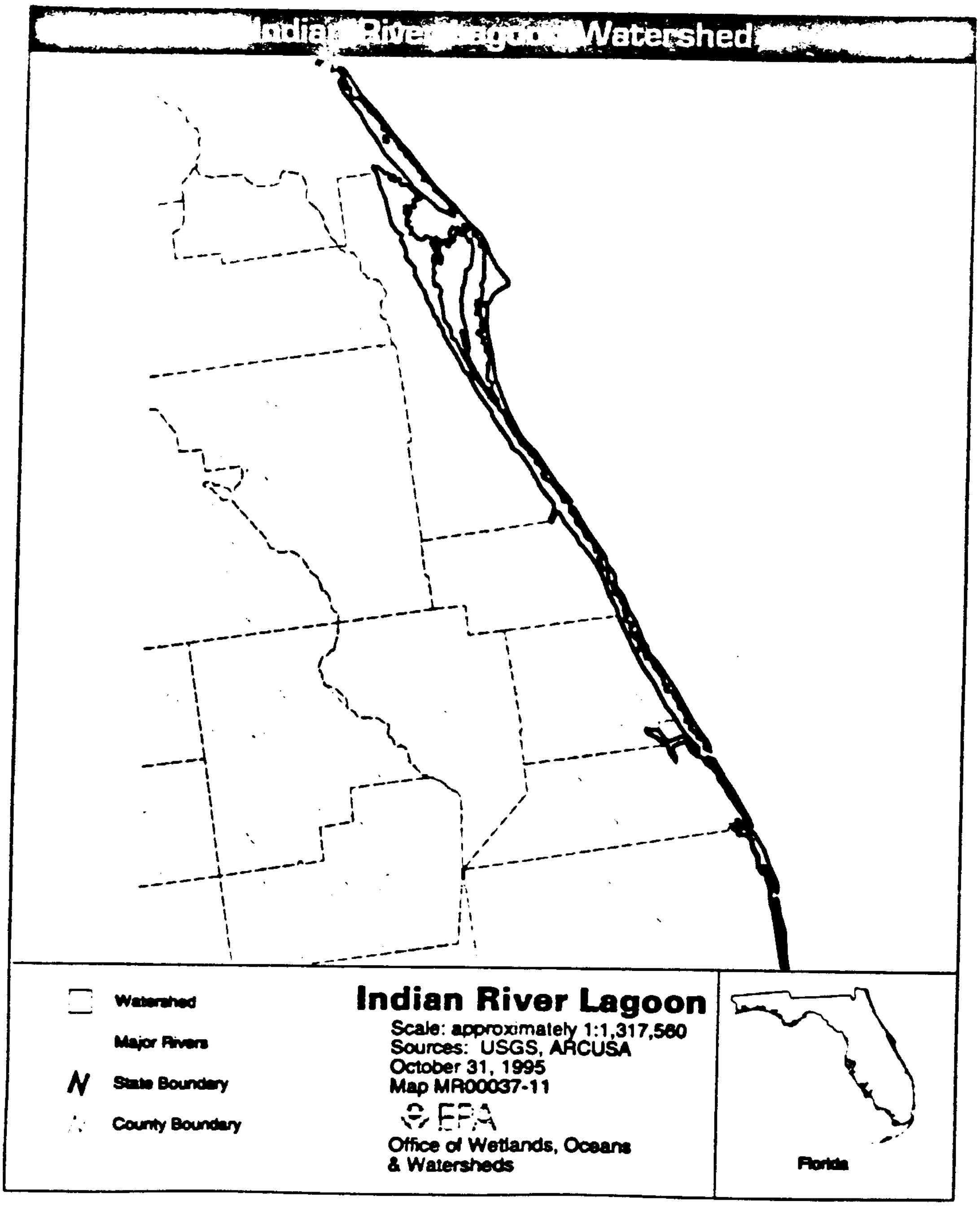
Indian River Lagoon Watershed
Watershed
Major Rivers
State Boundary
County Boundary
Indian River Lagoon
Scale: approximately 1:1,317,580
Sources: USGS, ARCUSA
October 31, 1995
Map MR00037-11
EPA
Office of Wetlands, Oceans & Watersheds
Florida

Lucie, Martin, and Okeechobee counties.[4] Two of the nation's fastest growing cities, Port Saint Lucie and Palm Bay, are located within the watershed. Other municipalities in the watershed include Melbourne, Fort Pierce, Titusville, Vero Beach, Cocoa, and Cocoa Beach. In 1990, more than 678,000 people resided within the watershed — a 124 percent increase since 1970.[5] The area's population is projected to surpass one million by 2010.[6]

The Lagoon receives a substantial amount of its freshwater from direct rainfall into the estuary and land drainage carried by creeks and canals, especially after heavy storms. The Lagoon is connected to the Atlantic Ocean through the Jupiter, Port Canaveral, St. Lucie, Fort Pierce, Sebastian, and Ponce de Leon inlets. The narrow width of these inlets causes limited water exchange between the ocean and the estuary. Winds have more influence on the movement of the estuary's brackish water than tides.

The Lagoon is located in a transition area between tropical and temperate zones. As a result, it provides a comfortable home to both tropical and subtropical species of flora and fauna. The diverse habitat types that can be found in the Lagoon include open water, seagrass meadows, mangrove forests, salt marshes, spoil islands, and shoal habitats. Over 200 spoil islands were created after dredged materials and sediments were deposited into open waters of the Lagoon during the 1950s.[7] Fortunately, the creation of new spoil islands is currently prohibited. Some of the effects of these massive dumping projects were increased turbidity and significant losses among seagrass habitat. Citizens from the town of Satellite Beach planted mangroves and other native vegetation to create a wildlife sanctuary out of a spoil island.

Values of the Lagoon

The Indian River Lagoon is an ecologically rich estuary which supports over 4,300 plant and animal species and contains a significant portion of eastern Florida's mangroves and salt marshes. The natural beauty of the Lagoon lures many vacationers to the area. Added features of the area include ocean beaches, recreational opportunities, public parks and refuges (including Pelican Island National Wildlife Refuge, established as the nation's first refuge in 1903), and various other tourist attractions. The biological productivity and tourist appeal of the Lagoon bring significant economic benefits to the region. The Lagoon area also helps support a $2.1 billion citrus industry that is distinguished worldwide.[8] Recognition of the connection between the ecological and economic values of the Indian River Lagoon is generating local interest in its preservation and restoration.

Recreation/Tourism

Florida's coastal waters lure millions of tourists and recreational enthusiasts to the State each year. In 1994, tourism revenues for Florida totaled approximately $33.4 billion.[9] A number of the State's most popular visitor destinations are located in the Indian River Lagoon area, including the Kennedy Space Center, the Cape Canaveral National Seashore, and Sebastian Inlet State Park, the most-frequented State park in Florida.

Sport fishing also generates significant revenue for the State. In 1991, the recreational fresh- and saltwater fishing industries employed over 58,000 people and generated approximately $3.5 billion in economic output.[10] In 1991, over two million saltwater anglers spent a total of 22.6 million days fishing off the coasts of Florida.[11] Over one-third of these anglers were non-residents of the State. In that year, approximately 30 percent of the total saltwater fishing days in the entire nation occurred off the coasts of Florida.[12]

Boating, swimming, waterskiing, windsurfing, sunbathing, camping, and hiking are some of the other recreational activities which engage visitors and residents of the Indian River Lagoon area. It is estimated that revenues from recreational fishing in the Lagoon totaled $54 million in 1990. In addition, more than 75,000 boats are registered in the area and marine/boating sales are estimated to exceed $300 million annually.[13]

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the South Atlantic region totaled approximately $215 million.

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Many of the commercially valuable species in the South Atlantic region depend upon the health of the Indian River Lagoon for survival. In 1994, the State of Florida's Gulf of Mexico and Atlantic Coast commercial landings of finfish and shellfish totaled approximately 177 million pounds and $239 million in dockside value.[14]

Fish caught from the Lagoon and nearby ocean waters account for 50 percent of Florida's total Atlantic Coast fish catch. In addition, clams harvested in the Lagoon comprise 90 percent of Florida's, and 15 percent of the nation's total clam landings. It is estimated that the total revenue generated from fisheries of the Lagoon is $300 million.[15] Spotted seatrout, red drum, mullet, blue crab, American oyster, and stone crab are other commercially valuable fisheries found in the area.

Unfortunately, population declines among commercial fisheries are affecting the productivity of the estuary, as well as the local economy. In an attempt to address the problem of population declines, there is a prohibition on the use of all commercial fishing nets in the State's inshore waters. Significant declines in the landings of spotted seatrout, American oyster, and hard clams have also occurred in the Lagoon due to overfishing, habitat destruction, and water quality impairments. The clam harvest, for instance, dropped from 1.5 million pounds in 1985 to 306,000 pounds in 1989.[16]

Wildlife

The Indian River Lagoon system includes five State parks, four National Wildlife Refuges, and a national seashore. All of these protected areas provide important habitat for the wildlife of the estuary. Approximately 680 fish, 367 bird, 52 reptile, 16 amphibian, and 30 mammal species can be found in the Lagoon ecosystem. Almost one-third of the bird species found in the Lagoon use the estuary for wintering habitat and 125 species breed in the area.[17] Very few, if any, estuaries in the United States can boast such a diversity of fishes and birds.

Of the 4,300 plant and animal species found in the Lagoon, 208 are classified as endangered, threatened, rare, or species of special concern by federal and State wildlife agencies.[18] No other estuary in the United States supports more protected species.[19] In addition, the Merritt Island National Wildlife Refuge, located in the central portion of the Lagoon, sustains the most endangered and threatened species of any National Wildlife Refuge in the continental United States.[20] The abundance and diversity of the area's wildlife appeal to the residents and visitors of the area. Measures to acquire vital habitats for wildlife, especially the rare, threatened and endangered species, are being considered in the comprehensive restoration plan.

Endangered species which depend on the Lagoon and its habitats include the Atlantic green sea turtle, Atlantic hawksbill sea turtle, Kemp's ridley sea turtle, wood stork, West Indian manatee, leatherback sea turtle, and red-cockaded woodpecker. Threatened species of the system include the Atlantic loggerhead turtle, Atlantic salt marsh snake, bald eagle, Florida scrub jay, piping plover, and roseate tern.[21]

For several protected species, the Indian River Lagoon provides crucial habitat. One of the Western Hemisphere's densest sea turtle nesting areas is found along the ocean beaches of the Lagoon.[22] The North Atlantic right whale uses the Indian River Lagoon and other coastal areas in Florida and Georgia as its exclusive calving area. The natural range of the Atlantic salt marsh snake is limited to this estuary.[23] Certain subspecies of Florida scrub jay, which are nearing extinction due to habitat destruction, live only on the barrier islands and Pleistocene dunes lining this estuary.

Manatees and bottlenose dolphins are also found in the Lagoon throughout the year. It is estimated that one-third of the total United States manatee population uses the Indian River Lagoon. An estimated 300 Atlantic bottlenose dolphins also live in the Lagoon year-round.[24] However, increased boating activities, habitat loss, and pollution are major threats to the area's manatee and dolphin populations.

Threats to the Lagoon

The natural beauty and resources of the Indian River Lagoon continue to attract more people to the

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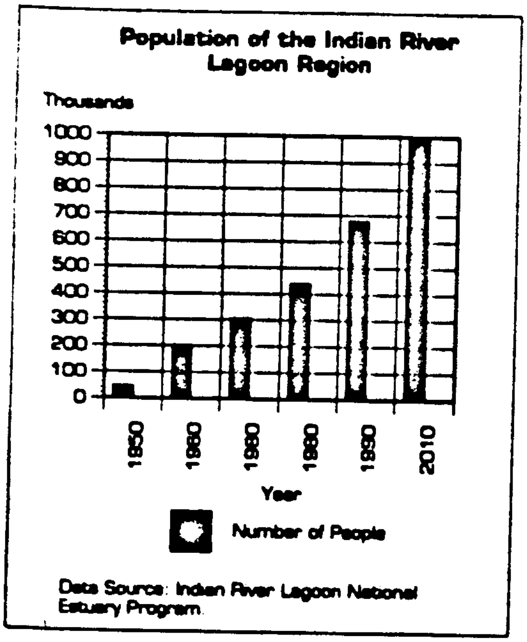

area each year, providing increased revenues to local communities. However, the appeal of the Lagoon also exposes the estuary to increased pollution, habitat alterations, and other stresses associated with extensive human activities. The Indian River Lagoon National Estuary Program identifies habitat loss, nutrient loadings, pathogen contamination, polluted stormwater, and loss of biological diversity as priority threats to the system. In addition, marine debris is a concern in the area. Rapid population growth and development in the area affect each of the identified problems.

Habitat Loss and Degradation

Seagrasses, salt marshes, and mangrove forests of the Lagoon are used by wildlife for spawning, nursery, and feeding grounds, and for shelter. These habitats were greatly altered by past activities conducted to encourage human settlement and commerce in the region. Flood and mosquito control projects, navigational projects, and urbanized development have taken their toll on the natural habitats of this estuary. For example, the ditching or re-routing of many wild, inland streams to control drainage and flood waters has effectively reduced groundwater tables and changed freshwater flow patterns.[25] That, in turn, has changed salinity rates in the Lagoon, which can harm wildlife, such as oysters, clams, spotted seatrout and many other fish.[26] Also, the dumping of dredged spoils from the channelization of the Intracoastal Waterway have destroyed seagrass beds. Salt marshes have been impounded (or separated from the Lagoon by manmade dikes) in order to reduce mosquito breeding grounds.

As the Lagoon's watershed has become more urbanized, its seagrass beds have rapidly declined. The Lagoon is a seagrass-based ecosystem rather than a phytoplankton-based ecosystem like most other estuaries. This means that seagrass is a basic part of the Lagoon's food chain, providing most of the food for animals in the system.[27] The extent of seagrass coverage is a strong indicator of the overall health of the estuarine system. Currently, more than 170,000 acres of the Lagoon are six feet deep or less, providing an ideal environment for seagrass growth. However, less than 50 percent of that area is covered by these productive aquatic plants — a substantial decline in seagrass coverage from a few decades ago.[28] Since the 1930s, the Lagoon has lost approximately 30 percent of its total seagrass coverage.[29] In the portions of the Lagoon near Palm Bay, Melbourne, and south of Vero Beach, and in the southern portion of the Banana River, seagrass loss exceeds 50 percent.[30] The creation of spoil islands, increased freshwater inputs, and turbid conditions are some of the major reasons for the loss of this valuable habitat.

Development projects also threaten salt marsh and mangrove habitats. Since 1950, more than 75 percent of the area's salt marshes and mangrove forests have been destroyed, modified, or isolated by impoundments.[31] The impoundments retain flood waters in former salt marshes where mosquitos would lay eggs. Culverts are being installed in many areas in order to reconnect the Lagoon with the impounded marshes so that fish can travel to these areas and marsh vegetation can recover. Although a different type of shallow water habitat replaces the

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salt marshes, and some restoration efforts are under way, these altered areas do not provide the same shelter and feeding advantages as the natural marsh.

The loss of marsh, mangrove and seagrass habitat in the estuary is directly linked to steep declines in many wildlife populations. Habitat loss is the primary cause of population declines for the majority of the Lagoon's animals facing the threat of extinction.[32] For instance, modifications in salt marsh habitat are responsible for the extinction of the dusky seaside sparrow.[33]

Wetlands provide breeding, nesting, and feeding grounds for fish and wildlife; however, they also serve other functions which benefit coastal communities. Marshes and mangroves filter pollutants which run off streets and lands, absorb the forceful impacts of coastal storms before they reach upland areas, and reduce flows of flood waters. Despite the significant losses of natural wetlands, the Indian River Lagoon area contains 20 percent of the mangrove forests located on the nation's east coast and 27 percent of the salt marshes on Florida's east coast.[34]

For the past several years, concerted efforts to acquire important habitats with local and State monies have occurred throughout the Indian River Lagoon. In addition, a private land trust was founded in 1991 by the Marine Resources Council of East Florida to purchase lands surrounding the Lagoon. These efforts have supplemented federal efforts to expand the Pelican Island National Wildlife Refuge and the proposed Archie Carr National Wildlife Refuge, and Governor Chiles' designation of Indian River Lagoon as a State "Greenway." These programs are becoming more important as the number of building permits in the area is dramatically increasing. Providing a balance between population growth and development, and the protection of vital habitats will be a challenge as people continue to move to the area.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by sewage treatment plants, agricultural runoff, stormwater, atmospheric deposition, septic systems, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Lagoon. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the estuary, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen needed by other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. The inundation of waterbodies with excessive levels of nutrients is called eutrophication.

In the Lagoon, sewage treatment plants are the primary source of nitrogen loadings; whereas agricultural runoff delivers most of the phosphorus to the estuary. Levels of nitrogen are greatest in the Banana River and the Cocoa and Cocoa Beach areas of the Lagoon. Additionally, several tributaries, including Turkey Creek, Sebastian River, and Vero Main Canal receive a significant amount of nitrogen. High levels of phosphorus are generally confined to the south-central Lagoon and the mouths of the Eau Gallie River and Crane Creek near Melbourne.[35] The northern portion of the Lagoon is especially sensitive to nutrient pollution because of its limited tidal flushing.[36]

The impacts of wastewater treatment discharges and stormwater on the Indian River Lagoon have been intensively studied. These studies indicate that the water quality of the Lagoon will deteriorate even further unless these pollutant loadings are reduced. In 1987, the Florida State Legislature passed the Surface Water Improvement and Management Act (SWIM) which addressed the abatement of stormwater impacts. In 1990, the Marine Resources Council worked to ensure the introduction of the Indian River Lagoon Water Quality Improvement Act calling for the elimination of domestic wastewater treatment plant discharges into Indian River Lagoon by July 1995. Recommended alternatives to discharging the effluent include wastewater reuse, land application, and deep well injection.[37] The cities of Cocoa and Cocoa Beach are employing wastewater reuse for city landscaping and lawn applications.

Polluted Stormwater

The Indian River Lagoon watershed receives about 50 inches of rain per year.[38] Stormwater carries

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nutrients, bacteria, toxins, chemicals, sediments, and litter from the land to the Lagoon. As more impervious surfaces, such as pavement and roofs, replace natural lands, greater concentrations of pollutants in larger volumes enter the Lagoon.

Sediments discharged into the Lagoon affect water clarity, hindering the ability of light to penetrate through the water. Consequently, seagrass growth is inhibited, and in turn populations of aquatic life decline. In addition, stormwater inflows reduce salinity levels in wide areas of the Lagoon, especially the St. Lucie estuary and the mouths of Turkey Creek and Sebastian River. These alterations affect the estuarine ecosystem by disrupting the productivity of aquatic plant life and organisms. Declining populations of oysters and clams are being linked to salinity modifications caused by storm events.[39]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter the Lagoon from wastewater treatment plants, septic system discharges, boating waste, stormwater, and runoff from pastures.[40] Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from ingesting pathogen-contaminated waters or seafood. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

The State of Florida does not have a statewide beach water monitoring program; nor does any of the five counties bordering the Lagoon monitor their ocean or estuarine beaches for bacteria to ensure swimmer safety. During 1994, government authorities did not close or issue health advisories due to bacterial contamination for any of the swimming beaches in the five counties — even after heavy rains.[41] Between 1985 and 1990, the percentage of shellfish beds approved for harvest dropped from 32 percent to 14 percent.[42] After storm events, several shellfish harvest areas of the Lagoon, especially those areas near Port St. John and Grant are routinely closed.

Soil conditions in the watershed are unsuitable for the large numbers of septic systems found throughout the watershed.[43] Septic systems are situated on over 270,000 acres of these well-drained, sandy soils. Septic system discharges tend to move quickly through these soils and enter the groundwater before the bacteria can be neutralized.[44] Some of the more productive shellfish beds are situated near Volusia and Brevard counties — areas with high densities of septic systems.[45]

Additional Concerns

Population growth, loss of living resources, and marine debris are other threats to the health of the estuary. The combined population of the five coastal counties bordering Indian River Lagoon is projected to increase by 346,000 people between 1988 and 2010. Over this 22-year period, the population growth rate for Martin and Indian River counties is anticipated to be 61 and 50 percent, respectively.[46] For the sake of comparison, fewer than 20 coastal counties in the nation are expected to surpass a 50 percent growth rate between 1988 and 2010.[47] As the population in the watershed continues to grow, additional transportation, dredging, and construction projects will negatively affect circulation, flushing patterns, and water quality of the Lagoon.

Marine debris which accumulates on estuarine beaches and in waters, endangers the birds, sea turtles, and other living resources of the Lagoon. On September 17, 1994, volunteers cleared 368,255 pounds of marine debris from 1,267 miles of Florida's beaches. Of the total amount of debris, 61.4 percent was plastic, 12.5 percent was metal, 11 percent was glass, and 15.1 was other materials.[48] Citizens and civic groups have adopted several ocean and estuarine beaches for regular clean-ups.

The Indian River Lagoon National Estuary Program

In 1981, scientists, researchers, government agency officials, and citizens assembled for a symposium in Melbourne, Florida, coordinated by the Florida Institute of Technology. As a result of the

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gathering, the Marine Resources Council of East Florida (MRC), consisting of leaders in business, industry, government, development, environmental groups, and commercial fishing was founded. By 1989, the MRC had persuaded then-Governor Martinez to nominate the Indian River Lagoon for inclusion into the National Estuary Program (NEP) established under the Clean Water Act. On April 13, 1990, EPA granted the petition which declared the Lagoon an estuary of "national significance." Less than a year later the Indian River Lagoon National Estuary Program (IRLNEP) was established and began to take shape. The IRLNEP is currently in the final stages of drafting its Comprehensive Conservation and Management Plan (CCMP). It is expected to be released for public comment in March, 1996 and final approval by the Governor and the EPA Administrator is expected by September, 1996.

The framework of the IRLNEP mirrored the committee structure established by the MRC. In its characterization of the problems in the Lagoon, the IRLNEP Policy Committee adopted the priority problems already identified by MRC and the nomination documentation. The Management Conference was established to identify and ensure coordination among various State, local, and regional programs, to incorporate those programs into the CCMP, and to initiate early action activities to begin addressing the problems.

The geography of the region has made it challenging for members of different committees to participate in all of the necessary meetings. The IRLNEP decided that the length of the study area for the Lagoon required the development of sub-regional management plans. North, Central, and South IRLNEP regions were formed to establish management centers along the entire length of the Lagoon. Although the decision to sub-divide the watershed may have allowed for greater participation, it was criticized for its rejection of pre-existing efforts to erase subjective regional boundaries so that the entire watershed population could work together on developing one plan. In addition, many believe that regional partitioning of the watershed has caused division and competition among the separate regions. In the end, the Program and meetings were centered in Melbourne and one comprehensive plan for the entire system was produced.

One of the early action projects identified as part of the CCMP was a demonstration project to reconnect 75 acres of coastal salt marsh to the Lagoon which had previously been separated for mosquito control purposes.[49] To begin to address some of the adverse effects of these impoundments, a Rotational Impoundment Management (RIM) system was created. Through RIM, water levels in these areas are maintained at levels appropriate to control mosquitos during the breeding season; and during the remainder of the year, the system allows the marshes to be reconnected with the Lagoon. Currently, about 70 percent of the impoundments have some type of connection to the waters of the Lagoon. However, private ownership of the remaining impounded areas may delay further implementation of plans.

The IRLNEP is also helping to conduct seagrass studies in order to quantify vegetation losses and determine possible restoration measures. Studies thus far indicate that the low-salinity waters in the Melbourne-Palm Bay area have suffered the greatest seagrass loss. Another study is determining the amount of light needed for seagrass to flourish. Water clarity standards are likely to be necessary in order to restore seagrass beds in many of the 100,000 acres of shallow waters where there is currently no growth.

The IRLNEP has also worked in conjunction with the State of Florida's Surface Water Improvement and Management program (SWIM), which develops federal, state, and local agency networks. These networks develop and implement plans to restore and protect the water quality throughout the State.[50] In the Indian River watershed, this inter-agency coordination has reduced duplication among various government bodies to facilitate comprehensive coastal resource management. An electronic bulletin board has been created by the IRLNEP to facilitate informational exchange among Lagoon stakeholders.[51]

Other projects promoted by the IRLNEP include educational workshops to train teachers throughout the watershed about Lagoon ecology, a

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seagrass initiative, and a data coordinating group. Each of these programs has been formed in order to help build public consensus around the actions needed to protect and restore the Indian River Lagoon. In addition, IRLNEP funded the Marine Resources Council's Water Quality Monitoring Program, which was initiated in the late-1980s. However, the relationship between the two groups has suffered over the years. Unfortunately, Marine Resources Council and the Indian River Lagoon National Estuary Program have for the most part, worked on parallel tracks with little mutual support. A disappointing outcome of the split has been a less harmonious working relationship among the partners dedicated to the Lagoon.

National Coastal Caucus

As mentioned above, the Marine Resources Council of East Florida was formed in 1982 following a symposium entitled "Future of the Indian River System" (FIRST), which brought together researchers, local residents, and area officials concerned about the deterioration of the Lagoon. The MRC has played an immense role in the preservation of the Indian River Lagoon and was essentially responsible for its inclusion in the NEP. Today, more than 700 individuals and organizations have been brought together by the MRC, based on the common understanding that everyone depends on natural resources for jobs, recreation, and lifestyle.

MRC members, as well as private and public citizens meet every two years in an "American Assembly" to build consensus for action on wisely managing barrier islands, beaches, and estuarine watersheds. During the 1980s, MRC defined the problems of the Lagoon and asked for a three-year NEP program so that implementation plans could be speedily adopted.

Actions taken by the MRC have ensured that future plans for use of the Indian River Lagoon resources have been incorporated into the six counties' and 33 cities' comprehensive plans, in addition to State management policy. The State Legislature now regularly addresses Lagoon issues and has dedicated funding, totaling more than $8 million to Lagoon restoration efforts. The MRC has served as a model for international, national and state consensus and research-based estuarine planning. In 1991 President Bush awarded MRC one of the first nine Presidential Environmental Challenge and Conservation Awards for fostering partnerships among environmental organizations, businesses and government.

Today, MRC programs focus on citizen education and action projects. Marine Resources Council's Citizen Volunteer Water Quality Program enlists 103 citizens for weekly shoreline monitoring of the Lagoon and tributaries. Sixty-five students, representing eight schools, also monitor areas of the Lagoon. The Greenway Committee has assisted local governments in receiving more than $7 million in grants to acquire wetlands and open space for the purposes of habitat restoration and recreation. Many canoe trails, bike paths and wildlife corridors are being planned as a result of these grants. MRC's Pepper Buster program relies on volunteers to cut Brazilian Pepper trees (exotic plants which have invaded natural mangrove habitats) and restore mangrove wetlands. So far, more than six miles of shoreline have been improved by this program. Finally, over 115 volunteer right whale spotters monitor and report on the endangered whales' behavior and migration patterns off the ocean beaches.

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Long Island Sound
in Connecticut and New York

Not only is Long Island Sound an invaluable economic and recreational resource, it is also a provider of immeasurable pleasure and happiness for tens of thousands of residents and visitors alike.

—John Atkin, Executive Director
Save the Sound, Inc.

Portrait of the Sound

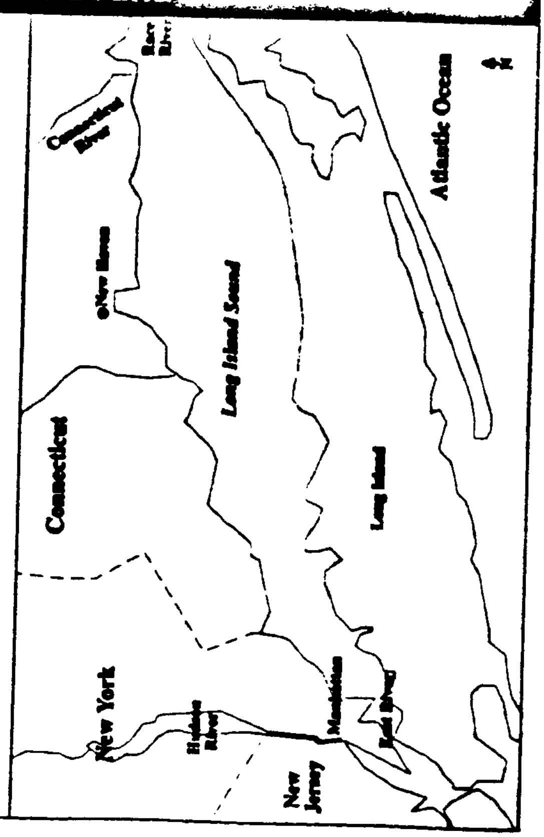
The Long Island Sound Study is examining the water quality and habitat problems of the Long Island Sound and the impact that the greater watershed area has on the estuarine system. Long Island Sound is the second largest waterbody in the mid-Atlantic region (although the Sound is sometimes perceived to be in New England). The mid-Atlantic is the most densely populated area in the United States, with a population

Long Island Sound

Area of surface water	1,320 square miles
Area of watershed	16,820 square miles
Average depth	63 feet
Shoreline	600 miles
Population	8.4 million people
Values	• Economic output for recreational fishing — $425 million (CT)* $1.4 billion (NY)*
	• Sound-related activities generate $5.5 billion
	• Habitat for a variety of endangered species
Threats	• Hypoxia
	• Pathogen contamination
	• Toxic pollution
	• Habitat loss and degradation
	• Floatable Debris
CCMP status	Approved in 1994

Designated as a "Nationally Significant" Estuary in 1987.

*State figures



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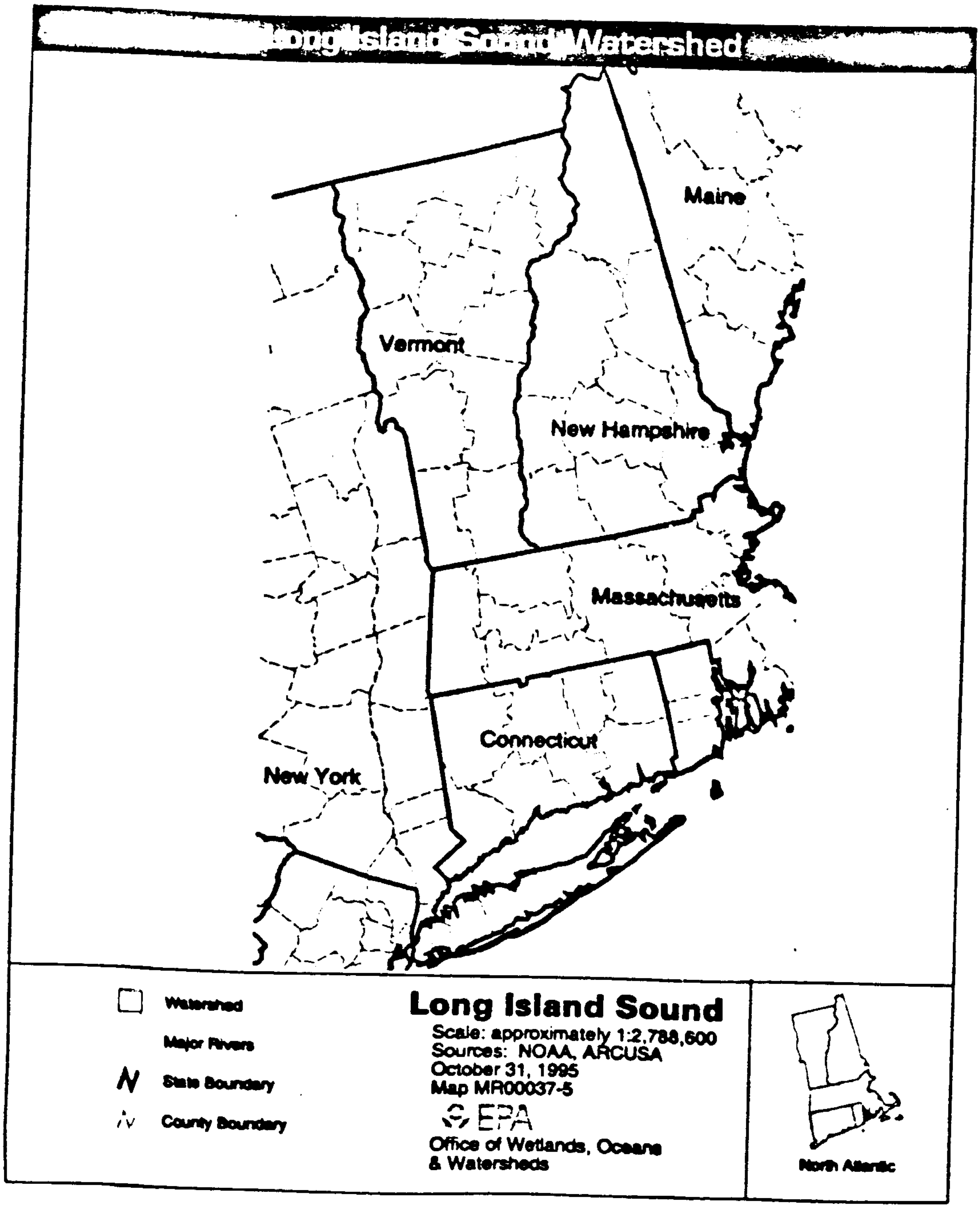

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density 40 times greater than the national average.[1] This region stretches from Buzzards Bay, Massachusetts to Chesapeake Bay in Virginia.

The water surface area of Long Island Sound measures 1,320 square miles.[2] Long Island Sound is approximately 100 miles long and spans 21 miles at its greatest width. The average depth of the Sound is 63 feet; however, some portions reach depths of 120 feet.[3]

The watershed of Long Island Sound covers 16,820 square miles and stretches to include most of Connecticut, and portions of New York, Rhode Island, Massachusetts, New Hampshire, Vermont and Canada.[4] Over 8.4 million people live in the watershed of the Sound.[5] Long Island Sound is bordered by a nearly unbroken chain of urban cities and towns along its 600-mile coastline. The Sound is bounded to the west by New York City; to the north by Stamford, Norwalk, Bridgeport, New Haven, and Clinton, Connecticut and Westchester County, New York; and to the south by Long Island, New York.

An unusual feature that distinguishes the Sound from most estuaries is its lack of a major, direct freshwater source at its head. The East River tidal straits are at the head of the estuary. A series of rivers, including the Connecticut, Thames, and Housatonic rivers, deliver freshwater to other areas of the Sound. Long Island Sound has two major connections to the Atlantic Ocean — one on each end of the estuary. The East River and the Upper Bay of New York Harbor link the western portion of the Sound with the ocean. The eastern opening to the Atlantic Ocean is through Block Island Sound and The Race. The Sound's circulation and flushing patterns are quite complex as a result of the unusual interchanges of fresh- and saltwater.[6]

Distinctive habitat types of the Sound include tidal wetlands, tidal flats, beaches, dunes, bluffs, rocky tidal areas, eelgrass, kelp beds, coastal shorelands, and open waters. Unfortunately, many of these habitats are stressed by increasing urbanization, population growth, and pollution.

Values of the Sound

"Long Island Sound is a national treasure and one of the nation's most important waterways," according to EPA Administrator Carol Browner.[7] The recreational value of this estuary, its proximity to New York City, and the fact that it provides an escape from the surrounding urbanization are some of the major attractions of the Sound and its coastline.

In 1990, the economic value of the Sound's resources was estimated to be more than $5.5 billion. Boating activities generated $3.3 billion of this total; sport fishing generated $1.1 billion; swimming produced $843 million; commercial fishing generated $148 million; and "intrinsic" values generated $152 million.[8] In assessing these figures, it is important to note that they have been understated. For instance, the commercial fishing data does not include the value of the processing, wholesaling and retailing sectors; nor does the recreational data include a full range of activities such as camping or hiking.[9] Furthermore, dollar figures cannot be placed on all values of the Sound. For instance, the value of the Sound as a natural resource and the importance of natural habitats and good water quality to near-shore residents are immeasurable.

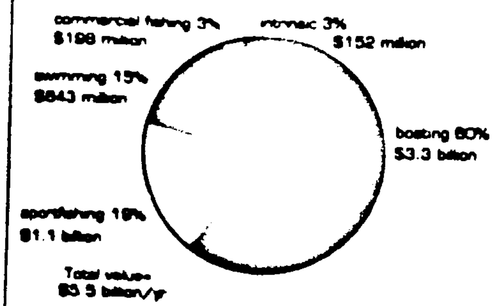
Recreation/Tourism

Of the approximately $5.5 billion generated each year from Sound-related activities, boating, sport fishing and swimming account for a large portion of this revenue — $5.2 billion. Two factors help to explain why the Long Island Sound is so popular. First, Long Island Sound is close to millions of people; a total of 15 million people live within 50 miles of the estuary.[10] The number of sunbathers, swimmers, and boaters using the Sound on a summer weekend day is often greater than the combined populations of Delaware and Alaska.[11] Second, Long Island Sound surpasses most other middle-Atlantic estuaries in the number of public outdoor recreational sites in its vicinity.[12] This combination ensures a steady flow of recreational enthusiasts to the Sound for fishing, camping, touring historical sites, boating and other activities.

Large numbers of boaters and anglers use the Sound. The estuary supports over 200,000 recreational boats and the Long Island Sound area has over 750,000 registered recreational fishermen.[13] For both Connecticut and New York, Long Island Sound is an important part of the States' recreational fishing industries. In 1991, freshwater and saltwater recreational fisheries

Long Island Sound

Estimated Value of Resources in the Sound



Source: Dr. Marilyn Altobello, University of Connecticut, The Economic Importance of Long Island Sound's Water Quality Dependent Activities (1992) 23

generated approximately $425 million in economic output and employed nearly 5,400 people in Connecticut; while in New York, sport fishing generated approximately $1.4 billion in economic outputand employed nearly 17,700 people.[14]

Fisheries/Seafood

Long Island Sound contributes valuable fishery resources to the Middle Atlantic and New England fishery regions of the United States.[15] In 1994, the market value of commercial finfish and shellfish landings in the Middle Atlantic region totaled approximately $149 million. In the same year, the New England region's total commercial landings value was $583 million.[16] Long Island Sound provides spawning and nursery habitat for many of these commercially valuable finfish and shellfish. In 1994, Connecticut reported an estimated 19.8 million pounds of commercial finfish and shellfish landings, valued at $44 million. In the same year, New York's commercial finfish and shellfish landings totaled approximately 44.7 million pounds of finfish and shellfish and were valued at $43 million.[17]

Prominent commercial fisheries of the Long Island Sound area include oyster, hard clam, American lobster, blackfish, bluefish, butterfish, mackerel, striped bass, winter flounder, and summer flounder. Long Island Sound is reputed as the leading producer of oysters along the east coast.[18] However, shellfish resources in the Sound are being adversely affected by pollution. In 1990, there were approximately 118,500 acres of productive shellfish beds in Long Island Sound. Of these productive beds, only 51,945 acres were approved for harvesting.[19]

Wildlife

Long Island Sound provides habitat for an abundance and diversity of wildlife. Although some plants and animals may not provide a direct economic benefit or aesthetic value, they are important because they are interconnected with other organisms in the food web and can be used as a barometer for the health of the Sound.

Hundreds of bird species, including osprey, cormorants, peregrine falcons, herons, egrets, and mallards use the area for nesting and feeding grounds, and for resting habitat along migratory routes.

Three marine mammals — bottle-nosed dolphins, harbor porpoises, and harbor seals — were once common inhabitants of the Sound, although their current numbers have been dramatically reduced. Today, only a few small schools of bottle-nosed dolphins can be found in the eastern and central Sound and porpoises can be observed using the estuary between Plum Gut and the mouth of the Thames River. The cause of their declines is believed to be either increased boating activities, a collapse of sea herring in the 1970s (a major food source), degraded water quality, or a combination of the three.[20] In contrast, after years of decline, populations of harbor seals have increased from 400 to 4,000 during the last decade.[21]

Other species designated as endangered, threatened, and of special concern use Long Island Sound and its wetlands for habitat. Piping plovers, roseate terns, least terns, Kemp's ridley turtles, osprey, and harbor seals are a few of these protected species which use Long Island Sound.

Threats to the Sound

Long Island Sound has been described as an "urban sea under siege."[22] The Sound has endured the stresses associated with over a century of industrial activities and over five decades of substantial population growth, with its accompanying residential

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and commercial development. All of these activities restricted access to the estuary, altered natural habitats, increased pollution, and reduced open spaces. The estuary became a convenient disposal site for human and other wastes.

Beginning in 1985, the Long Island Sound became the focus of several studies which assessed the quality of the estuary. Based on the results of these and subsequent studies, the Comprehensive Conservation and Management Plan for Long Island Sound identifies low dissolved oxygen levels (hypoxia), pathogen contamination, toxic pollution, habitat loss, and floatable debris as the most serious threats to the estuary system.[23]

Hypoxia (Low Dissolved Oxygen Levels)

Hypoxia, considered the primary threat to Long Island Sound, is the result of over-enrichment by nutrients.[24] Excessive loadings of nitrogen, phosphorus, and other nutrients from municipal wastewater discharges, combined sewer overflows, air deposition, stormwater, and urban runoff stimulate the growth of algae in the Sound. As the algae grow, they not only block sunlight needed by the estuary's submerged aquatic vegetation, but also require massive amounts of dissolved oxygen to decompose. As the algae are decomposed, the oxygen supply needed by other aquatic life in the Sound is depleted.

Low levels of dissolved oxygen cause adverse ecological effects in the bottom water habitats of the Sound. Research shows that hypoxic conditions result in reduced abundance and diversity of adult finfish; reduced growth rates among lobster and juvenile white flounder; reduced disease resistance in lobster; and death for immobile and slow-moving species.[25]

Hypoxic conditions were responsible for massive fish kills in the western portion of the Sound during the late 1980s. In 1989, scientists discovered hypoxic conditions in 40 percent of the Sound's bottom. This minimal level of oxygen was unsuitable for the survival of many aquatic species. Between July and mid-August of 1994, hypoxic conditions were experienced on the bottoms of the East River, the Narrows, and the Western Basin.[26] Hypoxic conditions have improved over the past few years. In 1995, only 22 percent of the bottom dissolved oxygen readings were hypoxic, compared to 33.3 percent in 1994.[27]

The total nitrogen load to Long Island Sound is 93,600 tons per year.[28] A significant percentage of this load originates from sewage treatment plant discharges, since only specifically designed treatment plants remove nitrogen from sewage prior to discharging the wastewater into receiving waters.[29] This is a particular concern for Long Island Sound due to the significant, nearby human population. Each day, Long Island Sound receives over one billion gallons of wastewater from 44 municipal sewage treatment plants.[30] For this reason, reducing nitrogen loadings from sewage treatment plants and other point sources is a priority of the restoration plan.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter the estuary through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, and boating waste. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from contact with pathogens. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria or enterococcus (indicators of pathogen contamination) are present in coastal waters.

The sewage treatment infrastructure for some of the municipalities that border the Sound is inadequate and outdated. Combined sewer systems are a leading source of pathogen contamination in Long Island Sound, particularly in the western portion of the Sound. In combined sewer systems, sewage conveyance lines and stormwater drains are linked. During severe rain storms, combined sewer overflows (CSOs) occur, releasing raw and partially treated sewage into the Sound and its tributaries through storm water pipes. In addition to combined sewer overflows, overloaded sewage treatment plants and marine vessel sewage discharges contribute to the amount of improperly treated sewage discharged into the Sound. Finally, contaminated stormwater also carries animal wastes washed from lawns and farmlands into the Sound.

Many shellfish beds in the Sound have been closed or restricted from harvesting for long periods

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due to the cumulative impact of pathogen contamination. In 1990, 73 percent of the Sound's productive shellfish beds in New York and 35 percent of its productive beds in Connecticut were closed to harvest due to pathogen contamination.[31]

Between 1986 and 1990, the following ten beaches were "chronically" closed to swimmers due to pathogen contamination: Scudder Park, Gold Star Battalion, the Mamaroneck area, Huntington Beach Community, the Hempstead Harbor area, Centerport Yacht Club, Fleets Cove, the Mamaroneck Beach Cabana and Yacht Club in New York; and the Norwalk and Milford beach areas in Connecticut.[32] In 1994, unsafe levels of bacteria resulted in the issuance of beach closures and health advisories at least 162 times at Connecticut's, and 227 times at New York's ocean and estuarine beaches.[33]

Toxic Pollution

Toxic chemicals enter the Sound through urban stormwater, polluted runoff, sewage discharges, industrial discharges, atmospheric deposition, and household waste disposal. Other sources of contamination include power plants, old land fills, chemical and oil spills and boating operations.[34]

Heavy metals and organic chemicals have contaminated the sediments in urbanized embayments of the Sound. Metals of greatest concern are cadmium, chromium, copper, lead, mercury and zinc. Long Island Sound is consistently one of the nation's most contaminated sites for copper; in addition, high levels of mercury have contaminated portions of the East River.[35] In many sites, toxic contamination of the underwater sediments is actually much worse than water column pollution. This is primarily due to discharges that predated current controls under the Clean Water Act.[36] However, in the western Sound the sediments are highly reactive chemically and exert considerable influence on the quality of the overlying waters.

Chemicals discharged into the Sound can accumulate in the tissues of fish species, harming fish populations and posing health risks to consumers. In recent years, high concentrations of PCBs found in the tissues of striped bass, bluefish, eel, lobster and crab have led authorities to issue consumption advisories.[37] There is also concern over contaminant levels found in the tissues of waterfowl. New York has issued an advisory for the consumption of mergansers and other waterfowl. Connecticut has funded research to examine contamination of a diving duck known as the greater scaup.[38]

Potential toxic hotspots in the Sound include: Bridgeport, Mamaroneck, Hempstead, the Lower Housatonic River near Devon, and Throgs Neck. Mussels and oysters in these regions have been documented with higher levels of heavy metals and organic compounds in their tissues relative to those found in other places in the Sound. Most of the contamination is believed to flow from the Connecticut, Housatonic, Quinnipiac, and Thames Rivers. In general, toxic contamination of the Sound worsens as one travels from the eastern portion to the west and is particularly severe in Throgs Neck.[39]

Habitat Loss and Degredation

Population growth and development activities after World War II significantly impaired the quality of water flowing into the Sound by increasing the overall level of pollution discharged into the estuary system and by destroying critical wetlands, upland habitat, and eel-grass beds. Wetlands losses in the Sound have far-reaching impacts on the biological diversity and water quality of the estuary due to the many valuable functions these natural areas perform. Wetlands provide important spawning and nursery areas for finfish and shellfish and nesting areas for birds. Coastal wetlands prevent shoreline erosion and protect inland areas from coastal storms. Finally, wetlands absorb flood waters, remove pollutants before the contaminants can reach the estuary, provide places for recreation, and serve other beneficial purposes.

The State of New York has lost 1.5 million acres of its original wetlands — a 60 percent loss. Connecticut has lost 500,000 acres — 74 percent of its original wetlands.[40] Over the past century, up to 35 percent of the Sound's tidal wetlands were destroyed by development.[41]

Urbanization and development in the watershed increase pollution in the Sound due to the replacement of natural lands with impervious surfaces, such as pavement and roofs. The replacement of naturally porous areas, such as wetlands, grasslands or barren earth, with impervious surfaces significantly restricts the filtration of pollutants. Therefore, more pollutants reach the estuary.

Hydrologic projects along the Sound's rivers and tributaries are also of concern. Dams and utility projects destroy habitat and block fish migration routes. These projects prevent migrating fish, such as alewives, smelt, blueback, herring, shad, and Atlantic salmon from reaching upstream spawning habitats.[42]

Floatable Debris

During the summer of 1988, the Sound's regional economy suffered severe losses as a result of litter and medical waste washing up on beaches. The litter caused beach closures and fueled a widespread scare among the public about potential health hazards. Public health concerns caused a decrease in attendance at area beaches for the entire summer, resulting in the loss of up to $2 billion in local revenues.[43] Floating litter from runoff and CSOs continues to reduce tourism and degrade the overall health of the estuary.

Trash which has accumulated on estuarine beaches also threatens the ecosystem and its wildlife inhabitants. On September 17 and 18, 1994, volunteers cleared 102,758 pounds of marine debris from 543.1 miles of New York's beaches. Of the total amount of marine debris collected in New York, 59.4 percent was plastic, 13 percent was glass, 10.2 percent was metal, and 17.4 percent was from other materials.[44] In the same year, on September 17, volunteers collected 7,256 pounds of marine debris from 35.3 miles of Connecticut's beaches. Of the total amount of marine debris collected in Connecticut, 61.4 percent was plastic, 9.8 percent was glass, 14.3 percent was paper, and 14.5 percent was from other materials.[45]

The Long Island Sound Study

In 1985 the U.S. Congress directed the States of New York and Connecticut, as well as the Environmental Protection Agency, to establish the Long Island Sound Study (LISS), the purpose of which was to assess the water quality of the Sound. In 1987 the LISS became one of the original six estuaries designated under the National Estuary Program of the Clean Water Act. A Management Committee and Citizens Advisory Committee were established to coordinate the Study and facilitate community involvement. Implementation commitments and bi-state cooperation are distinctive elements of the LISS.[46]

The LISS completed its Comprehensive Conservation and Management Plan (CCMP) in 1994 in an atypical manner. After the CCMP was approved by the lead regional and state environmental agency directors, a Long Island Sound Restoration Agreement was crafted which embodied the goals of the CCMP and committed the federal and state governments to its implementation. The Agreement was signed by the EPA Administrator and the Governors of New York and Connecticut. This federal/multi-state agreement is similar to agreements crafted for the Chesapeake Bay and Great Lakes programs. Local citizens hope the restoration initiative will strengthen and expand current partnerships for site-specific restoration projects, establish restoration priorities, and identify sites around the Sound that are candidates for restoration.

While the Sound Study and completion of the CCMP took nine years, there was enormous citizen involvement throughout the process. This level of participation was a major factor in establishing the agreement. Local, state, regional and national organizations not only participated heavily in EPA's Citizens Advisory Committee for the Sound, but also created private/public involvement programs and Sound-wide coalitions. For instance, in 1990, National Audubon Society organized a program entitled "Listen to the Sound." Hosting 15 citizen hearings around the Sound and attracting more than 1,500 participants, the findings of these hearings were put forth in a Citizen Agenda report in 1991. This Citizen Agenda for the Sound was the basis for the Long Island Sound Watershed Alliance (LISWA), a coalition of over 200 environmental, educational, local business and community organizations around the Sound. The Citizen Agenda served as the public measuring stick for reviewing CCMP proposals and had a major role in strengthening the final plan.

Other non-traditional coalitions were also created. The LISWA, in conjunction with other groups like the Long Island Soundkeeper Fund, worked to unite trade unions, environmentalists, and the construction industry into the Clean Water/Jobs Coalition, in order to address the problems of an aging and inadequate sewage and wastewater treatment infrastructure throughout the New York metropolitan region. The Clean Water/Jobs Coalition commissioned a study that showed how investing in Long Island Sound's and other estuaries' water quality improvements would not only benefit the estuarine environment, but also create more than 50,000 direct construction and indirect water-dependent jobs for every one billion dollars spent.

Public outreach continues to be a critical component of the implementation phase. Beyond helping to shape the content of the CCMP, citizens groups now closely monitor the implementation schedule. Organizations like the LISWA, the Soundkeeper, and Save the Sound, in addition to the Citizens Advisory Committee, are providing significant public support for action. The LISS office coordinates the activities of the federal and two state governments in the CCMP implementation, while providing the official mechanism to ensure public involvement.

To revitalize the estuary and reduce hypoxic conditions, the LISS promoted the use of innovative technologies for the removal of nitrogen from sewage treatment plant discharges.[47] The CCMP calls for a three-phase program to reduce such loadings. The first phase, which has since been achieved, calls for a no net-increase of nitrogen loadings, based on 1990 levels. The second phase, currently underway, calls for reduction of nitrogen loadings by 25 percent in New York and 15 percent in Connecticut. The third phase, to begin in late 1996, calls for major nitrogen loading reductions from both point and non-point sources to be achieved in the next century. This third phase is using new computer modeling results designed specifically for the Sound and is estimated to cost between $2-$6 billion depending on advancements in water pollution control technologies. Nitrogen reductions of up to 83 percent were achieved at the Stamford waste-water treatment plant as a result of using biological nutrient removal (BNR) technology.[48]

LISS also proposes a three-point solution to the problem of loss and degradation of living resources. This plan includes: (1) enhancement of federal and state wetlands protection, (2) restoration of fish migration routes and shellfish beds, and (3) creation of a reserve system.[49] Many believe that these actions alone are not sufficient, rather they are simply a first step to ensure that the living aquatic resources of the Sound are adequately protected. In order to avoid massive fish kills, the program has funded water quality monitoring projects to help better respond to and prevent hypoxic conditions.[50]

Finally, to reduce pathogen pollution, the Study has facilitated CSO abatement projects, initiated a stormwater permit program for construction sites, and created "no-discharge" areas for marine vessels in select embayments.[51]

Education is a primary focus of the CCMP. However, governmental cutbacks have stalled efforts to launch partnership programs between the EPA and private organizations to educate the public. The EPA Long Island Sound Office itself is seriously threatened by federal budget cuts. Without this office there would not be any entity charged with the responsibility to ensure that implementation actions are taking place and to coordinate the activities of the state and federal agencies on the Management Conference.

National Coastal Caucus

Long Island Sound is known for the grassroots activities of local, regional, and national organizations. The boards, staffs and members of these groups have participated in different ways in the LISS. Staff for Save the Sound (STS) and National Audubon Society act as Connecticut and New York co-chairs, respectively, of the Citizens Advisory Committee and utilize information provided by the governments to track CCMP implementation and keep the public-at-large informed. The Long Island Soundkeeper Fund also serves on the Citizens Advisory Committee, the Long Island Sound Advisory Council, and Connecticut's Council on Environmental Quality.

Save the Sound's mission is to protect and restore Long Island Sound and its watershed. It has extensive programs in education, research and advocacy. STS's "Soundshore Ecology" program is a model program for educating children and adults about the Sound. The "Sea Camp" program offers youngsters a unique opportunity to study Long Island Sound through hands-on activities. The research and advocacy components of STS programs call for the development of strong environmental policy at the local, state, regional and national levels. Its Adopt-a-Harbor program uses over 100 volunteers to monitor the water quality of 50 stations in 11 harbors. STS also has a laboratory to help determine the connection between algal blooms and hypoxia.

Save the Sound recently assumed management responsibilities of the operations of the Long Island Sound Watershed Alliance (LISWA) and currently coordinates its activities with a Steering Committee of Alliance members. LISWA, originally founded by National Audubon Society, is the network that brings 200 concerned organizations together to jointly advocate for the implementation of the CCMP, the enhancement and safeguarding of our federal/state environmental laws, the funding of Long Island Sound programs, and the creation of joint educational and public awareness programs. In addition, the Alliance hosts an Annual Citizen Summit Conference on the state of the Sound.

Soundkeeper is a nonprofit citizens watchdog organization dedicated to the protection and enhancement of the biological, physical and chemical integrity of Long Island Sound. It accomplishes its mission by patrolling, investigating, intervening and raising public awareness about the Sound's problems. Soundkeeper was founded in 1987 by the shellfishing and fishing communities concerned about the progressive pollution and destruction of habitat in the marine environment of the Sound.

The Soundkeeper Fund employs many tactics in preserving the Sound. These include bringing citizen action lawsuits; working on lead abatement efforts; mobilizing volunteers; providing a pollution hotline for citizen complaints, observations and tips regarding pollution in the Sound; and educating the public on watershed issues. Engaging in habitat protection and shellfish bed restoration projects is an important part of the work of the Soundkeeper Fund. The Soundkeeper, in a coalition with other organizations, helped to obtain $3 million from Congress to purchase 370 acres of Connecticut's largest remaining salt marsh, the Great Meadows Salt Marsh in Stratford, which were included in the Stewart B. McKinney - National Wildlife Refuge. The Soundkeeper also aided in the creation of a three-year, $4 million State restoration project of Connecticut's public shellfish beds. Between 1991 and 1995, 3,000 acres were restored and the project was nationally recognized as a model for sustainable aquaculture.

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Maryland Coastal Bays
in Maryland

Portrait of the Bays

The Maryland Coastal Bays Estuary Program is beginning to examine the water quality and habitat problems of the Maryland Coastal Bays system and the impact that the larger watershed area has on the estuary. The Maryland Coastal Bays are located off Maryland's Eastern Shore and stretch across the coast to include small portions of Delaware and Virginia. The estuarine study area includes four large, shallow bays — the Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays — as well as some smaller embayments. The average depth of the Bays is about seven feet.[1]

Maryland Coastal Bays	
Area of watershed	119,187 acres in Maryland
Average depth	7 feet
Values	• Tourists spend over $2.1 billion • Fisheries generate $162 million* • Sportfishing generates $524 million in economic output* • Home of the wild ponies in the Chincoteague National Wildlife Refuge
Threats	• Nutrient loadings • Habitat loss and degradation • Pathogen contamination
CCMP status	Expected in 1998

Designated as a "Nationally Significant" Estuary in 1995.

*State figure

The watershed of the Coastal Bays totals 119,187 acres in Worcester County, Maryland and extends into portions of Delaware and Virginia.[2] The northern portion of the Bays (Assawoman and Isle of Wight Bays) is quickly developing and supporting more recreational activities. In contrast, the southern portion of the Bays maintains a significant amount of forested and agricultural land. However, areas surrounding Sinepuxent Bay are beginning to be developed. The Chincoteague-Sinepuxent Bay complex, to the south of Ocean City Inlet, is bounded by approximately 23,000 acres of tidal salt marsh.[3]

Four major tributaries deliver freshwater to the Bays. These tributaries are the St. Martin River, Turville Creek, Herring Creek, and Trappe Creek.[4] In addition, groundwater delivers freshwater to the Bays. Two barrier islands, Fenwick Island and Assateague Island, run along the eastern edge of Maryland's Coastal Bays separating them from the Atlantic Ocean. Saltwater from the Atlantic Ocean enters the Bays through the Ocean City Inlet and the Chincoteague Inlet.

Values of the Bays

Maryland's Coastal Bays are ecologically and economically important to the communities of the Eastern Shore and to the entire State. These estuaries support commercially valuable fish and shellfish species, provide habitat for a variety of wildlife, and provide opportunities for numerous recreational activities.

Tourism/Recreation

Ocean City, a popular East Coast resort located in the northern section of the Bays, is visited by over 7.5 million tourists each year.[5] In 1988, direct tourist spending in the entire Coastal Bays area amounted

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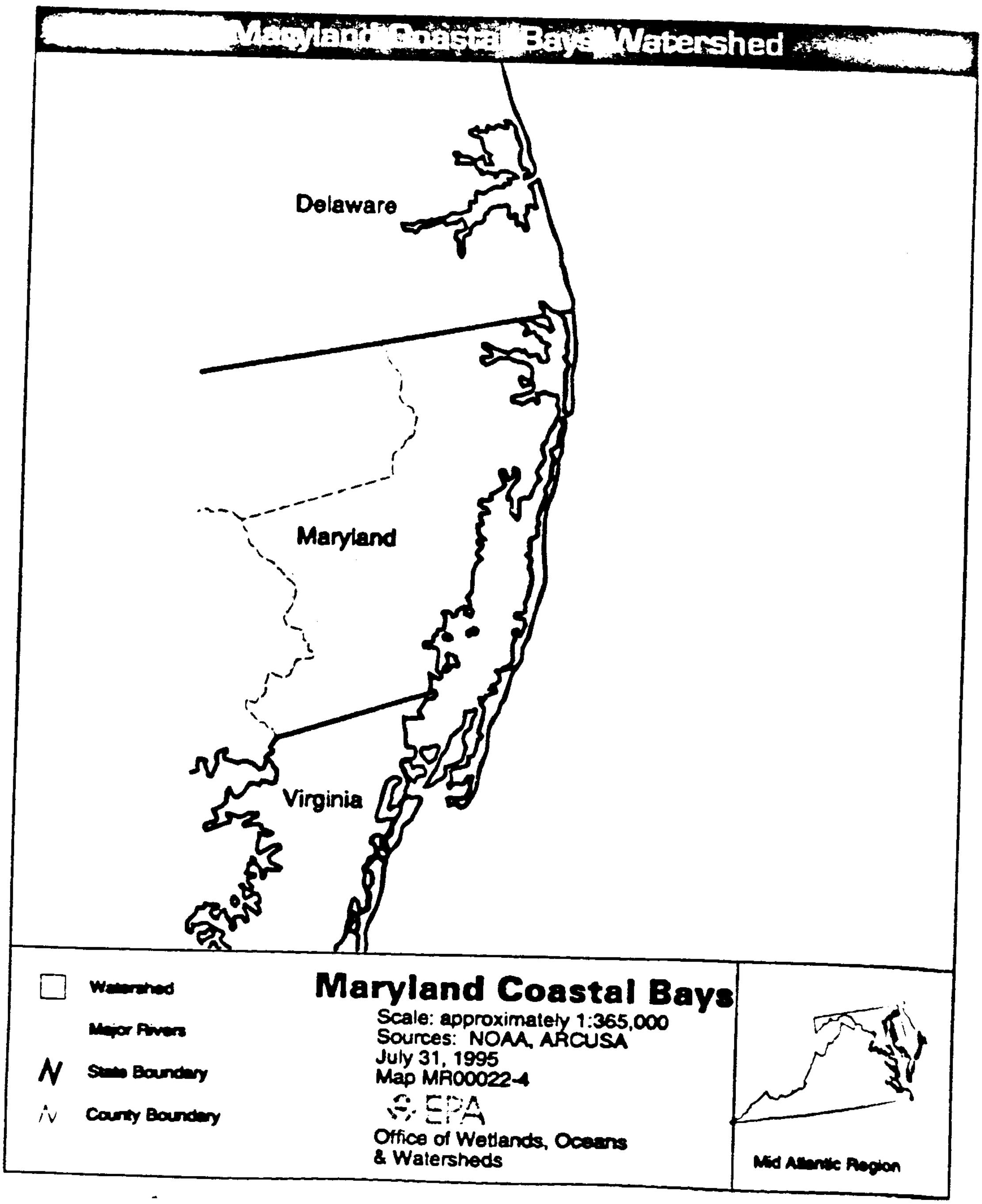

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to $2.1 billion and the tourism industry of the area helped to support 27,000 local jobs.[6] Sailing, swimming, camping, clamming, crabbing, fishing, and water skiing are favorite activities of the area.

Recreational boating is a popular weekend activity for residents and visitors of the Coastal Bays. In 1990, over 3,000 boats were registered with Worcester County residents. In addition, there are over 7,000 boat slips and numerous public access points located along the Coastal Bays.[7]

In the Coastal Bays and in the State of Maryland, sport fishing is a common recreational pursuit. For example, as many as 900 fishermen a day can be counted along a five-mile stretch of the Bays during the summer months.[8] Recreational fishing in the Bays helps to support a number of local businesses which service anglers. In 1991, recreational fishing in Maryland generated approximately $524 million in economic output and employed 8,315 people.[9] In that same year, approximately 431,000 saltwater anglers spent over 2.5 million days fishing off the coast of Maryland. Thirty-seven percent of the anglers were non-residents of the State.[10]

Fisheries/Seafood

In 1994, the combined value of the Chesapeake (Maryland and Virginia) region's commercial finfish and shellfish landings totaled approximately $162 million. Many of the fish and shellfish landed in these two States depend upon the estuaries of the Maryland Coastal Bays for spawning, nursing, and feeding grounds. In 1994, Maryland's commercial finfish and shellfish landings totaled approximately 68 million pounds, valued at $61 million.[11]

Twenty-five percent of Maryland's commercial fishery landings occur in the Coastal Bays.[12] Commercial shellfish and crustaceans harvested in the Bays include hard and soft crabs, oysters, and hard clams. Blue crab landings have been known to surpass one million pounds per year.[13] Sea trout, bluefish, flounder, and spot are some of the commercially valuable finfish species that inhabit the Bays. In four of the years between 1986 and 1991, finfish landings reached as high as 100,000 pounds.[14]

Wildlife

A number of protected lands and wildlife management areas are located within the Maryland Coastal Bays' watershed. The Assateague Island National Seashore, Chincoteague National Wildlife Refuge, Assateague State Park, and Sinepuxent Bay Wildlife Management Area host a variety of wildlife species and provide opportunities for bird watching and nature photography.

The Chincoteague National Wildlife Refuge is a well-known refuge along the nation's east coast. It provides year-round habitat and essential stopover points along the migratory flyways for thousands of birds, including snow geese, brant, dabbling ducks, hawks, peregrine falcons, and piping plovers. In addition, it is the famous home of a herd of wild ponies. Up to 1.5 million visits are made to the Chincoteague National Wildlife Refuge each year.[15]

Threats to the Bays

Existing information on the quality of the Coastal Bays points to a number of priority threats to the system. These problems will receive greater attention during the Bays' restoration planning process. The identified threats to the Bays include excessive nutrient loadings, habitat modifications and losses, finfish population declines, and pathogen contamination. In addition, the local program will study the impacts of polluted runoff from both agricultural and urban lands and the increasing human uses of the Bays.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by urban stormwater, agricultural runoff, sewage treatment plants, atmospheric deposition, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Bays. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bays, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. The inundation of waterbody with excessive amounts of nutrients is called eutrophication.

Studies of the Coastal Bays reveal that excessive nutrient loading is a prominent environmental problem for the estuary.[16] The greatest concentrations of nutrients are generally found in the upper portion of the Bays near the mouths of rivers. Losses of submerged aquatic vegetation in the upper Bays, plus the declines of benthic populations can be tied to the over-enrichment of nutrients.[17] In the Maryland Coastal Bays, stormwater, agricultural runoff, and groundwater are considered to be the principal sources of nutrient loadings.[18] Previous studies have shown that groundwater delivers up to 51 percent of the total nitrogen load and over 40 percent of the total phosphorus load to the Isle of Wight.[19] Further information about the extent of nutrient inputs into the Coastal Bays from groundwater is needed.

Habitat Loss

The State of Maryland has lost approximately 1.2 million acres of its historic wetlands — a 73 percent loss.[20] Many of the losses have occurred along the shorelines of the State. Tidal marshes near the Ocean City Inlet and other northern Bays locations have disappeared due to residential, marina, and other development. The loss of coastal wetlands adversely affects both the wildlife and human populations of the Bays. Coastal wetlands provide important spawning, nursing, and feeding habitat for fish and shellfish. In addition, they provide nesting grounds for birds. Coastal wetlands also perform a number of functions which benefit coastal communities. For example, they protect inland areas from the ravages of tidal storms, absorb flood waters and filter land-based contaminants before they can reach nearby surface waters and groundwater underflows. In the Coastal Bays area, wetlands are widely used for recreational activities, such as canoeing, kayaking, and bird watching.

Both the actual acreage loss and the reduced quality of submerged aquatic vegetation in the northern section of the Coastal Bays have been noted with concern by scientists studying the area. Because submerged aquatic plants are key habitats for shellfish and fish, declining populations of oysters, crabs, and finfish is one of the results of habitat degradation in the Bays.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through agricultural runoff, polluted urban stormwater, sewage treatment plant discharges, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in contaminated beach waters. Gastroenteritis, hepatitis, and other diseases can result from ingestion of contaminated seafood or waters. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

Shellfish harvesting has been limited in some areas of the Coastal Bays. Harvest closures and restrictions are usually the result of high levels of fecal coliform bacteria. Harvesting of shellfish in the St. Martin River has been restricted since 1974 because of high levels of bacteria and the proximity to sewage treatment plant outfalls.[21] As the year-round and seasonal populations of the Coastal Bays region continues to grow, more detailed studies about the extent of pathogen contamination in the Bays should be conducted.

Toxic Contamination

Analyses of the sediments in the Coastal Bays areas have revealed higher than normal levels of DDT, arsenic, chlordane, dieldrin and fluorine.[22] Significant amounts of the toxic chemicals which are found in sediment samples of the Bays have persisted in the estuarine environment for years. Presently, the major sources of toxic chemicals in the Bays are agricultural chemicals which run off farmlands and stormwater which carries oil and grease residues from streets and chemicals from lawns.[23]

Floatable Debris

Trash accumulated on estuarine beaches also threatens the ecosystem. The amount collected in just one day was staggering — on September 17, 1994, volunteers cleared over 14,000 pounds of marine debris from 48 miles of Maryland beaches. Of the total amount of marine debris collected, 55.1

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percent was plastics, 12.6 percent was metal, 11.9 percent was glass, and 20.4 percent was from other materials.[24]

Maryland Coastal Bays National Estuary Program

With the Environmental Protection Agency's acceptance of Maryland's Coastal Bays into the National Estuary Program, it became one of the most recent group of seven estuaries added to the Program. On July 6, 1995 Maryland's Coastal Bays was officially designated an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Shortly thereafter, the EPA convened a Management Conference responsible for coordinating the development of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect Maryland's Coastal Bays. The CCMP is expected to be completed in three years.

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End Notes

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Massachusetts Bays
in Massachusetts

Boston Harbor is unique among major urban estuaries in that nearly as much of its freshwater inflow comes from sewage effluent as from the major rivers (the Charles, Mystic, and Neponset) which empty there. In the past five years, proper treatment of sewage from the Greater Boston area has markedly improved water quality in the Bays. Now, the time has come to address non-sewage pollution to the Harbor and its tributaries, and the Massachusetts Bays Program has laid the groundwork with its Comprehensive Conservation and Management Plan.

—Jodi Sugerman, Policy Director
Save the Harbor/Save the Bay

Portrait of the Bays

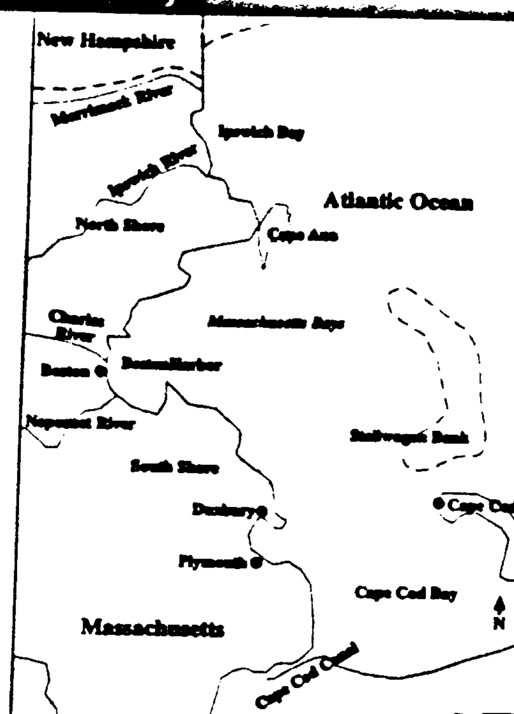
The Massachusetts Bays Program is examining the water quality and habitat problems of the Massachusetts and Cape Cod Bays and the impact that the greater watershed area has on the estuary system. The study area under the Massachusetts Bays Program (MBP) includes Cape Cod Bay, Massachusetts Bay, Boston Harbor, the Merrimack River, the North and South Shores, and the portion of Ipswich Bay in Massachusetts. The Massachusetts Bays system encompasses 1,650 square miles of water surface area and includes over 1,800 miles of historic shoreline.[1]

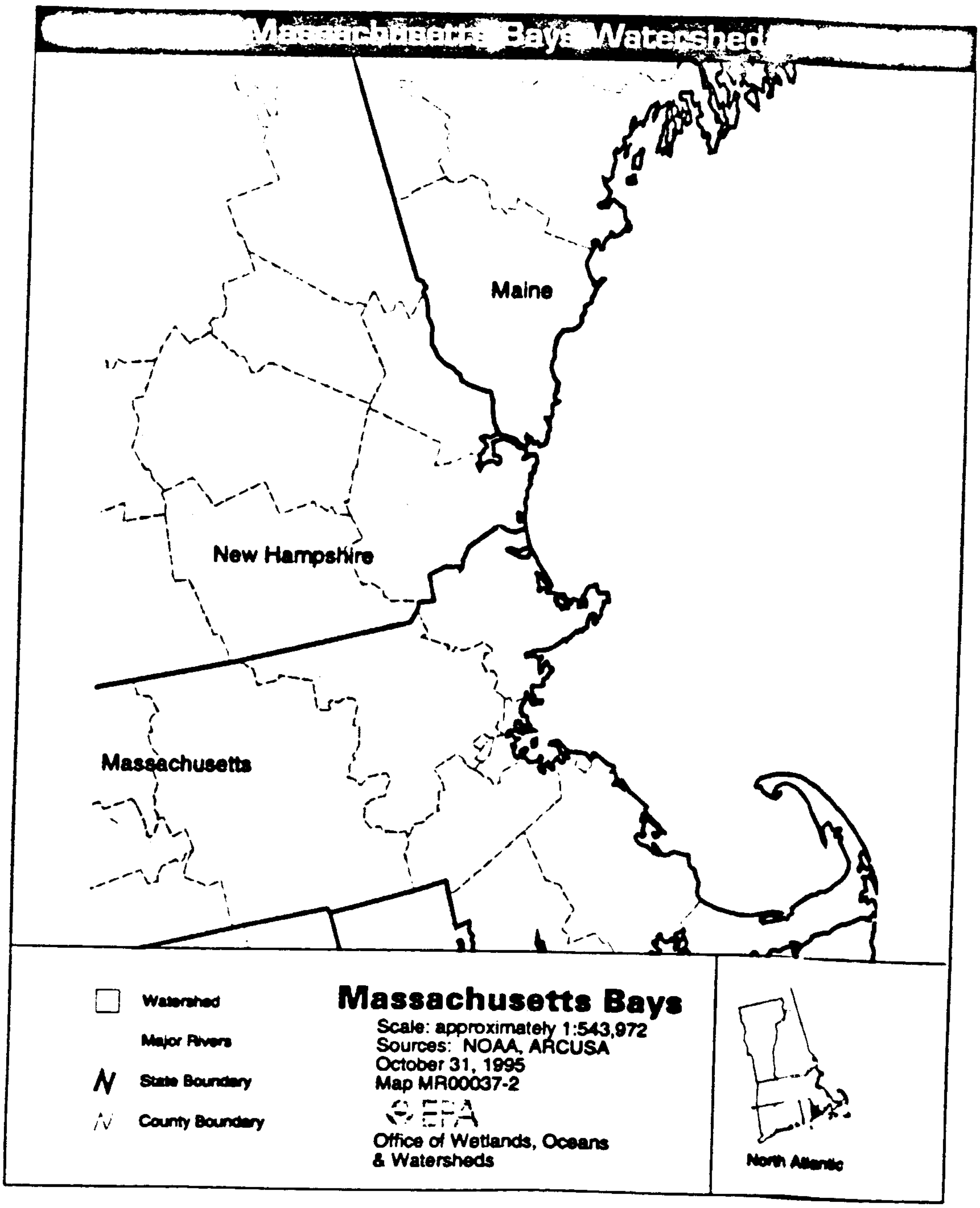
Massachusetts Bays

Area of surface water	1,650 square miles
Area of watershed	7,000 square miles
Shoreline	1,800 miles
Population	4 million people
Average depth	77 feet
Values	• Fisheries generate $53 million • Tourists spend $1.5 billion* • Recreational boating generates $472 million
Threats	• Pathogen contamination • Habitat loss and degradation • Toxic pollution • Floatable debris
CCMP status	Final CCMP expected in 1996

Designated as a "Nationally Significant" Estuary in 1990.

*Coastal Massachusetts figure




Massachusetts Bays Watershed
Maine
New Hampshire
Massachusetts
Watershed
Major Rivers
State Boundary
County Boundary
Massachusetts Bays
Scale: approximately 1:543,972
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-2
EPA
Office of Wetlands, Oceans
& Watersheds
North Atlantic

The Massachusetts Bays watershed measures 7,000 square miles. One-half of the watershed is located in the State of Massachusetts. The other half includes portions of New Hampshire that drain into the Merrimack River.[2] The MBP is dealing with one of the most densely populated estuarine regions in the nation. In 1990, the population density in Massachusetts' coastal area was 1,272 people per square mile.[3] Approximately 4 million persons,[4] most of whom reside in the Boston metropolitan area, live within the watershed and its more than 150 communities.[5]

Water depths in the Bays system vary greatly. Both Massachusetts Bay and Cape Cod Bay have average depths of 77 feet; whereas, the Merrimack River has an average depth of only 12 feet.[6] Compared to other estuaries, the Massachusetts Bays have higher salinity levels because they receive less than average freshwater inflows. The majority of the freshwater feeding into the Bays originates from the Merrimack and Charles Rivers. The Merrimack River flows into the northern end of the Bays, strongly influencing the water circulation of the system. Within the Cape Cod region much of the freshwater flows originate from groundwater sources.[7]

Around the Boston area, land use is dominated by urban activities. In other portions of the watershed, forests, salt marshes, tidal flats, rocky shorelines, coastal dunes and barrier islands are prevalent. Stellwagen Bank National Marine Sanctuary lies on the eastern edge of Massachusetts Bay.

Values of the Bays

The historical value and beautiful coastline of the Massachusetts estuary system attract millions of tourists annually. The rocky shores and coastal dunes provide scenic vistas of the Atlantic Ocean. The estuarine system is comprised of other diverse habitats including tidal flats, eelgrass meadows and barrier beaches that provide countless values difficult to measure in economic terms. These areas are home to diverse populations of wildlife and aquatic species, many of which are threatened or endangered. The Bays' habitats also provide spawning grounds for some of our nation's most valued fisheries, as well as opportunities for recreation.

Recreation/Tourism

Tourism is a prominent industry in the coastal region of Massachusetts. Tourists in the coastal counties of Massachusetts spent an estimated $1.5 billion in travel expenditures during 1993.[8] It is estimated that by cleaning up Boston Harbor beaches, millions of dollars could be added to the area's economy each year.[9]

Some of the popular activities for residents and tourists of this area are fishing, swimming, camping, sunbathing, and whalewatching. Although there is no easy way to analyze the economic benefit of beach-going (because most beaches are free and attendance data is not available), recreating on the system's more than 150 beaches remains one of the most popular uses of the Bays. Revenues generated just from the sale of parking stickers at Crane Beach, Cape Cod National Seashore, and Duxbury totalled over $1.6 million in 1990.[10] Significant revenue is also generated from recreational boating activities in the Bays, which account for up to $472 million annually.[11] In addition, an estimated 1.5 million whale watchers generate $23 million for the Massachusetts economy each year.[12]

In 1991, recreational fishing in Massachusetts generated approximately $770 million and employed nearly 10,500 people.[13] Currently, recreational fishing in the Bays yields a net benefit value of up to $355 million per year (in 1989 dollars), based on approximately 2.5 million individual fishing visits.[14] Saltwater fishing alone draws thousands of persons to Massachusetts each year. In 1991, approximately 393,000 saltwater anglers fished off the Massachusetts coast. Thirty percent of these fishermen were residents of other states.[15] Recreational shellfishing in Massachusetts and Cape Cod Bays accounted for an average of 7,000 bushels of shellfish each year between 1987 and 1990.[16]

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the New England region totaled approximately $583 million.[17] Many of the commercially valuable species in New England depend upon the health of the Massachusetts Bays for nursery habitat and feeding areas.

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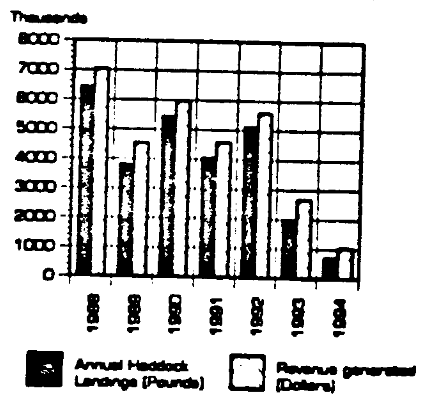
U.S. Domestic Haddock Landings



Data Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service

In 1987, Massachusetts' fisheries were ranked third in the United States in national value.[18] However, in recent years, troubling population declines have been noted among some of the most prominent fish species. The well-publicized, dramatic declines in the landings of haddock, flounder, and cod in this region due to overfishing and habitat destruction are contributing to economic hardships for many New England fishing communities. In 1985, Massachusetts' commercial finfish and shellfish landings were approximately 300 million pounds;[19] by 1994, the State's landings had dropped to 183 million pounds.[20]

In 1990, the combined revenue from commercial finfish and shellfish harvests in Massachusetts Bays was $53 million. Of the total combined harvest, lobsters accounted for almost 60 percent of the value in the Bays[21] and 85 percent of the value in Boston Harbor.[22] Shellfish commonly harvested in the Massachusetts Bays region include soft shell clams, quahogs, oysters, bay scallops, and blue mussels. Nearly 35 percent of the 1990 fish catch consisted of finfish landings.[23] The most valuable finfish caught in the Bays region include bluefin tuna, Atlantic cod, winter flounder, Atlantic flounder, Atlantic herring, and spiny dogfish. Bluefin tuna made up forty percent of the total value of the finfish catch for 1990,[24] currently the most commercially valuable fish in the region.[25]

Wildlife

Salt marshes and tidal flats, providing feeding and dwelling habitat for migratory waterfowl and other aquatic animals, line much of the Bays' shorelines. Forty seabird species have been sighted in the outer limits of the Bays near Stellwagen Bank, including kittiwakes, shearwaters, terns, and storm petrels.[26] Other coastal areas of the Bays attract larger diversities of bird species. South of the Merrimack River's mouth lies Parker River National Wildlife Refuge, a 4,660 acre barrier island. Over 300 bird species, including warblers, cormorants, snowy owls, Canada geese, and snowy egrets, have been spotted using the refuge for nesting, feeding, and resting along their migration routes.[27]

Several endangered and threatened species are dependent on the Bays ecosystem. Nine federally endangered species — the blue whale, fin whale, sei whale, humpback whale, North Atlantic right whale, Kemp's ridley sea turtle, shortnose sturgeon and roseate tern — and two federally threatened species — the loggerhead sea turtle and piping plover — can be found in the Massachusetts Bays region.[28]

The Stellwagen Bank National Marine Sanctuary is one of the most important areas in the North Atlantic for marine mammals, particularly whales. Its nutrient-rich waters provide critical habitat for 12 species of whales, dolphins, and porpoises. Endangered right whales, with a world-wide population of 200, are drawn to the abundance of life-supporting plankton found in Cape Cod Bay and the Stellwagen basin. In addition, loggerhead, leatherback, Kemp's ridley, and green sea turtles (federally-protected, threatened, or endangered species) use these waters.[29]

Threats to the Bays

For hundreds of years, Boston Harbor and the Charles, Mystic and Neponset Rivers were considered convenient sites for sewage disposal. These discharges, along with the dumping of industrial wastes, have played a major role in the degradation of the Bays' water quality. During the past two decades, however, efforts to abate the industrial and municipal sources of water pollution have taken center stage.

In the early 1980s, two inadequate and outdated sewage treatment plants servicing forty-three communities surrounding Boston Harbor regularly dumped untreated and partially treated sewage into the Harbor. As a result, the EPA sued Massachusetts for violating sewage treatment requirements under the Clean Water Act of 1972. This suit resulted in the creation of the Massachusetts Water Resources Authority and sparked the development of a multi-billion dollar project to repair Boston's sewage treatment system.[30] Although seven billion dollars of unfunded wastewater needs remain, the construction of these facilities has greatly improved the water quality of the Bays.[31]

The ongoing urbanization of the Massachusetts coastline brings additional pollution problems, such as polluted urban stormwater, combined sewer overflows, failed septic systems and boating discharges. The 1995 Comprehensive Conservation and Management Plan (CCMP) for Massachusetts Bays identifies pathogen contamination, habitat loss, and toxic pollution as priority problems affecting the water quality and living resources of the Bays.[32]

Pathogen Contamination

Pathogens are disease-causing bacteria and viruses found in animal and human wastes which enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat shellfish or recreate in beach waters. Gastroenteritis, hepatitis and other diseases can result from the ingestion of pathogens.

For the Massachusetts Bays, combined sewer systems, sewage treatment plants, and stormwater are significant sources of pathogens. In older cities, where the infrastructure is often more than 100 years old, combined sewer systems are a major cause of water quality declines in the Bays.[33] Each year, two billion gallons of waste from approximately 80 CSO outfall pipes enter Boston Harbor.[34] The Deer Island sewage treatment plant alone, which services over two million people in the Greater Boston area, discharges 455 million gallons of treated sewage into the Boston Harbor each day.[35]

Currently, more than 90,000 acres of Massachusetts' productive shellfish beds are closed permanently, seasonally, or conditionally.[36] Between 1985 and 1990, the acreage of shellfish beds that were prohibited from harvest in the Massachusetts Bay drastically increased from 12,000 to 92,000 acres. In Cape Cod Bay, the acreage of prohibited shellfish beds increased from 3,000 to 8,000 acres over the same period.[37] Even Plum Island Sound, bordered to the east by Parker River National Wildlife Refuge and reputed for its living resources and beaches, has experienced shellfish bed closures and declining fish populations due to bacterial contamination.[38]

Closed or restricted shellfish beds result in significant economic losses. For example, the town of Ipswich's local economy lost an estimated $3.4 million in harvest revenues in 1990.[39] Despite the restrictions on shellfish harvesting, many individuals are still becoming ill from eating contaminated seafood. The cost of seafood-born disease results in a loss of over $60 million a year to the State economy from lost work, medical bills, and liability suits.[40]

Contact with pathogen-contaminated water also raises health concerns for swimmers and recreational enthusiasts. An average of 44 documented beach closures occurred each year between 1988 and 1991 at North Shore, South Shore, and Boston Harbor beaches due to pathogen contamination.[41] Annually, an estimated 10,000 individuals become ill from the ingestion of pathogen-contaminated waters from the Massachusetts Bays.[42] In 1994, 59 beach closures and health advisories were issued in Massachusetts due to the occurrence of bacterial contamination and CSOs at bay and ocean beaches.[43]

Habitat Loss and Degradation

Urbanization in the Massachusetts Bays watershed is a contributing factor to many of the water quality problems in the estuary. As the population along the Massachusetts coast grows, pressure to convert salt marshes and tidal flats for human use continues to mount. However, the ecological integrity of the Bays system relies on the protection of these coastal habitats, as they support a number of

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fish, shellfish, and bird species and protect inland areas from coastal storms.

The State of Massachusetts has lost more than 50 percent of its original salt marsh acres. Currently, 48,000 acres remain.[44] Approximately 1,000 acres of coastal and inland wetlands are lost each year to development activities and projects. Only 36,000 acres of salt marsh remain in the Massachusetts Bays region.[45]

The surge of development activities in the coastal region of Massachusetts has resulted in the replacement of natural areas by impervious surfaces (roads, roofs, parking lots). These changes in the natural landscape hinder water and contaminant filtration by wetlands, soil, and other habitat types. As a result, more toxics, oil and grease residues, fertilizers, and nutrients enter the Bays from polluted urban runoff, stormwater and agricultural runoff. Currently, over 70 percent of the rivers and coastal areas in Massachusetts show evidence of impairment from these sources.[46] These contaminants degrade overall water quality, upsetting the balance of plant and animal life in the Bays.

Valuable eelgrass beds of the Massachusetts Bays are rapidly declining, especially in the Merrimack River estuary, Essex Bay, Cape Cod Bay, and the North Shore.[47] Eelgrass beds provide important nursery and feeding areas for finfish and shellfish. A variety of factors are responsible for the decline. Excessive amounts of nutrients carried by polluted urban stormwater, sewage discharge and agricultural runoff stimulate the growth of algae. Large algal blooms block sunlight needed for the growth of submerged aquatic vegetation, such as eelgrass meadows. As algae decompose, they require substantial amounts of dissolved oxygen, severely limiting the availability of oxygen for other aquatic life. The resulting low-oxygen condition, known as hypoxia, can lead to massive fish kills.

Toxic Pollution

Years of industrial activities and population growth in the Massachusetts Bays' watershed contribute to the present-day toxic contamination of the Bays' waters and sediments. Of the North Atlantic estuaries, the Massachusetts Bays have the largest number of industrial and municipal wastewater treatment discharge points. In 1990, Boston Harbor had 69 point sources, Massachusetts Bay had 72, and the Merrimack River estuary had 36 sources.[48] Stormwater discharge and atmospheric deposition are other sources of toxic pollution.

In a 1991 survey of the Bays, the North Shore and Boston Harbor were identified as the most serious spots for toxic contamination. Toxic contaminants found in the survey include polycyclic aromatic hydrocarbons (PAHs), copper, arsenic, lead, cadmium, mercury, chromium, nickel, zinc, polychlorinated biphenyls (PCBs), and pesticides.[49] Many of these toxic contaminants persist in the water column and sediments of the Bays. Over time, they can accumulate in the food chain and pose risks to aquatic life and humans. According to a 1994 EPA report, 84 percent of the estuaries surveyed in Massachusetts do not support fish consumption.[50] Winter flounder and lobsters in Boston Harbor and Salem Sound have revealed high PCB and PAH concentrations. Consumption advisories are in place for tomalley from lobsters caught in the Massachusetts Bay. An EPA report found that the risk of developing cancer from eating lobster tomalley is one in 100. Limited consumption advisories exist for lobster, flounder, bivalves, and bluefish caught in other portions of the Bays.[51]

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. In 1990, Massachusetts was ranked second in the nation for the highest incidence of sewage-related debris.[52] During the short period between September 17 and October 10, 1994, volunteers cleared 50,000 pounds of marine debris from 200 miles of Massachusetts beach area. Of the total amount of marine debris collected, 61.8 percent was plastic, 13.9 percent was paper, 8.9 percent was metal, and 15.4 percent was from other materials.[53]

The Massachusetts Bays Program

In the early 1980's, public awareness about the deterioration of Boston Harbor and the massive pollution problems of the surrounding Bays laid the groundwork for restoring the coastal water quality of the area. The Massachusetts Bays Program (MBP) was created in 1989 to bring together federal, state and local initiatives to address the threat of pollution in the Massachusetts and Cape Cod Bays. In 1990, the Massachusetts Bays system was officially designated under the NEP as an estuary of "national significance."

Due to the large number of communities bordering the Bays, the MBP has focused on developing regional collaboration among cities and towns. Fourteen communities within the watershed have already accepted the CCMP, while the remaining communities are in the process of signing on to the plan. The CCMP is expected to be approved by the EPA in 1996.

The MBP funds research projects to assess the health of the Bays and to determine the sources, transport, and effects of coastal pollution. The Program also encourages active public participation in designing solutions to the Bays' pollution problems. The MBP has developed educational materials for communities and landowners on topics such as proper land use practices to reduce polluted runoff. Land use restrictions instituted by local governments have proven to be successful, particularly in the protection of coastal ponds. The MBP also organizes educational workshops for municipal officials (planners, conservation commissioners, etc.), public works officials, and citizen volunteers on non-point source and stormwater pollution management.

In 1991, the MBP decided to implement three, five-year mini-bay demonstration projects for the Fore River Estuary, Wellfleet Harbor, and Plum Island Sound. Pollution problems within the mini-bays result from a wide variety of activities, ranging from recreational boating to intensive development. The bordering communities will rally public support and work to identify the sources of pollution, apply cost-effective management tools, and create monitoring programs. Another goal of the MBP is to restore 12 coastal wetland areas that have been degraded because of restricted saltwater flow.

The MBP Shellfish Bed Restoration Program's first success was the re-opening of 407 acres of shellfish beds in Cohasset and Scituate. These shellfish beds, which contain mussels and soft-shelled clams, were closed in 1985 due to water quality contamination. The two main sources of contamination that have since been corrected involved a failed septic system on the Cohasset side of the Harbor and an illegal sewer hookup to a storm drain in Scituate. A recently passed Betterment Bill, initiated by the NEP, will provide loans to landowners to replace failing septic systems.

National Coastal Caucus

Save The Harbor/Save The Bay (SHSB) and the Conservation Law Foundation of New England (CLF) have been actively involved in the development of the CCMP, as well as the interim measures taken to clean up the Bay. SHSB and CLF both have taken on leadership roles in the Coastal Advocacy Network (CAN), which represents over twenty citizen advocacy groups from across the region. It began as a citizens' advisory panel and has evolved into an active coastal advocacy coalition. The staff, Board of Directors, and members of CLF and SHSB have been involved in numerous capacities. As co-chair of and active participant in the Coastal Advocacy Network, SHSB and CLF, respectively, report regularly to the Management Committee of the MBP. In addition, CAN works closely with the MBP on the development of the CCMP.

SHSB was founded in 1986 by a group of citizens who realized that Boston Harbor was badly polluted, that it was getting worse, and that no citizen constituency existed for the Harbor. Now comprised of over 1,100 members, volunteers, and staff, SHSB's mission is to foster a positive vision of Boston Harbor and Massachusetts Bay and to build a constituency to promote the restoration and protection of these valuable resources. SHSB conducts an annual Swim for Boston Harbor, with about 150 swimmers and hundreds of spectators, to demonstrate that investments in Boston Harbor are truly paying off.

SHSB officially launched its Estuary Project during the summer of 1995 to address various pollution sources and protect Massachusetts Bays' estuarine ecosystems. As part of this project, SHSB was awarded a Massachusetts Bays Program Bays Action Grant to implement its "Storm Drain Detectives" volunteer monitoring program. Working collaboratively with the Mystic and Neponset River Watershed Associations, SHSB is training volunteers to test for pH levels, temperature, dissolved oxygen, biological oxygen demand, and turbidity and to sample for bacteria and nutrients. The Estuary Project also organizes educational workshops for municipal officials (planners, conservation commissioners, etc.), public works officials, and citizen volunteers.

SHSB's BayWatch Project patrols the water by using the boat "Shamrock," a public hotline, and a volunteer corps. The Project has repaired broken fish ladders, notified the public of broken sewer pipes to help prompt repair, monitored dredging activities, and documented the return of record numbers of harbor porpoises in 1995 to Boston Harbor.

The Sediment Security Project has focused mainly on the proposed dredging and disposal of Boston Harbor sediments, which are highly contaminated with heavy metals, PCBs, and other toxic chemicals, such as arsenic. SHSB has worked closely with the Army Corps of Engineers on project planning and environmental review to ensure that dumping does not occur adjacent to Stellwagen Bank where endangered right whales feed, and that other environmental safeguards are incorporated into the proposed dredging method.

CLF is a non-profit public interest environmental law organization founded in 1966. CLF employs a program staff of fourteen attorneys and five scientists who use the law to improve resource management, environmental protection, and public health throughout New England. CLF has a twenty year history of defending New England's fishing industry and the marine environment that supports the fisheries. In addition, CLF brought about the original litigation that resulted in the creation of the Harbor Cleanup Program.

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Mobile Bay
in Alabama

Portrait of the Bay

The Mobile Bay National Estuary Program is beginning to examine the water quality and habitat problems of Mobile Bay and the impact that the greater watershed area has on the estuarine system. The designated study area of the Mobile Bay Program includes the Bay, surrounding ocean waters, the Mobile-Tensaw River Delta, and the northern reaches of Mobile and Baldwin Counties. Mobile Bay is a drowned river valley located on the Alabama Coast of the Gulf of Mexico. The surface waters of the Bay measure 248,000 acres. The Bay's average depth is ten feet;[1] it is approximately 31 feet long and ten feet wide.[2]

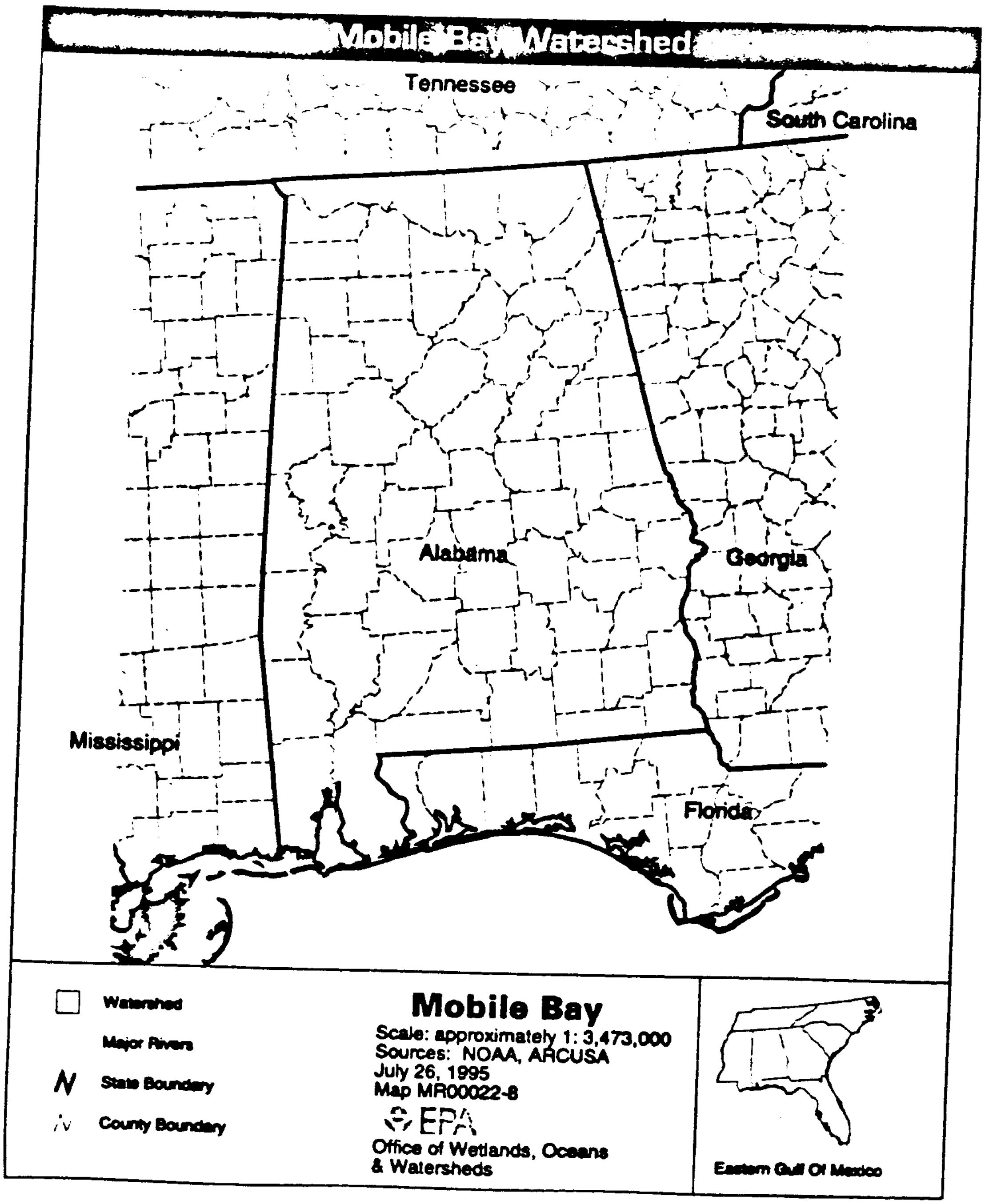
Mobile Bay	
Area of watershed	44,170 square miles
Area of surface water	248,000 acres
Average depth	10 feet
Population	484,000 (Mobile and Baldwin Counties)
Values	• Tourist spend approximately $200 million
	• Sport fishing generates $1 billion in economic output*
	• The rare black-knobbed sawback turtle lives exclusively in this area
Threats	• Toxic contamination
	• Nutrient loadings
	• Pathogen contamination
	• Habitat loss and degradation
	• Polluted urban stormwater
CCMP status	Final expected in 1998
Designated as a "Nationally Significant" Estuary in 1995.	
*State figure	

At the northern edge of the Bay is the Mobile-Tensaw River Delta. Extending northward to the confluence of the Alabama and Tombigbee Rivers, the Delta covers approximately 185,000 acres of primarily marsh, swamp, and forested wetlands.[3] Mobile Bay's watershed is the sixth largest drainage basin in the United States.[4] Sixty-four percent of Alabama and portions of Georgia, Tennessee, and Mississippi comprise the watershed, which measures 44,170 square miles.[5] The following major tributaries provide the Mobile Bay and Delta with freshwater: Mobile-Tensaw, Blakely, Apalachee, Dog, Deer, Fowl, and Fish Rivers.[6] In addition to freshwater, these rivers carry approximately 4.7 million metric tons of suspended sediment to Mobile Bay each year.[7] The Bay's primary opening to the Gulf of Mexico, Main Pass, is located between Dauphin Island (a barrier island) and the Fort Morgan Peninsula.

The City of Mobile, Baldwin County, and Mobile County surround the Bay. In 1990, the combined population of Baldwin and Mobile Counties was approximately 484,000 people — a 22 percent increase from the 1970 population. Another 54,000 people are projected to move to the two counties between 1990 and 2010.[8] The Eastern Shore of Baldwin County and the Fort Morgan Peninsula areas of the Bay are being intensively developed. The predominant land uses in the Mobile Bay area are residential development and undeveloped wetlands.[9]

Values of the Bay

The natural resources of the Mobile Bay and Delta provide numerous recreational opportunities


Mobile Bay Watershed
Tennessee
South Carolina
Alabama
Georgia
Mississippi
Florida
Watershed
Major Rivers
State Boundary
County Boundary
Mobile Bay
Scale: approximately 1: 3,473,000
Sources: NOAA, ARCUSA
July 26, 1995
Map MR00022-8
EPA
Office of Wetlands, Oceans
& Watersheds
Eastern Gulf Of Mexico

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and economic benefits for the visitors and residents of the area. The various habitats of the Bay and Delta include brackish waters, marshes, swamps, inland rivers, and bottomland forests. These provide nursery and spawning grounds for fish, shellfish, waterfowl, and other wildlife.

Recreation/Tourism

Mobile Bay is an attractive destination for individuals interested in sportfishing, kayaking, yachting, water skiing, bird watching, swimming, camping, and hunting. A 1988 estimate of the tourist expenditures in the south Alabama planning area, which includes Mobile, Baldwin and Escambia Counties, was approximately $200 million.[10] The Weeks Bay National Estuarine Research Reserve, the Audubon Bird Sanctuary on Dauphin Island, and several State parks border the Bay. The area also boasts historic properties, Native American shell mounds, and early eighteenth century fortresses.

Boating is a popular activity in coastal Alabama. In the Bay area, there are over 24,000 registered boats greater than 25 feet in length. Twelve marinas and numerous launching areas are situated along the Bay. [11]

Sport fishing is an important component of the local and State economies. In 1991, saltwater and freshwater recreational fishing in alabama generated approximately $1 billion in economic output and employed almost 17,000 people. [12] In the same year, approximately 137,000 saltwater anglers spent over 1.1 million days fishing off the coast of Alabama. An estimated 37 percent of these fishers were non-residents of the State.[13]

Fisheries/Seafood

Mobile Bay contributes valuable fishery resources to the Gulf Coast of the United States. In 1994, the combined value of the gulf Coast commercial finfish and shellfish industries totaled approximately $806 million. In the same year, commercial finfish and shellfish landings in the State of Alabama totaled approximately 23 million pounds and were valued at $48 million.[14]

It is estimated that Mobile Bay produces over one-third of Alabama's total seafood landings.[15]

Shrimp, blue crab, oyster, flounder, croaker, and mullet are important commercial fisheries based in the Mobile Bay area. However, between 1992 and 1993 there were dramatic decreases in landings of finfish, oysters, and crabs in the Bay. Commercial landings of finfish and oysters each dropped 23 percent, while crab landings fell 27 percent over this short period.[16] These recent declines in seafood production have caused fishers and residents of the area to express great concerns about the water quality of Mobile Bay.

Wildlife

An abundance of animal species, including approximately 425 fish, 15 shrimp, 300 bird, 57 mammal, and 21 turtle species, inhabit the Mobile Bay and Delta.[17] The Bay is distinguished for the diversity of birds which use its tidal marshes and barrier islands. Like many estuaries, Mobile Bay provides a critical stopping point for birds migrating to and from Central and South America. Thousands of ducks winter in the area.[18] Alligators, beavers, black bears, and river otters are a few of the mammals and reptiles that reside in the Bay and Delta.

The Bay and Delta provide special habitat for several species. The black-knobbed sawback turtle's entire habitat range is confined to this area.[19] In addition, two uncommon bird species, the Mississippi kite and the swallowtailed kite, dwell in the area.[20]

Threats to the Bay

In documents supporting the Bay's nomination into the National Estuary Program, State officials noted some of the principal water quality problems of the Bay. Priority problems that will be addressed during the development of a restoration plan are toxic contamination, nutrient enrichment, pathogen contamination, and habitat loss. The source of much of this pollution is uncontrolled, contaminated stormwater.

Toxic Contamination

Compared to other Gulf of Mexico estuaries, Mobile Bay sediment samples contain above-average levels of toxic contamination.[21] The Bay receives

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most of its heavy metals and organic chemical inputs from industrial and municipal discharges, dredging operations, and polluted urban stormwater. Some of the industrial sources of chemical toxics include paper mills, petrochemical plants, refineries, and paint pigment plants.[22] Significant levels of two heavy metals, zinc and mercury, have been detected in the Bay's sediments and aquatic life. In fact, a small area of Mobile Bay was closed to finfishing in the early 1990's due to high levels of mercury.[23]

Particles of toxic metals and organic chemicals settle on the floor of the Bay. These toxins persist in the system and are eventually consumed by aquatic organisms and passed throughout higher levels of the food chain. Because of the persistent nature of these contaminants, chemicals which were discharged into the system decades ago often have a present-day effect on the wildlife, water quality, and human populations of the Bay's watershed. Toxic contamination impairs the immune, reproductive and endocrine systems of aquatic wildlife. In addition, there is growing concern about the human health risks associated with eating contaminated seafood. This is a special concern for individuals who subsist on fish and shellfish caught in urban waters.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are deposited in the estuary by urban stormwater, sewage treatment plants, atmospheric deposition, and agricultural runoff. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by submerged aquatic vegetation, but also require a great amount of dissolved oxygen for decomposition. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. The inundation of nutrients in a waterbody is called eutrophication.

Algal blooms are becoming a common occurrence in Mobile Bay. Increased amounts of nitrogen and phosphorus enter the Bay after heavy rainfalls. During 1992 and 1993, six documented fish kills occurred in Mobile Bay. Four of the kills were suspected to be caused by hypoxic conditions.[24]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the incidental ingestion of pathogen-contaminated waters. Despite the known human health risks, Alabama does not conduct any monitoring or testing designed for swimmer safety or to inform beachgoers of potential hazards.

In 1990, all of the shellfish beds in Mobile Bay were harvest-limited.[25] Most shellfish harvest areas of the Bay are closed when intermittent bacterial pollution exists. In the summers of 1991 and 1992, Dauphin Island Bay was closed to oyster harvesting after *Vibrio cholerae* was detected.[26] The probable source of the bacteria was determined to be ballast and/or bilge water released from shipping vessels.[27]

Polluted Urban Stormwater

The Mobile Bay area receives an average annual rainfall of 62 inches.[28] Stormwater is the source of many of the contaminants which impair the water quality and natural resources of Mobile Bay. Stormwater carries fecal coliform bacteria, oil and grease, nutrients, and suspended sediments. As the population of the Mobile Bay area continues to grow, and as residential and commercial development projects are undertaken, the problems of stormwater are likely to intensify. The replacement of natural lands with impervious surface areas, such as pavement and roofs, results in more significant flows of stormwater carrying greater concentrations of contaminants into the estuary. Without natural lands along the Bay to absorb excess waters and filter out harmful contaminants, the aquatic system is placed at greater risk of degradation.

Habitat Loss and Degradation

Approximately 3.7 million acres of Alabama's historic wetlands have been destroyed — a 50 percent loss.[29] A significant amount of the lost acreage has been situated around the coastal areas of

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the State. It is estimated that the wetland losses around Mobile Bay during the past 40 to 50 years have been four times greater than the national average.[10] Coastal wetlands not only provide important habitat for fish, shellfish, and birds, but they also provide many benefits to coastal communities. For example, coastal wetlands filter pollutants carried by stormwater, absorb flood waters, and buffer inland areas from strong coastal storms. They also host numerous recreational activities and in some areas provide recharge groundwater which is used to support community drinking water supplies.

Floatable Debris

Trash accumulated on estuarine beaches also threatens the ecosystem. The amount of debris collected in just one day can be staggering — on September 17, 1994, volunteers cleared 64,365 pounds of marine debris from 125 miles of Alabama's beaches. Of the total amount of marine debris collected, 60 percent was plastics, 15.1 percent was metal, 10.2 percent was glass, and 14.7 percent was from other materials.[11]

Mobile Bay National Estuary Program

With the Environmental Protection Agency's acceptance of Mobile Bay into the National Estuary Program, it was included among the most recent group of seven estuaries added to the Program. On July 6, 1995 Mobile Bay was officially designated by the EPA as an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Shortly thereafter, the EPA convened a Management Conference responsible for coordinating the development of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect the Mobile Bay. The CCMP is expected to be completed in three years.

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Morro Bay
in California

Portrait of the Bay

The Morro Bay National Estuary Program is beginning to examine the water quality and habitat problems of the Morro Bay system and the impact that the greater watershed area has on the estuary. Morro Bay, situated along California's south central coast, is actually contained within a larger estuary, called Estero Bay. The water surface area of Morro Bay is 2,300 acres.[1] Two creeks, Chorro and Los Osos, provide the majority of freshwater to the estuary. The Bay's average depth is a shallow three feet.[2]

The Morro Bay watershed area encompasses 44,000 acres of San Luis Obispo County.[3] Over 35,000 people reside within the watershed — a population density of about 400 persons per square mile.[4] Since 1960, the population within the watershed has tripled.[5] It is estimated that the population of San Luis Obispo County will increase by 46 percent between 1988 and 2010.[6]

Approximately 60 percent of the land within the Morro Bay watershed is used as rangeland, primarily for beef production.[7] Publicly-owned lands within the Montana de Oro and the Morro Bay State Parks account for a sizeable amount of land within the watershed. Residential development and light industry are the typical urbanized land uses within the watershed.[8]

Morro Bay contains a great diversity of habitat types, including what has been described as the "largest and most unspoiled wetland habitat in south central and southern California."[9] The area contains over 700 acres of subtidal and intertidal eelgrass; 600 acres of salt, brackish, and freshwater marshes; and mudflats.[10] The Morro Bay Sandspit, a four-mile barrier beach along the western edge of the estuary, contains sand dunes undisturbed by roads or trails. The sand spit sustains thriving habitat for a variety of plants and animals.

Morro Bay	
Area of watershed	44,000 acres
Area of surface water	2,300 acres
Average depth	3 feet
Population	35,000 people
Values	• Sport fishing generates $3.2 billion in economic output*
	• Fisheries generate $159 million*
	• 270 bird species use the Bay
Threats	• Sedimentation
	• Pathogen contamination
	• Nutrient loadings
	• Toxic contamination
CCMP status	Expected in 1998

Designated as a "Nationally Significant" Estuary in 1995.

*State figures

Values of the Bay

Morro Bay provides wonderful, recreational opportunities and natural resources for the tourists and residents of California's south central coast.

Recreation/Tourism

Tourism represents the major component of the Bay area's local economy. Each year, an estimated 1.5 million visitors come to the Bay. Tourism revenues provide one-third of the general fund revenues and support 37 percent of the jobs in the City of Morro Bay.[11] Camping, fishing, swimming, bird watching, boating, kayaking, duck hunting, and clamming are some of the activities that residents and visitors of the Morro Bay area commonly enjoy.

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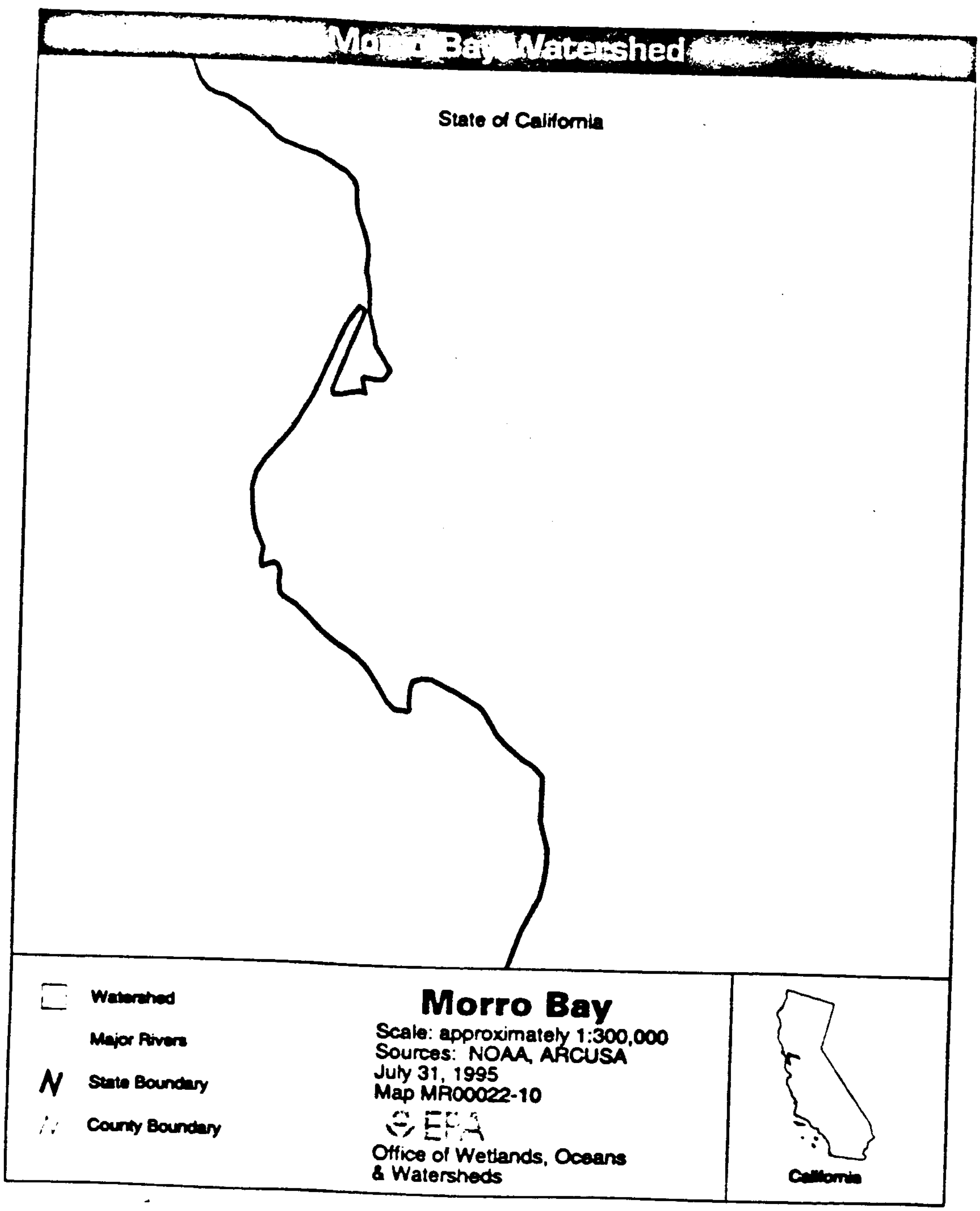
Morro Bay Watershed
State of California
Watershed
Major Rivers
State Boundary
County Boundary
Morro Bay
Scale: approximately 1:300,000
Sources: NOAA, ARCUSA
July 31, 1995
Map MR00022-10
EPA
Office of Wetlands, Oceans & Watersheds
California

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The boating harbor at Morro Bay is the only all-weather, year-round port between Santa Barbara and Monterey Bay (a distance of 225 miles). This access to the Pacific Ocean draws large numbers of boaters and fishers to the Morro Bay. Lingcod, rockfish, halibut and king salmon are abundant in the waters off the coast of this area. Most of the shellfish harvesting of the Bay is conducted by recreational fishers. Gross revenues from Bay fishing excursions total up to $1.5 million each year.[12] In 1991, approximately 1.1 million saltwater anglers spent over 5.5 million days fishing off the coast of California.[13] In the same year, recreational fishing in the State generated approximately $3.2 billion in economic output and employed approximately 40,000 people.[14]

One of the favorite tourist destinations of the area is Morro Bay State Park, which hosts over 500,000 people each year.[15] This State Park contains a 100-boat marina, 130 campsites and a major heron rookery.[16] A prominent landmark of the Bay area is Morro Rock, a 587-foot high volcanic plug, used by peregrine falcons for nests.[17]

Fisheries/Seafood

Morro Bay contributes valuable fishery resources to the Pacific coast of the United States. In 1994, the combined value of the Pacific region's (excluding Alaska) commercial finfish and shellfish landings totaled approximately $401 million. In 1994, California commercial finfish and shellfish landings totaled approximately 343 million pounds, valued at $159 million.[18]

The commercial fishing industry is second to tourism in its annual contributions to the local economy.[19] In 1993, the landing value of commercial fish caught from the Bay totalled $6.9 million.[20] More than 70 fish species use Morro Bay.[21] Many of these species, including rockfish, thornyhead, Dover sole, and salmon are valuable to the commercial fishery of the area.

Clams and oysters are among the 19 different shellfish which have been collected in Morro Bay.[22] Mudflats along the southern and central portion of the Bay are being groomed for increased oyster production.[23] The most commonly caught species are Washington, gaper, and geoduck clams.

Wildlife

The diverse habitats of the Morro Bay area support a wide variety of resident and migratory wildlife. Many endangered and threatened species depend on the Bay and its surrounding environment for habitat. Among the federally-listed species which live in the Bay watershed are the southern sea otter, peregrine falcon and marbled murrelet.[24] As coastal wetlands continue to be destroyed in other portions of the State, animal species increasingly depend upon the wetlands of Morro Bay for survival. California has already lost 91 percent of its historical wetlands base.[25]

Migratory birds use Morro Bay for critical wintering habitat or stopover areas along the Pacific Flyway. The United States Fish and Wildlife Service counts over 270 migratory bird species which use Morro Bay.[26] The rich eelgrass beds of Morro Bay attract wintering brant. Seventy-six percent of the brant which winter along California's coast choose Morro Bay for wintering grounds.[27]

Threats to the Bay

Studies conducted by the California Coastal Commission, individual scientists, and local task forces have identified several threats to the health of Morro Bay. Priority problems that will be addressed by the Morro Bay Program will likely include sedimentation, pathogen contamination, and nutrient loadings.

Sedimentation

Erosion of lands within the watershed and the increase of sediment deposits into the Bay are recognized as the leading problems in this estuary.[28] Changes in land use, alterations from levees and dredging activities, and wildfires in the upper portion of the watershed have increased the rate of sedimentation in the Bay.[29] A 1989 United States Department of Agriculture study estimated that the rate of sediment production in the Bay's watershed is 50 percent greater today than in the 1700s. An estimated 45,500 tons of sediment are deposited in the Bay each year.[30]

Sedimentation disrupts the growth of eelgrass in the estuary by increasing turbidity of the water. Greater turbidity blocks valuable sunlight from reaching the eelgrass beds. Some of the suggested actions to reduce the rate of sedimentation include fire control, gully controls, best management practices for rangeland and small pastures, and creek bed restoration.[31]

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Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, septic systems, polluted urban stormwater, agricultural runoff, and boating waste. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from incidental ingestion of pathogen contaminated water. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria or total coliform (indicators of pathogen contamination) are present in coastal waters.

The principal sources of pathogens in Morro Bay are malfunctioning individual septic systems in the Los Osos Creek area, boaters dumping human waste overboard (the Morro Bay State Park does not have pump-out stations), and livestock waste along Chorro Creek.[32]

Unhealthy levels of pathogen contamination have caused shellfish harvesting restrictions in Morro Bay. Before the 1970s, Morro Bay was one of California's leading producers of Pacific oyster; however, because of increasing sewage-related contamination, landings of Pacific oyster in the Bay began to decline during the 1970s. In 1979, 179,000 pounds of oysters were harvested from the Bay. The landings dropped to 12,000 pounds by 1985 and to zero by 1990.[33] Today, following heavy rainfalls, many acres of recreational shellfish beds are restricted from harvest due to increased bacterial contamination.[34]

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by runoff from agricultural land, animal waste, stormwater, septic systems, and sewage treatment plant discharges. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills.

Monitoring of the Bay has uncovered high levels of nitrate and phosphate in many areas of the Bay, Chorro Creek and Los Osos Creek.[35] In addition, the groundwater of the area is also being affected by nitrogen contamination.[36] Likely sources of groundwater contamination by nitrogen are septic systems and fertilizers which are applied to lawns. Septic systems are also being targeted as a primary source of nitrogen contamination in the portions of the estuary adjacent to Baywood Park.[37]

Toxic Contamination

In the upper portion of the watershed, abandoned mines are responsible for elevated levels of nickel and chromium in sediments. In fact, sediment samples from the Chorro Reservoir reveal levels of nickel in excess of hazardous waste standards.[38] The impact of the upper watershed's toxic contamination on the estuary has not been fully studied.

Samples of mussels taken from Morro Bay indicate that toxic chemicals are not a major threat to the health of the Bay. However, some samples have revealed higher-than-expected concentrations of cadmium, mercury, lindane, chlorbenside, and phosphorothoic acid.[39] In order to understand more about the current state of toxic chemicals on the Bay and to prevent worsening conditions, heavy metals and toxics are considered to be priority environmental problems for the Bay's future.

Additional Concerns

The potential increase in offshore oil development on the region's Outer Continental Shelf is another threat to the Bay. Located to the north of Morro Bay are four major marine terminals which are served by offshore oil activities in the Santa Maria Basin. Small spills have previously occurred in the area.

Trash accumulated on estuarine beaches also threatens the ecosystem. The amount found in just one day was staggering — on September 17, 1994, volunteers cleared 565,501 pounds of marine debris from 480 miles of California beaches. Of the total amount of marine debris collected, 54.1 percent was plastics, 18.5 percent was paper, 10.8 percent was metal, and 16.6 percent was from other materials.[40]

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The Morro Bay National Estuary Program

With the Environmental Protection Agency's acceptance of Morro Bay into the National Estuary Program, it became one of the most recent group of seven estuaries added to the Program. On July 6, 1995 Morro Bay was officially designated an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Shortly thereafter, the EPA convened a Management Conference responsible for coordinating the development of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect the Bay. The CCMP is expected to be completed in three years.

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Narragansett Bay
in Rhode Island

Narragansett Bay is a place where fresh water from the surrounding watershed meets the salt water of the Atlantic Ocean. Our Bay is one of the most biologically-productive ecosystems on earth - sustaining and embracing over 40,000 species of life, including people. Located primarily in Rhode Island, 60 percent of the Bay's watershed is in Massachusetts. Narragansett Bay is the heart of the region's environment and economy; draws visitors from all over the world; provides jobs and recreational opportunities for residents; and provides habitat for an incredible diversity of wildlife.

—Curt Spalding, Executive Director, Save the Bay

Portrait of the Bay

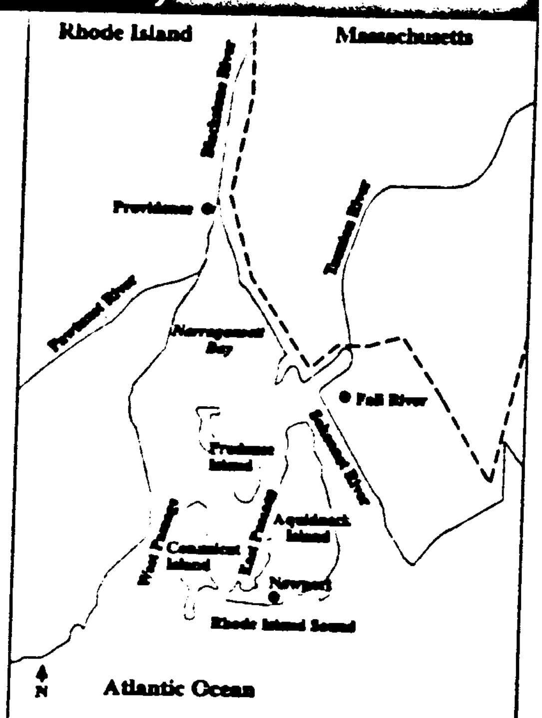
The Narragansett Bay Program is examining the water quality and habitat problems of the Narragansett Bay and the impact that the greater watershed area has on the estuarine system. Regarded as Rhode Island's most precious resource, Narragansett Bay consists of approximately 132 square miles of surface water.[1] The average depth of the Bay is 30 feet, a greater average depth than most of the estuaries located in the mid-Atlantic region.[2] The average salinity of Narragansett Bay is between 29 and 31 parts per thousand (the ocean has a 35

Narragansett Bay

Area of surface water	132 square miles
Area of watershed	1,853 square miles
Population	1.8 million people
Average depth	30 feet
Values	• Lobster catch generates $165 million* • Tourists spent $1.47 billion* • Habitat for the federally endangered bald eagle and piping plover
Threats	• Pathogen contamination • Nutrient loadings • Habitat loss and population growth • Toxic pollution • Floatable Debris
CCMP status	Approved in 1993

Designated as a "Nationally Significant" Estuary in 1987.

*State figures



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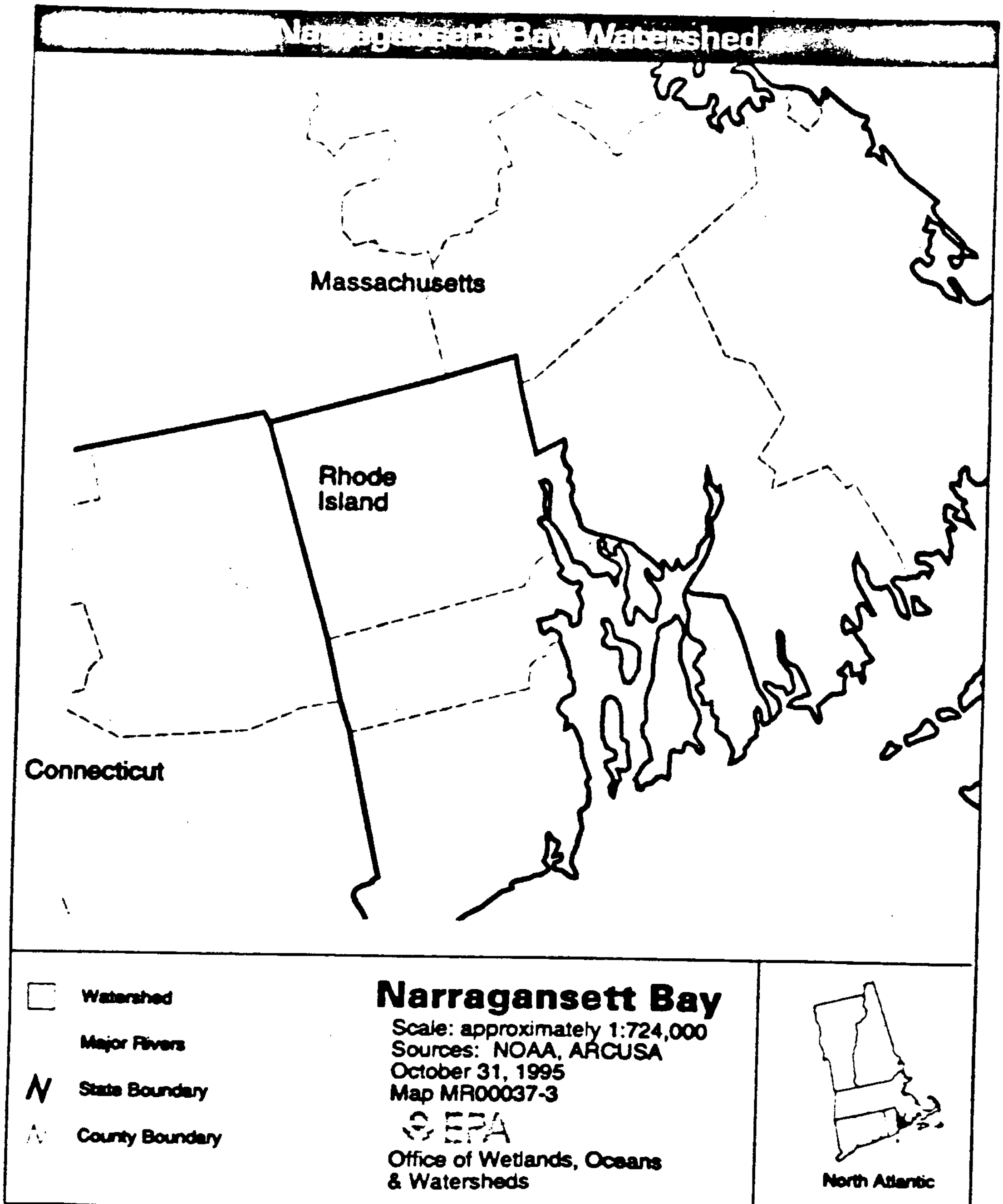

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parts per thousand salinity). This higher-than-average estuarine salinity is due to the minimal flow of freshwater into the Bay— less than 0.05 percent of the Bay's total volume is freshwater.[3]

The Narragansett Bay watershed area covers 1,853 square miles in Rhode Island and Massachusetts.[4] The Bay's watershed is one of the most densely populated in the nation. About 1.8 million individuals reside in the area, yielding a population density of over 1,100 persons per square mile.[5] Major municipalities in the watershed include Worcester and Fall River, Massachusetts; and Providence, Rhode Island.

The majority of the freshwater which flows into the Bay is delivered by three rivers—the Blackstone, Taunton, and Pawtuxet rivers. Smaller rivers and streams also carry freshwater to the Bay. Three drowned river valleys connect Narragansett Bay to Rhode Island Sound and eventually the Atlantic Ocean. These passages—East Passage, West Passage, and the Sakonnet River—are separated by the Aquidneck, Conanicut, and Prudence islands.

The Bay supports approximately 2,800 acres of salt marsh and 4,400 acres of tidal flats. Freshwater wetlands represent only six percent, or 63,000 acres, of the watershed.[6]

Values of the Bay

In 1989, the Bay contributed $2.5 billion to Rhode Island's economy through fisheries, tourism, marine industries, United States Navy-related activities, and marine education.[7] Popular recreational activities in the Bay include boating, camping, bird-watching, hiking, and fishing.

Recreation/Tourism

In 1994, tourists in Rhode Island spent $1.47 billion and supported over 25,000 tourist-related jobs.[8] Narragansett Bay and its shoreline attract many of these tourists to the state. It is estimated that annual Bay-related tourism is responsible for supporting over 15,000 jobs and generating over $390 million in revenue.[9]

Narragansett Bay is reputed as one of the best places in the world to sail. For this reason, recreational boating exceeds all other Bay activities in terms of total economic impact.[10] Other popular activities in the Bay are sunbathing, swimming, observing wildlife, and visiting historical sites. In 1991, an estimated 260,000 individuals observed wildlife; while 65,000 photographed wildlife in the State of Rhode Island.[11]

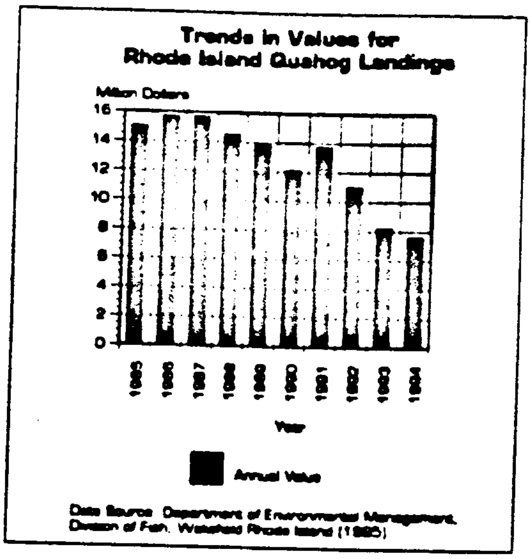
Recreational fishing provides another significant source of revenue for Rhode Island and the Narragansett Bay region. In 1991, an estimated 171,000 individuals spent over 2.1 million days fishing Rhode Island's fresh and salt waters.[12] Recreational fishing generated approximately $125 million in economic output and employed nearly 2,200 persons that year.[13] Saltwater fishing is a more popular pursuit for anglers than freshwater fishing. In 1991, more than 124,000 people enjoyed saltwater fishing in Rhode Island, spending $41.8 million.[14] Bluefish, striped bass, and flatfish are the most sought-after saltwater fish.

Fisheries/Seafood

The fisheries of Narragansett Bay are considered to be part of the New England fishery region. In 1994, the combined market value of commercial finfish and shellfish landings in the New England region totaled approximately $583 million. Many of the commercially valuable species in New England depend upon the health of Narragansett Bay for survival. In 1994, the State of Rhode Island's commercial finfish and shellfish landings totaled approximately 112 million pounds, valued at $77 million.[15] Commercial lobster landings alone generated $165 million for the State in 1993.[16]

Commercial fishing is a vital part of the Narragansett Bay area's economy. In 1993, the Bay's combined finfish, shellfish, and lobster landings generated $23.9 million in revenues.[17] The City of Newport is home to one of the largest lobster ports in the Northeastern United States.

Shellfish have historically provided substantial revenue for the Bay region; however, pollution, loss of habitat and overharvesting have decimated shellfish populations during this century. In the early 1900s, Narragansett Bay oyster production was a booming industry. However, in the 1930s and 1940s, the industry collapsed due to pollution, overharvesting, and a destructive hurricane. By 1957, the last Rhode Island oyster harvesting operation had closed.[18] Bay scallops, once plentiful, have also almost completely disappeared from the Bay.



The most profitable fishery of the Narragansett Bay is the quahog (hard clam), accounting for 84 percent of the Bay's total fishing revenue.[19] Yet, the quahog catch in Rhode Island has dropped from 4.2 million pounds (in weight of meats), valued at $15 million in 1985, to 1.6 million pounds (in weight of meats), valued at $7.6 million in 1994.[20] Landings have remained at historical lows due to extreme fishing pressure and continuing shellfish bed closures caused by bacterial contamination. In addition, the number of commercial shellfish licenses issued between 1991 and 1993 fell from 2,000 to 200 prompted by the closure of Greenwich Bay, a significant harvesting site in Narragansett Bay.[21]

Wildlife

A variety of wildlife depend upon the rich resources of the Bay for their survival. Migrating shorebirds use the Bay for foraging; while sea ducks depend upon the Bay for wintering grounds. The Bay's islands are used by harlequin ducks, tree swallows, herons, glossy ibis, snowy owls, purple sandpipers and over 200 other bird species at different times of the year.[22] In addition, large populations of osprey and other raptors nest in the area.[23]

Red foxes, weasels, minks, and harbor seals are also found in the areas surrounding Narragansett Bay. Rhode Island has 16 federally-listed threatened and endangered animal species.[24] Of these, the bald eagle and piping plover depend on the State's estuarine and marine wetlands for habitat.[25]

Threats to the Bay

Like other estuaries of the United States, Narragansett Bay and its resources are being affected by growth and urbanization throughout the watershed. Urban development compounds water quality problems by increasing the amount of contamination entering the Bay and by modifying and destroying important habitat. The Narragansett Bay Comprehensive Conservation and Management Plan (CCMP), approved in 1993, identifies pathogen contamination and excessive nutrient loadings as priority threats to the Bay's ecosystem. Additional threats to the health of Narragansett Bay include habitat loss, population growth, toxic pollution, and marine debris.[26]

Pathogen Contamination

Pathogen contamination is the most critical pollution problem for Narragansett Bay. Pathogens are disease-causing bacteria and viruses found in human and animal wastes that enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in polluted beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogens.

In Narragansett Bay, combined sewer overflows are the leading source of pathogen contamination. After periods of extensive rainfall or snow melt, the combined sewer systems often cannot handle the flow of stormwater and wastewater. As the system becomes overloaded, industrial wastewater and untreated or partially treated sewage combine with contaminated stormwater and then discharge into the Bay and its tributaries. Over 100 CSOs discharge four billion gallons of wastewater into Narragansett Bay and its tributaries annually.[27] Other sources of pathogens include wastewater treatment facility discharges, septic systems, cesspools, and boating discharges.

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Bacterial contamination forces the closures of shellfish harvesting areas in the Bay. Currently, over 36,000 acres (almost one-third of the total) of the Bay's shellfish beds are permanently closed or harvest-restricted as a result of unsafe bacterial levels.[29] In 1992, valuable winter shellfish harvesting areas were closed in Warwick and East Greenwich due to bacterial contamination. These closures in Greenwich Bay, which normally contribute four million dollars annually to the Bay region, devastated the shellfish industry.[29]

Nutrient Loadings

Nitrogen and other nutrients that flow into the Bay can damage submerged aquatic vegetation and contribute to conditions that cause large fish kills. Nutrients enter the Bay from many sources, including atmospheric deposition, urban and rural polluted runoff, groundwater, septic systems, publicly-owned treatment works, and CSOs.[30] Municipal wastewater discharges are the principal source of nitrogen loading in upper Narragansett Bay.[31] In addition to the four billion gallons of wastewater per year discharged by CSOs, the Bay and its tributaries receive over 73 billion gallons of treated wastewater annually from publicly-owned sewage treatment plants.[32]

Excessive nutrients stimulate the growth of algae. When large algal blooms form, submerged aquatic vegetation can not receive the amount of sunlight needed for its growth. Nutrient loadings in Narragansett Bay have caused dramatic losses among eelgrass beds, important spawning and nursery habitat for fish and shellfish. Another consequence of nutrient overloading is the depletion of dissolved oxygen. As algae decompose, they require large amounts of oxygen, often creating hypoxic ("low oxygen") conditions which threaten the aquatic life of the Bay. Over the years, fish kills in Narragansett Bay and its tributaries have occurred as a result of depleted oxygen levels.

Habitat Loss and Population Growth

The effects of human settlement and development have led to many water quality problems in Narragansett Bay. Since the 1780s, Rhode Island has lost over 37 percent of its historic wetlands acreage.[33] In addition, Rhode Island has lost a substantial portion of its original forested lands; between 1982 and 1988, 15 percent of the State's forests were cleared.[34] In addition, all of the major rivers in Rhode Island are dammed. These changes in the watershed have had severely negative consequences — less nursery habitat for fish, less contaminant filtration, increased amounts of polluted runoff and stormwater, and diminished freshwater flow — for the Bay.

Towns along the Narragansett Bay have experienced great population growth during the past few decades. The town of Narragansett's population tripled between 1960 and 1990. The town of East Greenwich doubled its population during the same period.[35] Population pressures are expected to continue. By the year 2010, Rhode Island's population is anticipated to grow by another 10 percent.[36] The increasing population will likely cause additional declines in water quality because of the limited capacity of existing wastewater treatment systems and the further destruction of habitat. As natural vegetation is replaced by impervious surface areas such as pavement and roofs, the absorption of stormwater and the filtering of pollutants is reduced.

Toxic Pollution

Toxic pollution is a consistent threat to the Narragansett Bay region. As recently as January, 1996, the Rhode Island coast was plagued by toxic contamination when a cargo barge ran aground and spilled over 800,000 gallons of heating oil. In the first two days after the spill, at least 11,000 dead lobsters washed ashore along Rhode Island's southern coast.[37] The complete impact of the spill on other wildlife and natural resources in Rhode Island has yet to be determined.

Industrial pollution such as this has been a long-standing problem for Narragansett Bay. By 1860, Rhode Island was considered the most industrialized State in the nation.[38] The early industrialization in Rhode Island and Massachusetts, combined with more recent industrial activities, presents tremendous challenges to the restoration of Narragansett Bay.

Sediments from the bottom of the Blackstone River are laden with toxins from metal plating and textile activities from the nineteenth and early twentieth centuries. Historically, toxic metals entered

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the Bay from jewelry manufacturing and electroplating plants, textile mills, cement companies, and other industrial sites. Petroleum-derived contaminants, such as polychlorinated biphenyls (PCBs) were used in electrical transformers before they were banned in 1977; however, they can still be found in the Bay system. Other toxic pollutants found in the Bay include copper, cadmium, lead, zinc, chromium, silver, nickel, and mercury. Copper pipes with lead solder that were used to transport drinking water to Bay communities are another source of these toxics.[39]

The toxic contamination of the sediments and waters of Narragansett Bay jeopardizes the Bay's aquatic life and poses risks to human health. Toxins accumulate in the tissues of fish and shellfish causing potential reproductive or mutagenic problems. Bioaccumulation of the toxics in the tissues of aquatic animals has led to lobster, mussel and plankton kills in some portions of the Bay.[40] In addition, humans who eat large quantities of contaminated fish put themselves at increased risk of developing cancer.[41]

Floatable Debris

Trash accumulated on estuarine beaches threatens the Bay ecosystem. On September 17, 1994, volunteers cleared 20,000 pounds of marine debris from 49 miles of Rhode Island beaches. Of the total amount of marine debris collected, 62.1 percent was plastic, 10.8 percent was glass, 10 percent was metal, and 17.1 percent was from other materials.[42]

The Narragansett Bay Project

In 1985, the Narragansett Bay Project (NBP) was created to assess the water quality problems of the Bay and to make the necessary recommendations. In 1987, Narragansett Bay was chosen as one of the original six estuaries to be included in the National Estuary Program. The coordination of the project was to be carried out by the NBP. The first task of the NBP team was to bring together interested parties to examine the primary sources of pollution to the Bay and identify solutions. The project team worked with representatives from industry, the scientific community, marine trade groups, citizen organizations, and state agencies. Since its inception, the NBP has initiated over 100 studies on the environment and management of the Bay.[43]

In January of 1993, the EPA approved the Comprehensive Conservation and Management Plan (CCMP) for Narragansett Bay which identified five goals: prevention of further water quality degradation; protection of critical resource areas; management of living resources; rehabilitation of degraded waters; and coordination and implementation of the CCMP.[44]

After the CCMP was approved, the NBP became administered by the Rhode Island Department of Environmental Management (DEM) where a small staff has been assisting in the implementation of the plan. An Implementation Committee and an Implementation Advisory Committee were established to oversee the actions of the NBP. The effectiveness of the NBP is limited in part because its funding sources are so tenuous. Without the ongoing commitment of state and federal resources it is difficult to ensure proper monitoring and implementation of the CCMP. There is also a serious problem regarding the lack of integration of the CCMP recommendations into state and local policy plans and actions. For instance, although the CCMP was adopted as part of the State Agency Guide Plan, and the Coastal Resources Management Council is obliged to follow the guidelines in the CCMP, there is no enforcement mechanism, and therefore, no oversight to ensure compliance with the provisions in the CCMP.

Nevertheless, great strides have been made in improving the environmental quality of the Bay, and there have been some tremendous programmatic accomplishments. An example of a successful NBP effort is the establishment of the Greenwich Bay Watershed Restoration Initiative. Restoration of the water quality of Greenwich Bay, a 3,200-acre embayment within the Narragansett Bay system, was recently targeted as a top priority by both NBP and the Rhode Island DEM. Save The Bay, a non-profit membership organization, was tapped to join in the efforts to address a range of pollution sources, such as failed septic systems, polluted stormwater and discharges of sewage from boats.

For decades Greenwich Bay has been a glorious vacation spot and a thriving resource, supporting scallops, oysters, and winter flounder. Within these waters are some of the most productive quahog beds in the world. The Bay's popularity eventually aided in its transformation into one of the most congested areas in Rhode Island. The population in some areas was six times the State average. Finally, the day of reckoning came in December, 1992 when unacceptable levels of bacterial pollution resulted in the closure of the area to shellfishing, and the loss of $4 million in commercial shellfish revenues.[45]

The immediate goal of the Restoration Initiative was to reduce bacterial pollution so that Greenwich Bay could be re-opened for shellfishing. These efforts involved such varied activities as door-to-door surveying to identify failed septic systems, building support for a bond referendum for the City of Warwick to pay for stormwater mitigation work, and constructing a two-mile sewer line. Throughout the process, Save The Bay has been committed to community education and volunteer monitoring projects, always stressing the role of the individual in cleaning up the Bay. Save The Bay is also involved in helping to meet the longer-term goal of improving the water quality so that the Bay can support eelgrass beds, bay scallops and other native aquatic resources.

Other successful NBP efforts include the Field's Point wastewater treatment facility which has achieved a 90 percent reduction of metal contaminants in its effluent compared to 1981 levels.[46] CSO problems are also being addressed by a project which will create two deep tunnels and storage facilities to more effectively treat combined sewer discharges in the upper Narragansett Bay. A 99 percent reduction in fecal coliform loadings from the CSOs is expected for this area of the Bay.[47] New pumpout stations are also under construction at marinas throughout Rhode Island to meet a "no-discharge" designation for the Bay, making all boat sewage discharges illegal.[48]

Although these and other projects are clearly important, the CCMP failed to highlight which projects are most significant for the health of the Bay and which ones should be carried out first. The CCMP includes hundreds of recommendations for protecting the Bay, but they are not listed in any priority order. In some cases it is also difficult for citizen activists to determine if their input throughout the process was actually given due consideration in the writing of the plan. In addition, the stakeholders who were involved in developing the plan have become frustrated with the lack of clarity, direction, and commitment to its implementation. This, in part, may be due to a lack of ongoing citizen involvement and public input in refining the CCMP over time.

National Coastal Caucus

Since 1970, when Save The Bay was formed by a handful of volunteers and grassroots activists, it has grown into one of the largest and most effective, non-profit, membership-based environmental organizations in New England. Headquartered in Providence, Rhode Island, with 15,000 members, an annual budget of approximately $1 million, and a staff of over 20 full-time professionals, Save The Bay employs education and advocacy to promote environmental protection, restoration, and preservation of Narragansett Bay.

Save The Bay has been involved in the NBP since its earliest days. The staff, Board of Directors, and membership have been involved in numerous capacities. In particular, they have served on the original NBP Team, Steering Committee, Critical Habitat Subcommittee, and the Non-point Source Subcommittee.

During the past 25 years, Save The Bay has worked collaboratively with others in the community, as well as with government agencies, to cut certain forms of pollution in Narragansett Bay in half, but much work remains to be done. Currently, Save The Bay's Narragansett Bay protection programs provide the public with a greater understanding of, and appreciation for, their place in the Bay ecosystem. Save The Bay's volunteer-based Bay monitoring program (Narragansett Bay Watchers), on-the-water action and response program (Narragansett BayKeeper), outdoor school and workplace-based education program (Explore The Bay), and Bay Habitat Restoration and Protection Program, offer individuals many opportunities to learn more about the Bay and to participate directly in Bay protection efforts.

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New Hampshire Estuaries
in New Hampshire

Portrait of the Estuaries

The New Hampshire Estuaries Project is examining the water quality and habitat problems of two New Hampshire estuaries, and the impact that their greater watershed areas have on these systems. The Great Bay Estuary and the Hampton Harbor Estuary, included in the New Hampshire Estuaries Project, are situated along New Hampshire's 150 miles of tidal shoreline.[1] The Great Bay Estuary and the Hampton Harbor Estuary are two distinct estuaries that will be jointly studied in order to address the problem of bacterial contamination and the resulting closure of shellfish beds currently at issue in both systems.

New Hampshire Estuaries

Area of watershed	• Great Bay 930 square miles
	• Hampton Harbor 47 square miles
Population Centers	• Great Bay (largest cities) 87,521 people
	• Town of Hampton 12,466 people
Values	• Fisheries generate $13 million*
	• Total economic output of recreational fishing — $178 million*
	• Support the largest wintering population of bald eagles in New Hampshire
Threats	• Pathogen contamination
	• Shellfish bed closures
CCMP status	Expected in 1998

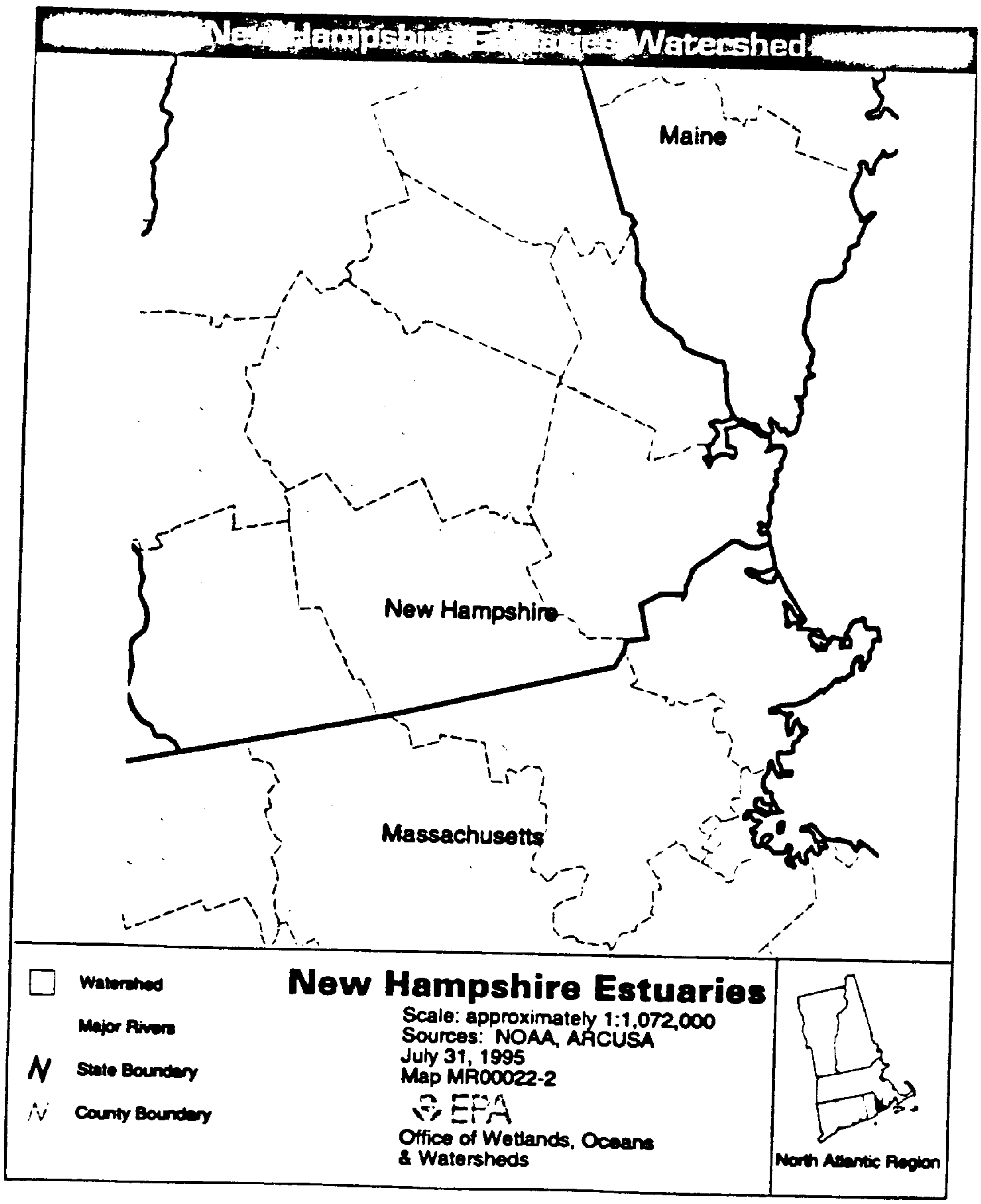
Designated as a "Nationally Significant" Estuary in 1995.

*State figure

The Great Bay Estuary is a drowned river valley located along the New Hampshire-Maine border.[2] Seven rivers provide freshwater for the Great Bay Estuary: the Lamprey, Oyster, Cocheco, Salmon Falls, Squamscott, Winnicut, and Bellamy Rivers.[3] The watershed area of the Great Bay Estuary covers 930 square miles.[4] Two-thirds of the Great Bay watershed is in New Hampshire; one-third is located in southern Maine.[5] The largest cities within the Great Bay watershed are the New Hampshire cities of Rochester, Dover, Exeter and Portsmouth. In 1993, these four cities had a combined population of 87,521.[6]

Habitat types within the Great Bay Estuary are varied. About 1,000 acres of saltmarsh; 52 acres of oyster beds; 2,575 acres of clam flats; 5,000 acres of subtidal eelgrass; many acres of mudflats; and rocky outcroppings combine to provide habitat for an abundance of plants and wildlife.[7] Sixty-six percent of the watershed's land cover is forested; 10 percent consists of wetlands; another 10 percent consists of urbanized lands; and the remaining 14 percent consists of agricultural, disturbed, cleared and water habitats.[8]

At the southern end of the New Hampshire coast lies Hampton Harbor, a shallow estuary bordered by salt marsh. Mill Creek, and the Taylor, Hampton, Browns, and Blackwater Rivers are Hampton Harbor's primary sources of freshwater.[9] The watershed area of the Hampton Harbor Estuary is 47 square miles.[10] Eighty percent of the Harbor's watershed is in New Hampshire; the remaining 20 percent is located in Massachusetts.[11] The largest municipalities in the Hampton Harbor watershed include Hampton, Hampton Falls, and Seabrook, New Hampshire. The town of Hampton, with an estimated 1993 population of 12,466, is the largest population center of the watershed.[12]


New Hampshire Estuaries Watershed
Maine
New Hampshire
Massachusetts
Watershed
Major Rivers
State Boundary
County Boundary
New Hampshire Estuaries
Scale: approximately 1:1,072,000
Sources: NOAA, ARCUSA
July 31, 1995
Map MR00022-2
EPA
Office of Wetlands, Oceans & Watersheds
North Atlantic Region

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Hampton Harbor's land area is made up of 40 percent forested lands, 23 percent urbanized lands and 21 percent wetlands. The remaining 16 percent of land is a mixture of agricultural, disturbed, cleared and water habitats.[13] Hampton Harbor's developed areas consist primarily of residential areas and summer resorts which border the beaches. During the summer months, the town of Hampton's population climbs substantially. On some days, as many as 100,000 people (vacationers, permanent and summer residents) recreate along Hampton Harbor beaches.[14]

For both of the Estuaries, development is concentrated near the tidal waters and does not expand too far into the watershed.[15] Light industrial operations and low-to-moderate density residential areas comprise most of the urbanized use of land in the watersheds.[16]

Values of the Estuaries

The Hampton Harbor and Great Bay Estuaries are rich in recreational opportunities, fisheries, and wildlife. Natural resources and recreational activities generate significant amounts of revenue for local economies.

Tourism/Recreation

Tourism is the second largest industry along New Hampshire's coastline, supporting 15 percent of the regional work force.[17] Many residents and tourists sail, fish, water ski, swim, and dive in the Estuaries of New Hampshire. A number of parks and trails border the Estuaries. In 1991, recreational fishing in New Hampshire generated approximately $178 million in economic output and employed nearly 3,000 people.[18] In the same year, approximately 75,000 saltwater anglers spent over 293,000 days fishing off the coast of New Hampshire. Fifty percent of the anglers were non-residents of the State.[19]

The Hampton Harbor area is New Hampshire's primary summertime beach resort area. Sandy beaches of the Estuary are a major tourist attraction. One unique feature of the Hampton Harbor Estuary is the 5,000 acres of salt marsh it contains. This feature attracts a number of recreational softshell clam harvesters, distinguishing Hampton Harbor Estuary as the most popular location in coastal New Hampshire for softshell clamming.[20] The oyster, clam, and mussel shellfisheries are important recreational resources for the New Hampshire Estuaries and the State of New Hampshire. Recreational shellfishing generates an estimated $3 million per year for local and state economies.[21] In recent years, an average of 5,000 bushels of oysters, worth $300,000, have been harvested from Great Bay oyster beds each year.[22]

Recreational anglers fish for Atlantic silverside, rainbow smelt, killifish, white perch, and flounders in the Great Bay. Charters take a number of anglers out to fish for bluefish, striped bass, cod, and mackerel. In 1990, saltwater fishermen spent over $52 million on fishing-related activities.[23] Lobstering is another valuable recreational activity in the Estuaries. Portsmouth Harbor within the Great Bay Estuary is one of the most popular lobster trapping areas in New Hampshire.[24]

Fisheries/Seafood

The New Hampshire Estuaries contribute valuable fishery resources to the New England region of the United States. In 1994, the combined value of New England's commercial finfish and shellfish industries totaled approximately $583 million. During that same year, commercial finfish and shellfish landings for the State of New Hampshire totaled approximately 12 million pounds, valued at $13 million.[25]

A remarkable array of fish and shellfish depend on the New Hampshire Estuaries for breeding grounds, nursery areas, and principal habitat. The Estuaries support anadromous fish runs for sturgeon, smelt, shad, salmon and alewives. Lobsters, winter flounder, cod, and striped bass rely on the Estuaries for nursery habitat. Oysters, softshell clams, blue mussels, and razor clams also inhabit the Estuaries.[26] Major commercial fisheries of the Great Bay include eel, lamprey, and lobster. Current annual lobster catches for the Bay are estimated at over 880,000 pounds and $4 million.[27]

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Wildlife

New Hampshire is home to 10 federally-listed threatened or endangered species,[28] including the federally endangered shortnose sturgeon which relies on the Estuaries.[29] Over 110 bird species frequent the Estuaries.[30] Cormorants and gulls are common year-round seabirds. Black ducks and Canada geese can be observed during the fall and winter.[31] Wading birds which use the estuarine habitat of the area include great blue herons, snowy egrets, glossy ibis, and the common least tern, which is threatened in the State of New Hampshire. The Great Bay Estuary supports the largest wintering population of bald eagles in New Hampshire — up to fifteen eagles have been observed in recent winters.[32] Mammals common in the Estuaries include otters, minks, beavers and harbor seals.[33] The Great Bay National Wildlife Refuge recently opened 1,000 acres of wildlife habitat previously used by the Pease Air Force Base.

Threats to the Estuaries

As previously noted, the most crucial problem affecting the Great Bay and Hampton Harbor Estuaries is bacterial contamination and the subsequent closure of shellfish harvest areas. Prime shellfish beds and flats in the Great Bay Area (including most of Little Bay, the Piscataqua River, and smaller tidal rivers) are closed or limited to harvesting due to bacterial contamination. Soft shell clams are the predominant shellfish of the Hampton Harbor Estuary. Major clam flats in the Harbor were closed in 1988 as a result of high bacteria levels. In September of 1994, a few of the flats were reopened on a conditional basis.[34]

Over the years, Great Bay and Hampton Harbor Estuaries have been the focus of several studies conducted by the University of New Hampshire, Jackson Estuarine Laboratory, and several New Hampshire State agencies. These studies have identified polluted runoff as the underlying cause of bacterial contamination in the Estuaries.[35] Stormwater, on-site sewage disposal systems, agricultural runoff, and runoff from shoreline development are some of the primary sources of bacteria, nutrients, heavy metals, and sediments that threaten the Estuaries.

Significant declines among shellfish populations and approved shellfish harvesting beds have been widely noted in many harvest area assessments and are of major concern to government officials and local citizens in the area. The New Hampshire Estuaries Project proposes to emphasize shellfish bed closures as an indicator of the environmental quality and a measure of successful restoration in the Estuaries.[36] The Project will focus on polluted runoff controls as a way to limit the bacterial contamination responsible for closing shellfish beds. In areas around Hampton Harbor Estuary, individual septic systems are believed to be responsible for loadings of bacteria and nutrients in the Estuary.[37] In 1990, 72 percent of the shellfish beds in the Great Bay were harvest-limited.[38]

Floatable Debris

Trash accumulated on estuarine beaches also threatens the ecosystem. The amount collected in just one day of an organized clean-up was staggering. On October 1, 1994, volunteers cleared 14,300 pounds of marine debris from 20 miles of New Hampshire beach area. Of the total amount of marine debris collected, 53.7 percent was plastics, 14.1 percent was metal, 11.8 percent was paper, and 20.4 percent was from other materials.[39]

The New Hampshire Estuaries Project

With the Environmental Protection Agency's acceptance of the New Hampshire Estuaries into the National Estuary Program, it was included among the most recent group of seven estuaries added to the Program. In July, 1995, the New Hampshire Estuaries were officially designated as "nationally significant" under the National Estuary Program of the Clean Water Act. The Project has established a three-year schedule to complete its Comprehensive Conservation and Management Plan (CCMP). The Project is currently exploring the possibility of adding representatives of Maine and Massachusetts to the Management Conference. The Project has decided not to have a free-standing Citizens Advisory Committee and Science/Technology Advisory Committee. Instead, it will incorporate citizens and technical experts on all Project committees.

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Washington, D.C. 20515
U.S. Capitol Switchboard: (202) 224-3121

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New York-New Jersey Harbor Estuary
in New York and New Jersey

The Estuary is like a family. Its' air, water, land, and communities of people and communities of wildlife, all related, all living together. It is a marvelous organism whose life and health depends on us all, and benefits us all. The Estuary is alive!

—Steve Barnes, Conservation Director
NY/NJ Baykeeper

Portrait of the Estuary

The New York-New Jersey Harbor Estuary Program is examining the environmental problems of the Harbor system and the impact that the greater watershed area has on the Estuary. The New York-New Jersey Harbor Estuary is comprised of the New York-New Jersey Harbor and a complex of tidal rivers and streams. Its core area, called the Hudson-

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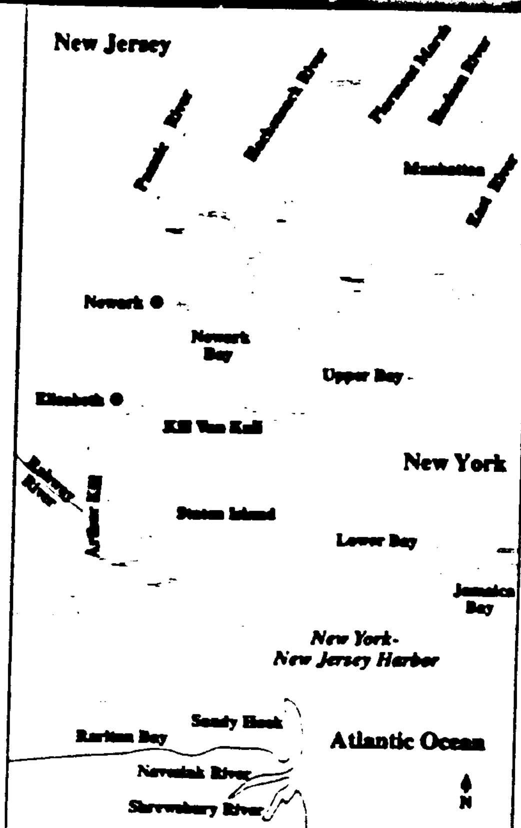
New York-New Jersey Harbor Estuary

Area of surface water	298 square miles
Area of watershed	16,500 square miles
Average depth	21 feet
Shoreline	481 miles
Population	20 million people
Benefits	• Economic output of recreational fishing — $1.3 billion (NJ)* $1.4 billion (NY)* • Coastal tourism generates $2.9 billion (NY) • Ocean-front tourism generates $4 billion (NJ)
Threats	• Habitat loss and degradation • Toxic pollution and contaminated sediments • Pathogen contamination • Floatable debris • Nutrient loadings
CCMP status	Proposed CCMP was released in 1995; Approval expected in 1996

Designated as a "Nationally Significant" Estuary in 1987.

*State figures



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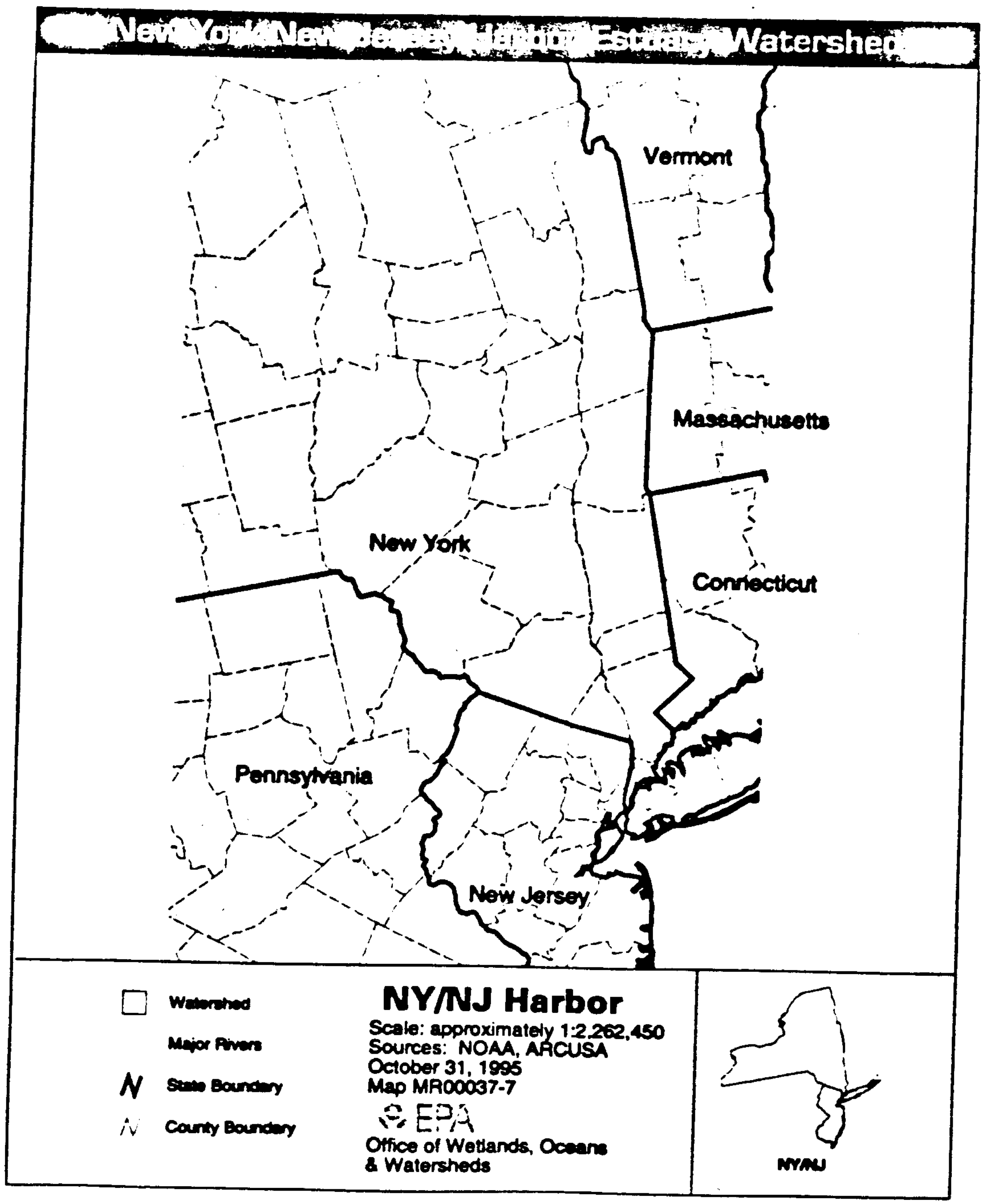
Watershed
Vermont
Massachusetts
New York
Connecticut
Pennsylvania
New Jersey
Watershed
Major Rivers
State Boundary
County Boundary
NY/NJ Harbor
Scale: approximately 1:2,262,450
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-7
EPA
Office of Wetlands, Oceans
& Watersheds
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Raritan Estuary, extends from the Piermont Marsh in New York State to the Sandy Hook-Rockaway Point Transect. This region of the Harbor includes the bi-state waters of the Raritan Bay, Upper and Lower Bays, Hudson River, Kill Van Kull, Arthur Kill, and other tributaries.[1] The Estuary covers approximately 298 square miles of surface water.[2] The average depth of the Estuary is 21 feet.[3]

The watershed area of the Estuary extends into southwestern Vermont, northwestern Massachusetts, and portions of upstate New York. The watershed measures approximately 16,500 square miles.[4] New York City, Jersey City, and Newark are all part of the watershed. The Ports of Newark, Elizabeth, and New York lie at the heart of the Estuary. Together they comprise one of the largest port areas in the world.[5] This heavily urbanized Estuary is enjoyed by 20 million residents[6] and over 17 million annual visitors.[7] The Arthur Kill sub-watershed alone has 690,000 residents, a density of 5,300 people per square mile.[8]

More than two-thirds of the Estuary's freshwater is delivered by the Hudson River.[9] On average, the Estuary receives approximately 26,700 cubic feet of freshwater per second, a high rate compared to other estuaries of the middle Atlantic region.[10] The New York Bight is another special feature of the area. The Bight includes the ocean waters from the Sandy Hook-Rockaway Point Transect approximately 100 miles to the Outer Continental Shelf. Since there is a clear linkage between the Bight and the New York-New Jersey Harbor, efforts to restore both of these areas have been combined and are being addressed by the Estuary Program.

Tidal rivers, salt and fresh tidal marshes, woodlands, shallow bays, barrier beaches, and sand dunes can be found in the Estuary. Water is the predominant habitat type in the Estuary. Salt- and freshwater tidal marshes cover 180,000 acres in New Jersey and 25,000 acres in New York.[11] Approximately 75 percent of the salt and freshwater tidal marshes in New Jersey and New York have been lost to development. In addition, there are probably no more than 15-17,000 acres of tidal wetlands left within the core area of the Harbor Estuary.[12] The Estuary has approximately 481 miles of shoreline; however, human-developed structures, such as piers and bulkheads, make up 75 percent of this shoreline.[13]

Benefits of the Estuary

The New York-New Jersey Harbor Estuary provides a wealth of economic benefits and recreational opportunities. The Port of New York and New Jersey contributes $14 billion per year to the area's economy and employs approximately 200,000 people.[14] Estuarine-based attractions of the area include the Hackensack Meadowlands, the Manhattan skyline, Battery Park, the Statue of Liberty, Sandy Hook National Park, Liberty State Park, and Jamaica Bay National Wildlife Refuge.

Recreation/Tourism

Millions of tourists and residents use the Harbor ecosystem each year and participate in a variety of recreational activities. Sailing, sport fishing, waterskiing and beach-going are some of the activities enjoyed by these visitors. This recreational value translates into tremendous economic benefits for the region. The State of New Jersey alone gains $4 billion annually from revenues generated by oceanfront tourism;[15] while New York's coast generates $2.9 billion from tourism.[16]

Pollution episodes and their effects on the living resources and habitat of the Estuary can devastate the coastal tourism industry of the area. During the summers of 1987 and 1988, medical waste and floatable debris washed ashore and resulted in severe economic losses from fewer tourist expenditures. It is estimated that New York lost between $900 million and $2 billion and that New Jersey lost between $900 million and $4 billion in revenues as a result of these pollution episodes.[17]

The New York-New Jersey Harbor provides important fishing grounds for sport fishermen. Striped bass, fluke, bluefish, and winter flounder are commonly caught by the recreational anglers. In 1991, recreational fishing in New Jersey generated approximately $1.3 billion in economic output and employed nearly 17,000 people. In the same year, recreational fishing in New York generated approxi-

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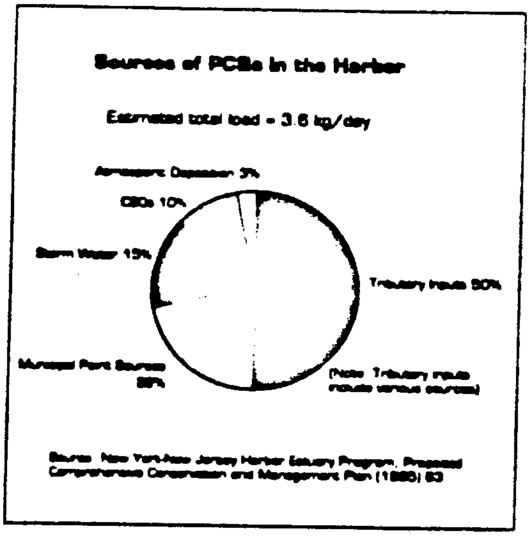

mately $1.4 billion in economic output and employed nearly 18,000 people.[18] In 1991, approximately 491,000 anglers spent over 3.5 million days saltwater fishing off the coast of New York. During the same year in New Jersey, approximately 746,000 saltwater anglers spent over 6 million total days fishing.[19]

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the middle Atlantic region totaled approximately $149 million. Many of the commercially valuable species in the middle Atlantic region depend upon the health of the New York-New Jersey Harbor for survival. In 1994, the State of New York's commercial finfish and shellfish landings totaled approximately 45 million pounds, valued at $43 million. In the same year, New Jersey's commercial finfish and shellfish landings totaled approximately 202 million pounds, valued at $100 million.[20]

The waters of the New York-New Jersey Harbor Estuary have traditionally supported productive finfish and shellfish populations. However, over the past 100 years, there have been significant declines in these populations because of overfishing, habitat destruction, and declining water quality. In the past, oysters and American sturgeon were regularly harvested from the Estuary. However, pathogen contamination and habitat destruction have led to severe declines in oysters such that no commercial harvest exists today. In addition, only a small commercial harvest exists for American sturgeon.[21] A naturally-occurring disease has caused further declines among lobster, crab, and shrimp populations within the estuary.[22]

Today, the leading commercial fisheries in the Estuary are winter flounder, menhaden, bluefish, weakfish, and baitfish. A modest fishery exists for American shad.[23] Hard and soft-shell clams, ocean quahogs, sea scallops, and blue mussels are commercially valuable shellfish found in waters of the Harbor and Bight.[24]

Wildlife

Many wildlife species inhabit the areas surrounding the estuary and rely upon the various estuarine habitats for their survival. The loss and modification of coastal habitat to serve development interests have caused coastal bird and mammal populations to decline in the Estuary area.[25] The coastal habitat which does remain provides critical nesting and foraging habitat for birds and other wildlife species, including the federally threatened piping plover and federally endangered roseate tern. The Arthur Kill area supports nesting herons and egrets. Osprey and hawk populations are beginning to rebound in the area after an absence primarily caused by the use of now-banned pesticides.[26] The extensive riparian area of the Harbor watershed also forms vital habitat for aquatic species.

Although the New York-New Jersey Harbor is rich in aquatic and semi-aquatic species, human impacts, such as, urban growth and toxic pollution, threaten the future of wildlife populations and diversity. As more vegetated land within the Hudson-Raritan Estuary is destroyed by urban development, the preservation and restoration of the remaining natural areas in the Estuary will become increasingly essential to protect wildlife populations and diversity.

Threats to the Estuary

The urbanized nature of the New York-New Jersey Harbor Estuary contributes to many of the water quality and habitat problems of the system. The urban population's impact on the waters presents obstacles to the restoration of the Estuary. The proposed Comprehensive Conservation and Management Plan (CCMP) identifies seven areas where the health of the Estuary is seriously impaired: loss of habitat and living resources, toxic contamination, dredged material management, pathogenic contamination, floatable debris, nutrients and organic enrichment, and rainfall-induced discharges.[27] However, there is a growing belief that the way these problems are addressed should reflect their effects on habitat. Therefore, the threats listed below emphasize the impacts of population growth, and habitat loss, as well as the impacts to habitat from toxic pollution, contaminated sediments, pathogen contamination, floatable debris, and nutrient loadings.

Habitat Loss and Degradation

The shorelines, beaches, and tidal rivers in the Estuary are subject to pressures from urban and coastal development. Constructed piers, bulkheads, and rip-rap; the filling and dredging of wetlands; and the accumulation of floatable debris in marshlands are a few examples of the human activities which have altered the estuarine environment. These structures also disrupt spawning patterns of fresh and saltwater fish by altering natural erosion and accretion processes.

As natural areas diminish and are replaced by impervious surfaces, such as pavement and roofs, the biological integrity of the estuary is seriously impaired. It is estimated that at least 75 percent of the historic tidal wetlands in each of New York City's boroughs and in New Jersey counties surrounding the Harbor have been destroyed. Additional estimates indicate 99 percent of New York City's historic freshwater wetlands have been lost.[28] The cumulative consequences of these lost wetlands are significant as the valuable functions that they perform cannot be matched by human-made structures.

Habitat is also affected by the damming of rivers within the watershed and the diversion of the Harbor and Bight's freshwater to serve municipal and industrial uses. By changing the mixing ratios of fresh- and saltwater and altering the natural vegetation, the aquatic life that use the estuary are negatively impacted.[29] However, pressures to convert more natural areas within the Harbor Estuary into developed land are, unfortunately, likely to continue. Studying the full consequences of future coastal development projects is an essential part of the efforts to restore the New York-New Jersey Harbor Estuary.

Toxic Pollution and Contaminated Sediments

The New York-New Jersey Harbor has suffered from a long history of abuse initiated by industrial and urban development. In 1990, there were 582 industrial and 287 municipal point sources discharging pollution in the Harbor.[30] For decades, toxic contaminants have accumulated in the sediments of the Harbor, posing major threats to aquatic life and surrounding human populations. In the Port Newark-Port Elizabeth complex for example, sediments contaminated with dioxin from a site in the Passaic River continue to enter Newark Bay. Proposed dredging of these toxic sediments has sparked a public debate over the impact sediment disposal would have on the aquatic environment of the Harbor Estuary, on fishery resources, and on New Jersey's commercial and recreational fishing industries.[31]

Toxic chemicals can be found in the waters, sediments, and fish and shellfish tissues throughout the Harbor and Bight. Areas with the greatest concentration of toxic contamination include Newark Bay, the tributaries leading into Newark Bay, and the Kills. Chemicals of concern in the Harbor-Bight include mercury, copper, nickel, lead, cadmium, arsenic, polychlorinated biphenyls (PCBs), dioxin, PAHs, and pesticides.[32]

The bioaccumulation of toxics in the food chain threatens the health of wildlife populations and people throughout the watershed. Fish caught with tumors and other physical abnormalities and birds with reproductive problems are considered to be linked to the toxic pollution in the Harbor/Bight.[33] In addition, consumption advisories for certain fish exist throughout the entire New York - New Jersey Harbor Estuary system. Some examples include: advisories for bluefish, striped bass, American eel, white perch, and white catfish in Sandy Hook and Raritan

Bays; and advisories for all fish, shellfish and crustaceans in the Kill Van Kull.[34] Furthermore, New York has completely closed its striped bass commercial fishery in the Harbor and in portions of the Bight due to high PCB levels.[35] There is growing concern that subsistence fishers and their families' health is at risk because of their above-average consumption of fish and shellfish caught directly from the waters of the Harbor.

Municipal and industrial point sources, atmospheric deposition, stormwater, and combined sewer overflows (CSOs) are leading sources for the loadings of heavy metals into the Harbor. Trends indicate that metal loadings into the Harbor and Bight were reduced between 1985 and the early 1990s, when an industrial pretreatment program became effective and a corrosion control program was established for New York City's water supply.[36] The principal sources of PCBs into the Harbor are tributary flows, municipal point sources and stormwater. Finally, PAHs, which are found in petroleum and other products, are introduced into the Harbor by atmospheric deposition, stormwater, CSOs, and oil and gas spills.[37]

Pathogen Contamination

Pathogens are disease-causing bacteria and viruses found in human and animal wastes which enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted urban stormwater, agricultural runoff, boating waste, and septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in contaminated beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogens in water. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

Pathogen contamination has been a problem in the New York-New Jersey Harbor area for decades. Before passage of the Clean Water Act in 1972, environmental conditions in the New York-New Jersey Harbor were poor. For instance, one-half billion gallons of raw sewage flowed into the Harbor per day; fifty percent of the wastewater treatment plants discharged effluent which had received only primary levels of treatment (the initial phase of sewage treatment which is designed only to remove solids and floatables); and CSOs sometimes occurred even in dry weather.[38] Under- or untreated sewage has caused widespread pathogen contamination in the Harbor and Bight and has devastated many fisheries and shellfish areas.

During the past two decades, wastewater technology upgrades have helped to stem pathogen contamination in the Estuary. Currently, only two treatment plants lack secondary treatment technology (a process which biologically removes much of the suspended solids and pathogen content).[39] Still, malfunctions and system overloads can occasionally lead to discharges of under-treated sewage.

Combined sewer overflows cause significant problems for the health of the Estuary, with estimates of the total number of documented combined sewer outfall pipes reaching 730.[40] CSOs in New Jersey contribute only seven percent of the freshwater input into the Estuary, yet they are the source of over 90 percent of the pathogens entering the system.[41]

Currently, shellfish areas are either closed or restricted in all portions of the Harbor's core area and in many back bay areas near the Bight.[42] In the Bight itself, most waters are approved for shellfish harvesting.[43] The States of New York and New Jersey regularly test their ocean waters for pathogens. However, New Jersey's program has more stringent monitoring and closure protocols that require mandatory closures when a bacteria standard is violated.[44] During 1994, New Jersey beaches in the Harbor area were closed on five occasions for a total of 25 days due to stormwater pollution and suspected sanitary sewer leaks.[45] In the same year, Harbor area beaches on Staten Island, Coney Island, and Rockaway in New York were closed for health reasons.[46]

Floatable Debris

In the late 1980s, national attention was focused on the beaches of New Jersey and New York and public concern was raised after beaches closed because of medical wastes and other trash washing ashore. Types of debris affecting the Harbor-Bight

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include wood, street litter, vegetation, sewage-related waste, fishing gear, and medical waste. Principal sources of this debris are combined sewer overflows, urban stormwater, littering, land-fill operations, and vessels.[47]

The public's disinclination to recreate on littered beaches and extended beach closures can cause significant economic losses to the region. During the infamous summers of 1987 and 1988 when the medical waste and other debris that washed on the shores steered tourists away in droves, the States of New York and New Jersey lost between $1.8 and $6 billion in recreational and tourist revenues.[48] The Army Corps of Engineers data indicates that in 1987 floating garbage caused an estimated $48 million worth of damage to shipping vessels.[49] In 1989, the area extending from the Upper Bay to the Raritan Bay was afflicted with 164 garbage slicks.[50] These impacts also result in population declines in fish and wildlife species due to the entanglement in and ingestion of wastes.

On September 17 and 18, 1994, volunteers cleared 102,758 pounds of marine debris from 543.1 miles of New York's beaches. Of the total amount of marine debris collected, approximately 59.4 percent was plastic, 13.04 percent was glass, 10.2 percent was metal, and 17.36 percent was from other materials.[51] In the same year on October 15 and 22, volunteers cleared 73,782 pounds of marine debris from 171 miles of New Jersey's beaches. Of the total amount of marine debris collected, approximately 66.3 percent was plastic, 10.4 percent was paper, 8.2 percent was metal, and 15.1 percent was from other materials.[52] In New Jersey, a coordinated campaign to sweep beaches of debris is underway. This project, called Operation Clean Shores, collects 10 million pounds of debris each year.[53]

Nutrient Loadings

Excessive nutrient inputs, also called eutrophication, into the Harbor and Bight are a serious problem. Excessive levels of these nutrients, such as nitrogen and phosphorus, stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen for other aquatic life. Low oxygen conditions (called hypoxia) can result in large fish kills. Hypoxic conditions often occur in portions of the Harbor and Bight. Throughout the Harbor this problem has resulted in the destruction of fish and shellfish populations and habitat.[54]

The leading sources of nutrients into the New York-New Jersey Harbor are municipal and private wastewater and sewage treatment facilities, atmospheric deposition, tributary inputs, urban stormwater, agricultural runoff, boater discharges, and combined sewer overflows. Every day, about 2.6 billion gallons of wastewater are discharged into the Estuary by New York and New Jersey sewage plants alone.[55] Reducing the nitrogen loadings from these discharges is key to eliminating the hypoxic conditions of the Estuary.

The New York-New Jersey Estuary Project

In 1987, the New York - New Jersey Harbor Estuary was designated by Congress as an estuary of "national significance," and was initiated into the National Estuary Program (NEP) under the Clean Water Act. The following year, the New York-New Jersey Harbor Estuary Project (HEP) was formed to coordinate the drafting of a Comprehensive Conservation and Management Plan (CCMP) to restore the Harbor Estuary and the adjacent New York Bight. The draft CCMP has been endorsed by the HEP Policy Committee and awaits approval by the EPA Administrator and State Governors in July, 1996.

The HEP has assumed a tremendous challenge, as compared to some of the other NEP projects. The study area includes one of the most complex estuarine areas and some of the most diverse user groups. In an attempt to provide a forum for all groups interested in the Estuary, the HEP has organized a partnership among federal, state and local agencies, scientists, fishing organizations, environmental groups, business, industry, civic groups and other members of the public to participate in the Manage-

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ment Conference and the drafting of the CCMP. The proposed CCMP identifies seven areas where the health of the Estuary is seriously impaired: loss of habitat and living resources, toxic contamination, dredged material management, pathogenic contamination, floatable debris, nutrients and organic enrichment, and rainfall-induced discharges.[16]

To begin to address these concerns the HEP has taken on several initiatives. The HEP has established waste-load allocations to limit the influx of toxic discharges for heavy metals commonly found in the Harbor and its sediments. Models for toxics monitoring are being developed and bio-monitoring of sediment movements is being initiated to prevent the continued degradation of water quality.[17] To educate the residents within the watershed, a "Lifestyle Guide" was developed to encourage oil recycling, water conservation and boater pollution prevention.

The HEP has also developed a long-term strategy to address the floatable debris problem, including the Operation Clean Shores program in New Jersey which has removed 5,000 tons of debris from beaches.[18] In addition, the HEP will coordinate its efforts with the Hudson River Estuary Program which manages living resources from Troy to the Verrazano Narrows.[19] Most recently, the States of New York and New Jersey have prioritized the protection of coastal habitats in the watershed.

In late 1993, in an attempt to ensure that the CCMP would reflect public priorities for restoring the Estuary, the Citizens Advisory Committee, the Science and Technical Advisory Committee and 32 grassroots organizations co-sponsored eight regional pre-CCMP public meetings. Over 350 persons participated in these meetings and clearly reiterated several key priorities, including the need to: enhance public education and outreach and to make special efforts to ensure participation by all income, age and ethnic groups; increase the focus on habitat protection; place particular emphasis on beneficial re-use when determining dredged disposal options; use watershed planning as a means to limit waterfront development and to emphasize the cumulative environmental impacts of upriver actions; ensure better enforcement of the laws and stricter penalties; and to abate pollution in general.

Another round of public hearings took place after the release of the final CCMP in 1995. However, the end result of this process has been met with mixed reaction. Citizens groups still do not feel that these comments will be actively incorporated into the final plan.

Unfortunately, many citizens groups in the HEP believe that most of the actions proposed in the Draft CCMP will result in little more than maintenance of the 'status quo'. In addition, they believe that the proposed CCMP still does not adequately reflect their major concern expressed at public hearings: the loss of habitat. They believe that all the sections of the Draft CCMP that address specific impacts (Toxics, Pathogens, Floatables, etc.) should be related to the effects these problems have on habitat for both people and wildlife. In this way, the CCMP will reflect an ecological approach to managing the Harbor-Estuary that will benefit both human and wildlife communities, and sustain the economic benefits of the Estuary to the region and nation for many years to come.

In addition, public interest groups believe that it is essential to obtain a strong commitment from the States to undertake actions that will result in positive, measurable improvements to the Estuary if the goals of the Plan are to be attained.

National Coastal Caucus

The Baykeeper Program is devoted to protecting and preserving historic and environmentally significant areas of coastal land and waterways of the New York/New Jersey Harbor Estuary. The Baykeeper Program was established in 1990 as a program of the American Littoral Society, a national, non-profit public interest organization founded in 1961 to encourage a greater understanding of aquatic environments and to provide a unified voice advocating protection of the delicate fabric of life along this shore. The Society, and the Baykeeper Program are both headquartered at Sandy Hook, New Jersey.

Baykeeper is one of the "keeper" programs established throughout the country. The Baykeeper and his staff, along with dozens of concerned citizen volunteers, participate in varied activities designed to preserve and protect the Harbor Estuary's ecosystem.

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They work in cooperation with federal, state and local government agencies, and coordinate their efforts with those of other environmental and conservation organizations.

Members, staff and boardmembers of the Baykeeper and the ALS have been involved in numerous capacities in the development of the CCMP and in monitoring of the interim actions and other steps taken to implement the plan. Baykeeper has served as a member of the Habitat Work Group and the Citizens Advisory Committee, and ALS has served as host for public hearings on the Draft CCMP.

Efforts by grassroots groups, such as Baykeeper, focus on ensuring federal and state commitments to achieving the objectives and recommended actions in the CCMP. Baykeeper and other groups have also been successful in advocating an ecosystem-based habitat focus for the entire CCMP.

Baykeeper and ALS have recently begun work on a new grassroots habitat effort called the "Hudson-Raritan Habitat Initiative" (HRHI). HRHI is designed to help guide and coordinate public and private planning and resources for habitat preservation, restoration, and long-term management projects in the Estuary and its watersheds. While HRHI is not affiliated with the HEP, its work directly addresses the recommendations contained in seven of the twelve objectives of the CCMP.

Another Baykeeper initiative is called the Fisher's Information Network. The goal of the Network is to provide information to the citizens of Newark about the dangers and health concerns of eating fish and crabs from the Newark Bay and the Passaic River. The target audience is pregnant and nursing women and subsistence anglers of all ethnic groups and incomes, especially those who do not speak English or are of low income, who may not be aware of State issued advisories. This goal is achieved through the distribution of a fish advisory brochure; posting of multi-language, illustrated signs during the fishing season that state the reason one is not supposed to take, eat or sell fish or crabs from the targetted waterways; a survey aimed at anglers to determine whether they are fishing for subsistence or recreation; and working with health clinics and social services organizations to distribute a survey to determine their clientele's cooking, cleaning, and source of fish.

Other programs conducted by the Baykeeper include the Baykeeper Citizen Volunteer Water Monitoring Program and the Baykeeper Boat Auxiliary of volunteers that spot and report violations of environmental regulations.

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Peconic Bays
in New York

In 1995, as the Brown Tide once again started inundating our beautiful bay system, discouragement crept in. Where had our courage gone? Our steady faith in the face of adversity? It's still there, it just seems to get clouded over at times, as do the Bays with Brown Tide. We must have faith that our positive actions are having a positive effect. Just remember how beautiful, clear, and clean the Bays were last year without the Brown Tide. And how these same crystal clear waters brought us the best scallop harvest since the Brown Tide decimated this economic mainstay of the East End in the mid-1980s. We ARE making a difference. Let us continue to do so!

—Gayle Marriner-Smith, President
Save the Peconic Bays

Portrait of the Bays

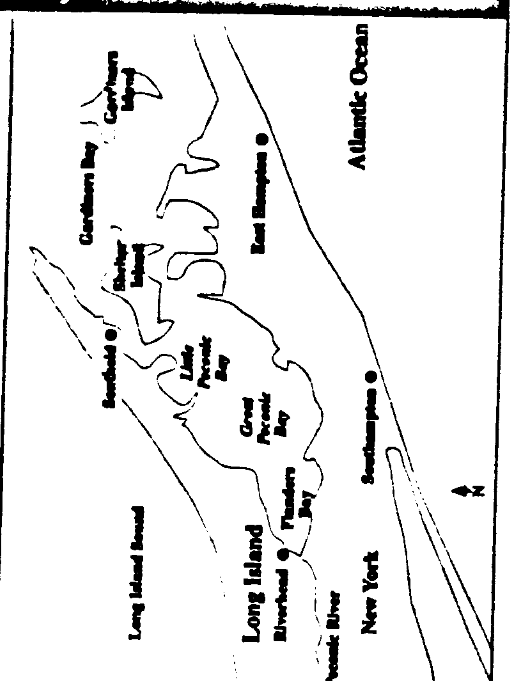
The Peconic Estuary Program is examining the water quality and habitat problems of the Peconic Bays and the impact that the greater watershed area has on the estuarine system. The Peconic Bays system is situated about 80 miles east of New York City, between the North and South Forks of eastern Long Island, New York. The system is comprised of over 100 distinct bays, harbors, embayments, and tributaries.[1] The four largest bays in the system are Great Peconic Bay, Flanders Bay, Little Peconic Bay, and Gardiners Bay. The system's surface water area measures approximately 100,000 acres.[2] The average

Peconic Bays

Area of surface water	100,000 acres
Area of watershed	110,000 acres
Average depth	5 to 21 feet
Shoreline	340 miles
Population	115,000 people
Values	• Fisheries generate $43 million*
	• Boating generates $200 million
	• 125 species of birds breed in the Peconic Bays
Threats	• Brown tide
	• Nutrient loadings
	• Pathogen contamination
	• Habitat loss and degradation
	• Floatable debris
CCMP status	Draft to be completed in 1996

Designated as a "Nationally Significant" Estuary in 1992.

*State figure



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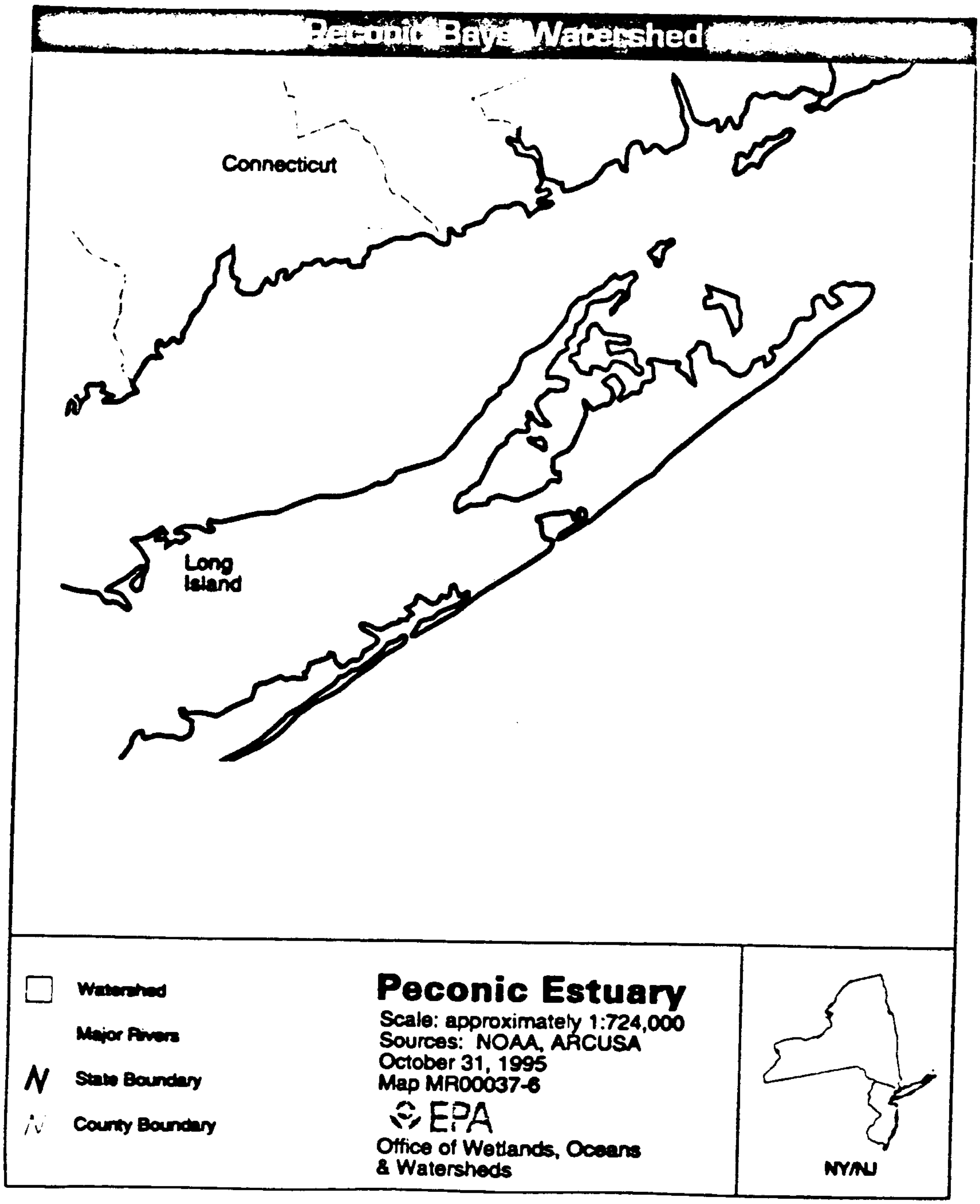

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depth of the marine waters ranges from five feet in Flanders Bay to 21 feet in Little Peconic Bay.[3] The flushing time of the Bays (the time it takes to recycle the total amount of water in the estuary) varies from approximately three months in western Flanders Bay to three weeks in the far eastern portions of Gardiners Bay.[4]

The watershed area of the Bays covers 110,000 acres of land.[5] The watershed's western boundary is marked at the headwaters of the Peconic River. Montauk Point and Plum Island form the watershed's eastern boundary. A total of 340 miles of coastline border the estuarine system.[6]

Freshwater draining from land intermixes with saltwater from oceans to create productive estuaries such as the Peconic Bays. In the Peconic estuary system, freshwater is delivered by the Peconic River, other streams and creeks, and groundwater flows. A wide passage at the eastern end of the system connects the estuary with the ocean.

The Peconic Bays' watershed area is the year-round home to approximately 115,000 people and contains all or part of the six "East End" towns of Long Island — Brookhaven, East Hampton, Riverhead, Shelter Island, Southampton, and Southold.[7] The population is projected to increase by 21,000 people by the year 2000.[8] Unlike many Atlantic Coast estuaries, the watershed area of the Peconic Bays is lightly populated and undeveloped. Almost 24 percent of the land in the watershed is used for recreation and "open space;" 23 percent of the land is used for residential, commercial, and industrial purposes; and 11 percent is used for agricultural purposes.[9]

Most of the estuary's primary habitats — sandy beaches, cliffs, dunes, salt marshes, and freshwater wetlands — remain in a fairly natural condition. Over 3,600 acres of tidal wetlands are located in the estuary system.[10]

Values of the Bays

The Peconic estuary system is esteemed for both its rarity and diversity of habitats and wildlife. The Nature Conservancy designated the estuary system as one of the "Last Great Places" in the Western Hemisphere. The system includes the internationally rare dwarf pine plains and 14 other ecosystems noted for their rare occurrences on Long Island.[11] Also, over 40 areas in the system have been chosen by the New York State Coastal Management Program as significant coastal fish and wildlife habitat.[12]

The natural resources of the Bays are not just renowned for their ecological importance, they are also economically significant. A community survey conducted by the Suffolk Community College showed that 81 percent of the area's residents believe the Peconic Bays are "very to extremely important" to the local economy.[13] Maintaining a healthy and productive estuary is a clear objective in ensuring a sound future for the coastal communities.

Recreation/Tourism

The Peconic estuary is an important recreational resource for the residents and visitors of the area. Over 5,000 acres of the watershed are publicly-owned parklands, recreational areas, and wildlife refuges.[14] In addition, there are 30 public beaches, 69 marinas, and 14 public boating launch sites along the coasts.[15] Boating, hiking, sport fishing, camping, scuba diving, and biking are some of the more popular recreational activities to enjoy in the Peconic Bays area.

Tourism is one of the leading industries in the area. During the summer months, the area population exceeds 280,000 people — a 143 percent increase from the year-round population.[16] By the year 2000, the area's summer seasonal population is projected to reach 365,000 people.[17] The estimated value of tourism throughout Long Island is $7-9 billion.[18]

Recreational fishing and boating are other important components of the local economy. Direct boating revenues in the Peconic Bays area exceed $200 million annually.[19] In addition to the open estuary water, anglers fish along the rivers, creeks, and shore areas of the Bays. According to recreational use surveys, over 348,000 anglers fish on Long Island.[20] Over 80 fish species, including winter flounder, striped bass, bluefish, snapper, weakfish, porgy, and hard clams are commonly caught in the Peconic system by sport anglers and recreational clammers.

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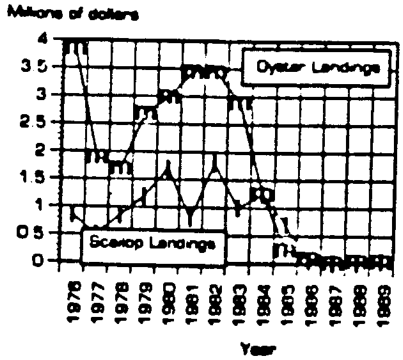
Oyster and Scallop Landing Declines in Peconic Estuary



Source: Suffolk County Department of Health Services, Brown Tide Comprehensive Assessment and Management Program 1992 (Volume I) 2-50,2-53.

In 1991, 491,000 saltwater anglers spent approximately 3.6 million days fishing in waters off the New York coast.[21] The Peconic Bays are important to the State's saltwater fishing industry for their critical role in providing habitat for juvenile fish. Also in 1991, the State of New York's fresh- and saltwater recreational fishing industries generated approximately $1.4 billion in economic output and employed nearly 18,000 people.[22]

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the Middle Atlantic region totaled approximately $149 million.[23] Many of the most valuable species in the region, such as bay scallops and hard clams, depend upon the health of the Peconic Bays for survival. In 1994, the State of New York's commercial finfish and shellfish landings totaled approximately 45 million pounds, valued at $43 million.[24]

The Peconic Bays have an extensive fishing and maritime heritage. Historically, bay scallops, oysters, hard clams, and blue mussels have been the leading fisheries of the estuary. In 1982, bay scallops caught from the estuary comprised almost 28 percent of the nation's total bay scallop landings.[25] The dockside value of the estuary's bay scallop fishery in the early 1980s was as high as $1.8 million.[26] Since 1985, an unpredictable and recurring Brown Tide has decimated bay scallop populations. Landings of bay scallops, which between 1966 and 1986 averaged 271,000 pounds annually, dropped to only 250 pounds in 1988.[27] The 1988 value of the bay scallop harvest was just $2,300.[28]

In the late 1800's, oyster harvesting began in Peconic Bays and became a productive fishery of the estuary. In 1982, almost 800,000 pounds of oysters with a value of approximately $3.4 million were harvested from the Peconic system.[29] After the Brown Tide bloom devastated oyster production, the value of the oyster harvest plunged to less than $10,000 in 1987—a 99.7 percent drop from 1982.[30] The scallop and fish populations are showing some signs of rebounding after the economically devastating Brown Tide blooms of the 1980s.

Wildlife

The variety of habitats found in the Bays system support a great diversity of wildlife, including migratory birds and a number of imperiled species. Birds migrating along the Atlantic Flyway use the Peconic estuary system for resting, feeding, and wintering grounds. Scoters, mergansers, black ducks, mallards and Canada geese can be found using the habitats of the system. A New York State inventory of breeding bird species found that 125 of the 245 bird species which breed in the State use the Peconic Bays area for breeding grounds.[31]

A number of nationally protected, endangered and threatened species inhabit the Bays system. Endangered species which use the Peconic Bays system include the Kemp's ridley turtle, loggerhead sea turtle, leatherback sea turtle, green sea turtle, and roseate tern. In addition, the threatened piping plover dwells in the area.[32]

Threats to the Bays

During the 18th and 19th centuries, numerous sailing vessels used in the whaling, fishing, and shipping industries were based on this area of Long Island. The maritime ports of Riverhead, Hampton Bays, and Southold prospered during these days.

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During the 20th century, scallop and oyster harvests added to the national reputation of the Peconic estuary. Today, the water-based economy of the East End is threatened by Brown Tide blooms and increasing pollution, especially in the western portion of the estuary.

The major threats to the estuary as identified by the Peconic Estuary Program are the Brown Tide, nutrient loading, and pathogen contamination. The adverse impacts of increased development and recreational use on habitats and wildlife are additional concerns.

Brown Tide

The most overwhelming problem of the Peconic Bays system is the Brown Tide, an algal bloom of the species *Aureococcus anophagefferens*. The microscopic algal bloom was first detected in the Peconic system in 1985 and was, at the time, an unknown alga species. Since then, it has reappeared in 1986, 1987, 1988, 1990, 1991, 1992, and 1995. The appearances and durations of the Brown Tide blooms are unpredictable. The suspected causes of the Brown Tide include organic nutrients, chelators such as citric acid, and certain metals such as iron, selenium, vanadate, arsenate, and boron.[33] The principal sources of the suspected causes vary. The chelator citric acid is a detergent additive; arsenate is used in fertilizer and is a by-product of fossil fuel combustion; boron is derived from soap products; and vanadate occurs from the burning of oil and coal.[34] Excessive inputs of nitrogen and phosphorus, which have been attributed to large, destructive algal blooms in other estuaries, have neither been identified nor eliminated as a cause of Peconic Bays' Brown Tide.

Although the alga itself is microscopic, past blooms have grown to cover large portions of the surface water of the Peconic estuary system. The most frequent locations of the Brown Tides in this area have been in the Peconic and Flanders Bays and the South Shores bays.[35] Flanders Bay and West Neck Bay, bordering Shelter Island, have experienced some of the most severe Brown Tides during the past decade.[36]

The Brown Tide inhibits the growth of plankton, the basis of the estuarine food chain. It is also responsible for virtually eliminating the bay scallop and oyster populations, depleting other shellfish and finfish populations, and decimating eelgrass beds of the estuary. The Brown Tide grows so thickly in the estuarine waters that it blocks the sunlight needed by eelgrass for growth. As the coverage and density of eelgrass decreases, juvenile aquatic species lose the vital spawning and nursery habitat that the submerged vegetation provides. The severe losses of scallops and oysters have devastated the local fishing industry. Following the Brown Tide blooms, the annual landings and dockside values of scallops and oysters fell to less than four percent of the total shellfish harvest for both weight and value. Scallops and oysters had accounted for over 80 percent of total pounds landed and over 90 percent of total value prior to the blooms.[37]

The occurrence of Brown Tide has secondary effects. After the bay scallop fishery collapsed, commercial fishermen began harvesting hard clams to such an extent that sustainable hard clam populations quickly became threatened. In addition, East End communities have suffered economic losses due to reduced recreational opportunities around the estuary.[38]

The Brown Tide problem has been the subject of numerous studies. The Peconic Estuary Program is continuing to fund extensive research and monitor the impacts on and restoration of eelgrass beds and bay scallop populations.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to estuaries by sewage treatment plants, polluted stormwater, agricultural runoff, atmospheric deposition, septic system operations, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Peconic estuary system. As the algal blooms grow, they not only block sunlight needed by the submerged aquatic vegetation of the estuary, but also require a great amount of dissolved oxygen for decomposition, which reduces the levels of oxygen needed by other aquatic life. Low oxygen conditions (called hypoxia) can cause large fish kills.

Nitrogen loading is a particular concern in the western portion of the system (Flanders Bay and the mouth of the Peconic River). In this portion of the estuary, flushing is poor, hence, it is more sensitive to pollution impacts than the eastern section, which consistently has good to excellent water quality.[39] Significant sources of nitrogen inputs to the western Bays system include Meetinghouse Creek, the Peconic River, and the Riverhead Sewage Treatment Plant.[40] Additional sources of nitrogen include sediment flux (the chemical exchange between sediments and the water column), sanitary systems' contributions to groundwater underflows, atmospheric deposition, and stormwater carrying fertilizers applied to residential and agricultural lands.[41]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, combined sewer overflows (CSOs), polluted stormwater, agricultural runoff, boating waste, and septic systems. Stormwater, which carries animal wastes from residential lawns and agricultural lands, is the principal source of pathogen contamination in the Peconic Bays system.[42] Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result even from the incidental ingestion of pathogen-contaminated waters. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

In the Peconic Bays, over 4,000 acres of the estuary's shellfish beds are closed or harvest-restricted because of excessive levels of fecal coliform bacteria.[43] Many of the impaired shellfish beds are situated in semi-enclosed embayments and near-shore areas. In addition to shellfish closures, the Bays are sometimes closed to recreational uses. The Suffolk County Health Department regularly tests the beaches along the Peconic Bays for the presence of bacteria and closes the beaches when State-established bacterial standards are exceeded.[44] After significant rainfalls, the County also posts bathing advisories to warn the public about impaired water quality.[45] During the summer of 1995, none of the beaches along the Peconic Bays system were closed due to bacterial contamination.[46]

Habitat Loss and Degradation

A 1988 survey of land uses in the Peconic Bays area indicated that 46 percent of the land was either vacant or serving agricultural purposes and available for development.[47] As both the year-round and seasonal populations of the Peconic Bays area expand, pressures to develop rural and vacant lands will mount, resulting in more pollution. Replacing natural lands with impervious surfaces, such as pavement and roofs, causes greater flows of stormwater carrying higher concentrations of nutrients, toxic metals, organic chemicals, and pathogens to discharge into the Bays.

Eelgrass, tidal wetlands, and freshwater wetlands will be affected by increased development in the watershed, putting further stresses on the valuable fish and shellfish resources of the estuary. Tidal wetlands and eelgrass beds provide important nursery and spawning grounds for commercial finfish and shellfish. The distribution of eelgrass beds within the Bays is already in serious decline due to the Brown Tide blooms.[48] The impact of greater nutrient inputs both from contaminated stormwater and groundwater underflow could cause nutrient-based algal blooms which destroy eelgrass beds.

Between 1976 and 1988, the Peconic Bays area only lost 21 acres of tidal wetlands and 26 acres of freshwater wetlands.[49] Avoiding losses of these important habitats is important to the communities of the East End. These wetlands provide countless benefits to coastal communities by reducing the impact of coastal storms, absorbing excess waters during heavy rains, filtering pollutants before they contaminate the Bays, serving as recreation sites, providing habitat for waterfowl, and performing other key functions.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The

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amount found in just two days was staggering — on September 17 and 18, 1994, volunteers cleared 102,758 pounds of marine debris from 543 miles of New York's beach areas. Of the total amount of marine debris collected, 59.4 percent was plastic, 13 percent was glass, 10.2 percent was metal, and 17.4 percent was from other materials.[9]

The Peconic Estuary Program

The Peconic Estuary Program (PEP) was formally accepted into the National Estuary Program on September 9, 1992 when it was officially designated as an estuary of "national significance" under the Clean Water Act. The Suffolk County Department of Health Services, Office of Ecology was established as the central program office to oversee the drafting of a Comprehensive Conservation and Management Plan (CCMP) for the Bays. Since the inception of the PEP in April, 1993, it has worked in cooperation with government agencies from federal, state, and local levels, technical experts, citizens, business interests, baymen, boaters, and civic groups. The PEP will be conducted during a four-year period rather than the five-year standard project period for other estuaries because of the work already performed by the Brown Tide Comprehensive Assessment and Management Program (BTCAMP). A draft of the CCMP is scheduled to be released during the summer of 1996 and the final plan is scheduled for completion in July, 1997.

The Peconic Estuary Program has developed an Early Action Plan, using the data gathered in the BTCAMP plan conducted by Suffolk County as its foundation. The Action Plan which was finalized in December, 1994, outlines recommendations for specific management actions that will be incorporated into the CCMP. One of the objectives of the Plan calls for a "no net increase of nitrogen" for the tidal Peconic River and Flanders Bay. In the eastern portions of the Estuary, a "no substantial degradation" policy has been established. The PEP also carried out other types of actions identified in the Plan, such as a program to plant bay scallops in Flanders Bay and to monitor and evaluate the repopulation process. To reduce coliform and nutrient loadings, the plan also called for the construction of a grass filter strip to control stormwater discharging into Gardiners Creek, and implementation of Open Marsh Water Management techniques at Long Beach in Southold.

The PEP is conducting a full range of other activities. For example, to address one of the Bays' most severe problems, the Brown Tide, the PEP is expanding and refining the water quality work of the BTCAMP. After the 1995 outbreak of Brown Tide, PEP organized a Brown Tide Summit attended by prominent algal experts. A result of this meeting was the formation of the Brown Tide Research and Management Initiative. Proposals to fund the Initiative have been sent to local, state, and federal governments and agencies. Suffolk County's monitoring program for Brown Tide outbreaks has expanded with the assistance of the NEP. Information gathered from over 30 locations and eight point sources is being used in a model to facilitate improvements in water quality in the main bays, peripheral creeks, and embayments. In addition, the PEP is adding an important natural resources component in an effort to preserve the Bays. The PEP is using Geographic Information Systems (GIS) technology to inventory and map wetlands, submerged aquatic vegetation, and hard clam beds. The data will be used to aid in integrating water quality and natural resource issues. Numerous other efforts are underway, including stormwater control projects at Southold and Shelter Island to limit nitrogen and fecal coliform pollution; the restoration of alewife runs along the Peconic River in Riverhead; and testing ultraviolet disinfection processes at the Shelter Island sewage treatment plant to replace chlorine.

The PEP has set forth an ambitious agenda for a four-year project. It will be a testament to the desire to protect the Bays if all of the stakeholders involved in the project are willing to take responsibility for ensuring that the plan is fully implemented. History has shown in some of the other NEPs that it may take substantially longer to reach agreement among all of the stakeholders on some of the more difficult

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decisions. To date, however, there appears to be a high level of participation from both the environmental and business communities. There also seems to be a good mix of early action projects and steps toward longer term planning.

National Coastal Caucus

Save the Peconic Bays, Inc. is a non-profit organization dedicated to the protection, wise management and enjoyment of Long Island's coastal waters with special concern for the Peconic Bay Estuary. Founded in 1988 to enlist support to address the Peconic Estuary's problems, including the Brown Tide, Save the Bays is an educational organization working to raise public awareness of the problems and possible solutions concerning the system's waters. Save the Peconic Bays was the umbrella organization that spearheaded the effort to include the Peconic Bays into the National Estuary Program.

Members, board and staff of Save the Peconic Bays (SPB) have served in numerous capacities in the development of the CCMP and the implementation of the Action Plan. SPB has been involved in the NEP since its inception. In fact, between 1988 and 1992 the organization had two major goals: 1) to raise public awareness regarding the Bays' problems and to develop solutions to those problems; and 2) to include the Peconic/Gardiners system in the NEP. Today, the President of Save the Bays serves as the PEP Public Participation Coordinator, and the organization has representation on the Citizens Advisory Committee.

With help from private citizens, progress has been made on two priority natural resource issues: protecting scallops and restoring eelgrass beds. Major seeding and planting efforts are already underway. As a result of the reseeding efforts and wetlands restoration projects, the bay scallop returned to the Bays in 1994, yielding the best harvest since the Brown Tide blooms of the 1980s.

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Puget Sound
in Washington

Puget Sound, a fjord-like estuary in Washington State, adjoining the inland marine waters of British Columbia, is home to orca whales, salmon runs, an internationally-significant shellfish industry, and 3.5 million people. The Sound's water quality is threatened by toxic chemicals accumulating in the sediments and poisoning the food chain; by polluted runoff that has closed nearly half of the commercial shellfish harvest areas; by sprawling growth that damages wetlands, streams and other habitat; and by the ever-present risk of oil spills. A landmark estuary management plan, developed in the 1980's by the Puget Sound Water Quality Authority, is at risk of never coming to fruition: in 199[illegible], the Legislature failed to reauthorize the Authority, cut back on water quality funding, and tried to destroy the State's oil spill prevention program.

—Kathy Fletcher, Executive Director
People for Puget Sound

Portrait of the Sound

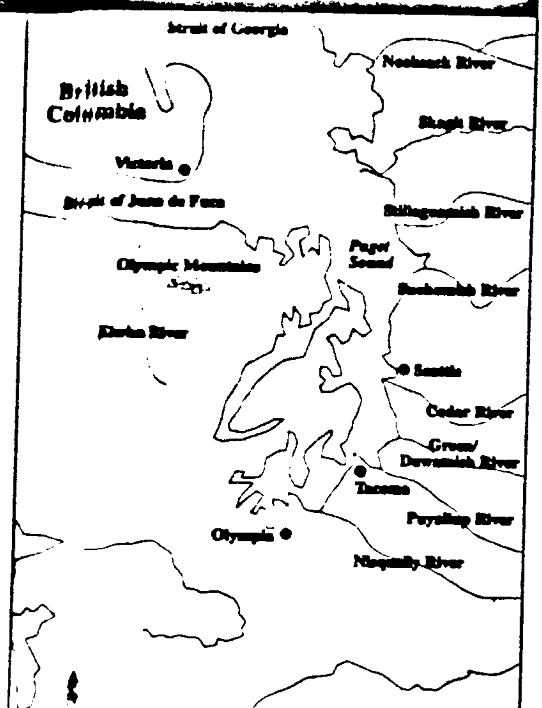
The Puget Sound Water Quality Authority has worked since 1985 to protect and restore the water quality and habitat of Puget Sound and is examining

Puget Sound

Area of surface water	931 square miles
Area of watershed	16,000 square miles
Population	3.5 million people
Average depth	450 feet
Values	• Tourism generates over $4 billion • Fisheries generate $175 million* • Home to four National Wildlife Refuges
Threats	• Toxic Pollution • Oil spills • Pathogen contamination • Habitat loss • Land use and population growth • Floatable debris
CCMP status	Approved in 1991

Designated as a "Nationally Significant" Estuary in 1988.

*State figure



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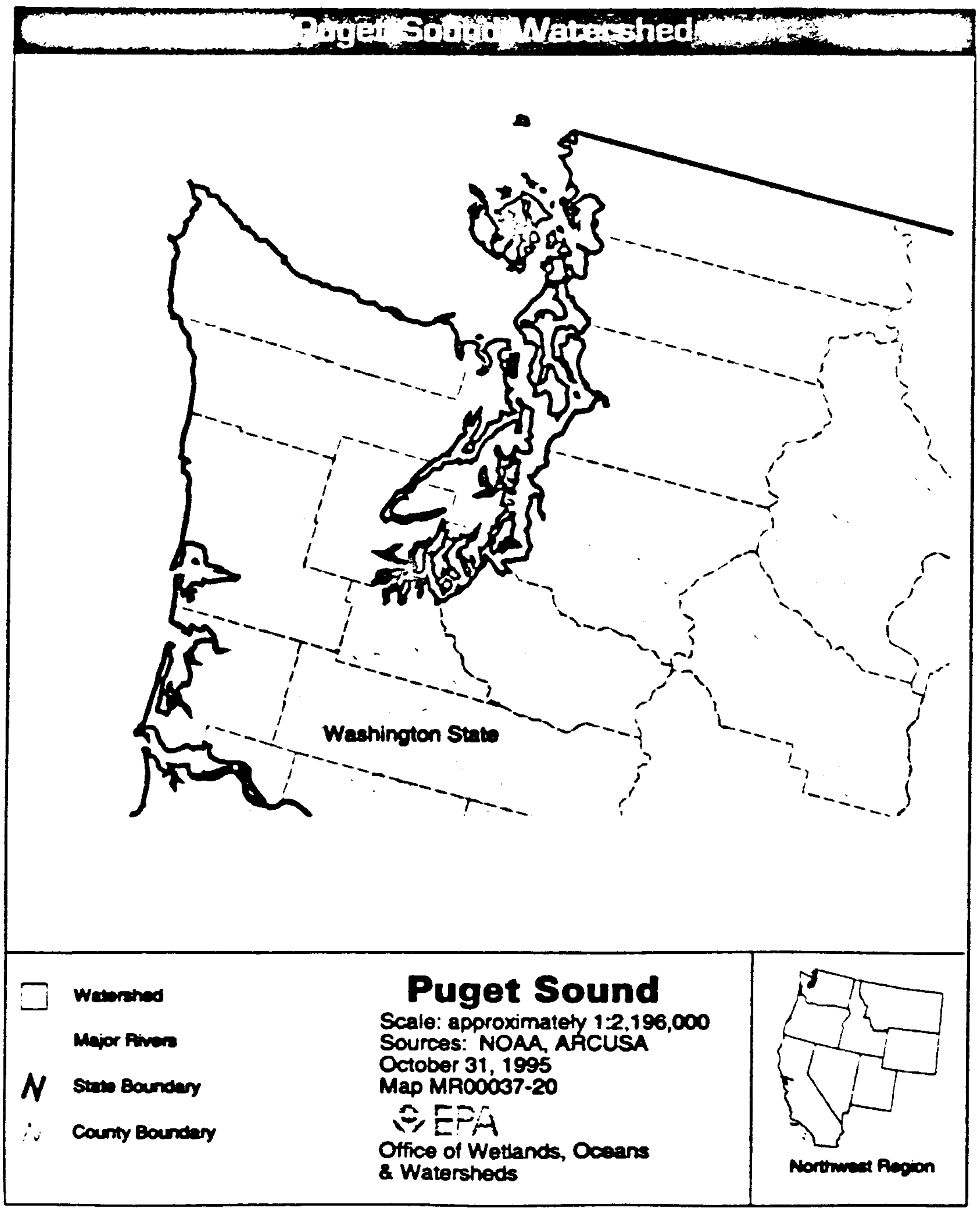
Puget Sound Watershed
Washington State
Watershed
Major Rivers
State Boundary
County Boundary
Puget Sound
Scale: approximately 1:2,196,000
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-20
EPA
Office of Wetlands, Oceans
& Watersheds
Northwest Region

the impact that the greater watershed area has on the estuarine system. Puget Sound is a protected inland sea in northwestern Washington. The Sound is a deep estuary which was formed by the retreat of glaciers 13,000 years ago. Averaging 450 feet deep, the Sound is deeper in the northern end than in the southern portion. At its deepest point, Puget Sound measures over 930 feet deep.[1] The water surface area of the Sound is 931 square miles.[2]

Puget Sound's watershed area is 16,000 square miles,[3] of which only 20 percent is actually water.[4] The eastern borders of the watershed are the Cascade Mountains and the western borders are the Olympic Mountains. Waters drain from the crests of these mountain ranges into the Sound. The watershed's population exceeds 3.5 million people — more than two-thirds of the entire State's population.[5] Over 120 cities and counties, as well as 16 tribes, are located within the Puget Sound watershed area.[6] Some of the largest cities in the watershed are Seattle, Tacoma, Olympia, and Bellingham. A similar mosaic of people and jurisdictions exists on the Canadian side of the shared marine waters of the Sound and Straits, where Vancouver and Victoria are the largest cities.

Freshwater draining from land intermixes with saltwater from oceans to create productive estuaries such as Puget Sound. Saltwater from the Pacific Ocean enters the Sound through the Strait of Juan de Fuca. Freshwater is delivered to the estuary by over 10,000 streams and rivers, groundwater underflow, and direct precipitation.[7] Approximately 39 million acre-feet of freshwater flows from the rivers in the watershed into Puget Sound each year.[8] Ten river systems — the Nooksack, Skagit, Snohomish, Stillaguamish, Cedar/Lake Washington Canal, Green/Duwamish, Puyallup, Nisqually, Skokomish, and Elwha Rivers — account for over 85 percent of the freshwater flowing into the Sound.[9]

The many islands, inlets, and narrow passages in the Sound actually inhibit circulation. As a result, it sometimes takes up to 300 days to replace or "flush" water in some parts of the Sound, making the estuary susceptible to the retention of harmful pollutants that settle out as sediments on the floor of Puget Sound.[10]

Predominant habitat types in the Puget Sound region include open water, islands, beaches, bluffs, deltas, mudflats, and wetlands. The shoreline of the greater Sound area stretches for over 2,250 miles.[11]

Values of the Sound

The global reputation of the Pacific Northwest is strongly tied to its legendary waters. Whether it's the Olympic Coast, the salmon runs, or Puget Sound itself, local residents take pride in their waters. Tourism and water-based recreational activities around the Sound provide substantial economic benefits for local communities. The estuary's fisheries and diverse wildlife are other important qualities which enhance the value of the Sound.

Recreation/Tourism

Puget Sound receives over three million visitors each year, many of whom come purely to enjoy the beautiful coastlines and participate in numerous recreational activities.[12] Tourism generates up to $4 billion and supports over 60,000 jobs in the Puget Sound region every year.[13]

Recreational attractions are plentiful in and along the Sound. Dozens of Washington State parks, recreational areas, natural areas, and wildlife refuges border the shore of the Sound, providing opportunities to camp, canoe, kayak, fish, sail, bird watch, and swim. The Puget Sound region boasts the highest per capita rate of boat ownership in the nation, with a total of over 300,000 pleasure boats.[14]

Recreational fishing is an especially popular activity for the residents and visitors of Washington. In 1991, freshwater and saltwater sport fishing generated approximately $1.9 billion in economic output and supported over 27,000 jobs.[15] In the same year, approximately 504,000 saltwater anglers fished a total of 3.5 million days off the Washington coast.[16] Puget Sound provides valuable recreational fishing areas for the State's sport fishers and serves as important nursery, spawning, and feeding grounds for many prized sport fish that could be caught outside of the Sound. Recreational harvesting of shellfish is also prevalent in the Sound. Recreational clammers harvest more than 3.3 million pounds of clams each year, generating over $11 million for the local economy.[17]

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the Pacific region (excluding Alaska) was approximately $401 million. Many of the commercially valuable species found in the Pacific region depend upon the health of Puget Sound for survival. During the same year, the State of Washington's commercial finfish and shellfish landings totaled approximately 528 million pounds, valued at $175 million.[18]

In 1990, the most recent year for which Sound-specific data are available, the total value of the Sound's commercial fisheries was $73.5 million.[19] Although the 1990 harvest was substantial, its economic value was significantly lower than the 1987 harvest which was approximately $125 million.[20] In fact, commercial fishing harvests are at their lowest levels in 55 years. The populations of many of the Sound's fish are declining, and as a result, officials are closing or restricting many harvests. For instance, different types of harvest restrictions are in place for Pacific cod, Pacific herring, Pacific hake, pollack, lingcod, rockfish, English sole, and salmon.[21]

Water pollution, loss of habitat, overharvesting, and poor forest practices threaten shellfish, salmon and other finfish. The depleted salmon runs of the region are of special concern. It is estimated that some salmon runs have been reduced by as much as 90 percent.[22] Nine Puget Sound salmon stocks are now extinct.[23] In 1994, the State of Washington placed unprecedented emergency restrictions on the commercial and recreational salmon harvests in Puget Sound. Salmon are more than a prized commercial and recreational fish — they are a symbol of the bountiful and robust heritage of the Northwest. The severe decline of wild salmon populations in the Pacific Northwest has raised alarms about the potentially disastrous state of the region's ecosystems.

Oysters, clams, and mussels are among the principal shellfish found in the Sound. Over 200,000 oysters, clams and mussels are harvested each day off Whidbey Island alone.[24] Commercial shellfish harvesting in Puget Sound was worth $42 million in 1993, according to the Pacific Coast Oyster Growers Association.[25] Harvests in the Sound could be much greater, but failing septic systems, agricultural runoff, and other pollution problems have closed 40 percent of the commercial harvest areas. These restrictions cost an estimated $3 million in lost revenues each year.[26]

Wildlife

Puget Sound is also appreciated for its diversity of wildlife, including over 220 species of fish, 26 species of marine mammals, and 100 species of seabirds, shorebirds, and waterfowl.[27] Four National Wildlife Refuges (NWR) are located in the greater Puget Sound area. Dungeness Spit NWR, in the Strait of Juan de Fuca, is a coastal spit with marshes and lagoons which is frequented by loons, cormorants, grebes, bald eagles, ducks, and black brant. The Nisqually NWR protects part of the last unspoiled estuary in the Sound, the delta of the Nisqually River. The delta's mudflats, freshwater wetlands and salt marshes support migrating shorebirds, herons, beavers, otters, and black-tailed deer. In the San Juan Islands, the Jones Island National Wildlife and Migratory Bird Refuge and several units of the San Juan Islands NWR protect critical nesting habitat for puffins, pelagic cormorants, and auklets.[28]

Estuaries provide important habitat for a number of endangered, threatened, and rare species. Of Washington State's 22 federally protected, endangered and threatened species, the endangered American peregrine falcon and sockeye salmon, and the threatened bald eagle, stellar sea lion and Aleutian Canada goose rely on the State's estuarine wetlands for survival.[29] The San Juan Islands, in the northern part of the Sound, support one of the densest nesting populations of bald eagles in the lower 48 states. Between 1980 and 1994, the bald eagle population in the Sound increased by over 400 percent; however, it is feared that continued habitat degradation may result in a gradual decline in their numbers.[30] The imperiled marbled murrelet also lives in the Puget Sound region. The survival of this seabird is threatened by the loss of old-growth forest habitat, saltwater oil spills, and entanglement in fishing nets.

Some of the marine mammals that can be observed in the Sound include the harbor seal, orca

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(killer whale), California sea lion, Stellar sea lion, and Dall's porpoise.[31] Harbor porpoises, once abundant in the area, are rarely observed in the southern and central portions of the Sound today.[32] The unique and fragile character of Puget Sound has led to proposals to establish a national marine sanctuary in the area of the northern Sound and Strait of Juan de Fuca.[33] The planning process for a sanctuary is currently underway.

Threats to the Sound

Rapid urbanization and development in the Puget Sound region have placed many of the estuary's resources in jeopardy. The loss of wetlands and salt marshes, the depletion of salmon populations, and the closure of shellfish harvest areas are a few of the more striking examples that have resulted from decades of unimpeded expansion. As the area's population continues to grow, the estuary system will experience even more environmental stresses. The Puget Sound Water Quality Authority has identified toxic contamination, pathogen contamination, habitat loss, diminishing living resources, and conventional water quality impairment as the priority environmental problems of Puget Sound.

Toxic Pollution

Toxic contamination is a growing concern in Puget Sound. Heavy metals and organic chemicals enter Puget Sound through industrial and municipal discharges, urban stormwater, atmospheric deposition, and agricultural land runoff. Particles of toxic metals and chemicals eventually settle out in the sediments of the Sound and its tributaries. Not only do many of these contaminants persist in the estuarine environment, but many also "bioaccumulate" through the food chain. Crabs, clams, oysters, bottomfish, and even gray whales depend on sediments of the Sound for food and habitat.[34] Bottom-dwelling organisms, fish, birds, and harbor seals in the Puget Sound region have exhibited reproductive and developmental problems associated with toxic contamination. Near urban areas of the Sound, fishing for bottom-dwelling species such as flounder and sole, is discouraged due to human health concerns about contaminated seafood.

Toxic pollution causes developmental, reproductive, and immune system problems in aquatic species and birds. About 40 percent of the English sole in Duwamish waterway and Eagle Harbor show signs of reproductive failure.[35] Other bottomfish in urban bays of the Sound have a higher incidence of cancerous liver tumors than fish in less urbanized areas of the Sound.[36] Recent studies have shown that juvenile chinook salmon in the Duwamish waterway exhibit a number of adverse effects due to PCBs and other toxins. Continual uptake of these chemicals during migration has altered immune system functions and reduced survival rates of the salmon.[37]

As a result of the high levels of toxic contamination, a large number of urbanized and industrial bays in the Sound contain "toxic hot spots," where toxic chemical concentrations in sediments far exceed federal and State standards. Special areas of concern are Sinclair and Dyes Inlets for consistently exceeding allowable State levels for mercury, and Elliott Bay for its high level of polycyclic aromatic hydrocarbons (PAHs).[38] Six Superfund sites are located in five urbanized portions of the Sound — Commencement Bay, Eagle Harbor, Elliott Bay, Sinclair Inlet, and Dyes Inlet.[39]

Oil Spills

Oil spills continue to threaten the Sound and its fish, bird, and marine mammal inhabitants. The 1991 spill of 100,000 gallons of diesel fuel, and the oils from the sunken fish processing vessel, the *Tenyo Maru*, cost nearly $9 million to clean up. Damages to natural resources cost from $5-13 million.[40] Although less spectacular and less publicized, the cumulative impact of countless smaller unreported spills may be even greater. Approximately two million gallons of used oil are dumped illegally down storm drains or improperly disposed of within the watershed each year.[41]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter Puget Sound through improperly sited or malfunctioning septic systems, runoff from agricultural and urban lands, polluted urban stormwater, sewage treatment plant discharges, combined sewer overflows (CSOs) and boating wastes. One-third of the residents in the Puget Sound watershed use septic systems for waste disposal, up to 12 percent of these systems fail each year.[42] In some areas of the Sound, failure rates are as high as 40 percent.[43] About 28 major sewage treatment plant dischargers and 71 minor municipal dischargers dump wastewater into waterbodies that empty into the Sound.[44] Other wastes make their way to the Sound, including about 20 million gallons of minimally-treated wastewater that is dumped into the Strait of Juan de Fuca each day from Victoria, British Columbia.[45]

Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or accidentally ingest contaminated waters while swimming. Gastroenteritis, hepatitis, and other diseases can result from this kind of contact with pathogens. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

Pathogen contamination is the principal cause of shellfish bed closures in the Sound. Over 40 percent of the Sound's commercial shellfish beds are currently closed to harvest.[46] Since 1981, almost 41,000 acres of commercial shellfish beds have been closed in Puget Sound.[47] Increasing numbers of restrictions occur in portions of the estuary bordering rural areas. In fact, agricultural runoff was largely responsible for two of the most extensive shellfish bed closures in the past eight years.[48] In addition, four of the ten major rivers draining into the Sound — the Sammamish, Puyallup, Nooksack, and Green rivers — have levels of fecal coliform bacteria which exceed State standards. State monitoring indicates that pathogen contamination is a severe and chronic problem for the Sammamish and Puyallup rivers.[49]

In certain areas of the Sound, shellfish beds are being reopened due to improvements in sewage treatment plant operations. Since 1989, about 5,500 acres have been upgraded; but overall, pathogen contamination remains a serious problem for the Sound.[50] The State monitors and classifies approximately 70 recreational shellfish beaches. In 1994, 37 of these beaches were closed.[51] However, the State of Washington does not regularly test its bay and ocean beaches to ensure safe swimming waters.

Habitat Loss

The eelgrass beds, kelp beds, mudflats, salt marshes and beaches of Puget Sound provide important habitats for wildlife and perform a number of beneficial functions for coastal communities. As recreational and commercial development accelerates along the Puget Sound shore, these habitats become increasingly stressed.

According to a marine science advisory board established in 1994 by British Columbia and Washington, stemming the loss of these nearshore habitats is the single greatest priority to protect the future health of Puget Sound. Although minimal data exist on the types and amounts of nearshore habitats present in the area, studies do indicate that vast areas of valuable wetlands habitat in the Sound region have disappeared. It is estimated that 73 percent of the original salt marshes of the Sound have been destroyed, as have virtually all of the river delta marshes in urbanized areas.[52] Agricultural diking and draining are responsible for the reduction of up to 95 percent of the wetlands in the Skagit Valley.[53]

The loss of coastal wetlands has an adverse impact on the wildlife of the estuary. Shellfish, salmon, and other aquatic animals of commercial and recreational value in Puget Sound depend on wetlands for food, spawning and nursery habitat.[54] Chum and chinook salmon are heavily reliant on estuarine wetlands. In addition, juvenile coho, pink, and sockeye salmon use estuarine wetlands during at least one stage of their life cycles.[55] Habitat alterations and losses have been linked to up to 30 of the region's declining salmon stocks. In addition to supporting aquatic and terrestrial species, coastal wetlands filter pollutants carried in stormwater before they reach the Sound, absorb excess flood waters, recharge groundwater supplies, and protect shorelines from erosion. Wetlands also support a number of recreational activities.

There are many causes of habitat destruction. Dredging to build harbors and ports has destroyed great areas of eelgrass, essential habitat for numerous species, including herring, salmon, and Dungeness

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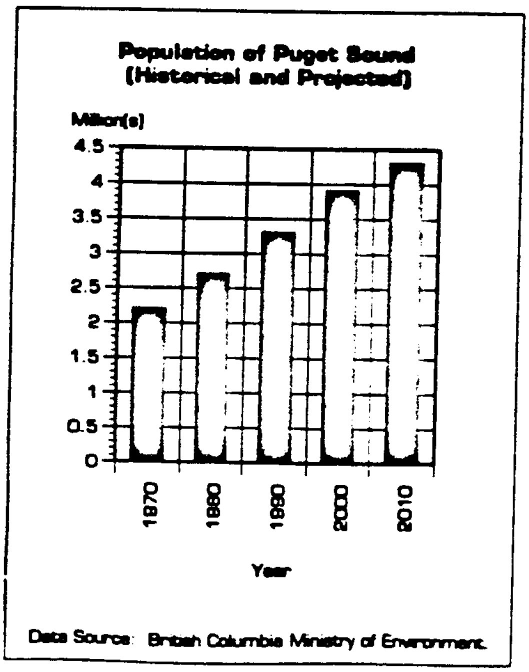
crab. Activities in upland areas are also leading to habitat loss, as forestry, agriculture, and development permanently alter the landscape. Logging and land clearing increase erosion and sedimentation, destroying in-stream salmon spawning habitat. Dams reduce flows and alter sedimentation patterns in river deltas, destroying coastal mud flat habitat. Buildings, roads, and other impervious surfaces replace natural lands in the watershed, resulting in increased stormwater flows that scour rivers and coastal areas.

Land Use and Population Growth

The population of the Puget Sound region is expected to increase by one-third between 1994 and 2010, growing from 3.4 million to 4.4 million people in 16 years.[56] The population boom is expected to have severely negative consequences for the health of the Sound. Land use projections forecast a 62 percent increase in urban development by the year 2000.[57] Unless carefully managed, this intensified land use will mean the further loss of wildlife habitat and severe increases in polluted runoff. Currently, about 900 million gallons of wastewater are discharged by municipal and industrial treatment plants each day.[58] As demands on the Sound's treatment plants intensify with a growing population, the estuary will be afflicted by more harmful contaminants.



Data Source: British Columbia Ministry of Environment.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The amount collected in just two days was staggering — on September 17 and 18, 1994, volunteers cleared 34,260 pounds of marine debris from 63 miles of beaches in Washington State. Of the total amount of marine debris collected, 67.3 percent was plastic, 12.4 percent was paper, 9 percent was metal, and 11.3 percent was from other materials.[59]

The Puget Sound Water Quality Authority

In 1985, prior to the establishment of the National Estuary Program (NEP), the State of Washington created the Puget Sound Water Quality Authority to develop a comprehensive plan for water quality protection in the Sound. First published in 1987, this plan, to be implemented by State and local governments, was the first comprehensive estuary plan in the nation. In 1988, the Environmental Protection Agency designated Puget Sound as an estuary of "national significance" and officially brought it into the NEP. In 1991, the Water Quality Authority's plan was approved as the Comprehensive Conservation and Management Plan (CCMP) for the Puget Sound Estuary Program.[60]

As one of the original NEPs and the first to complete its CCMP, Puget Sound has been considered a national and international model for dealing with complex estuary management challenges. Yet, since the approval of the CCMP, implementation of the different aspects of the Plan has been carried out with varying degrees of success.

For instance, although the State has developed sediment quality standards, some places in the Sound still have concentrations of toxic contaminants elevated 100 times or more over the levels in the cleanest rural bays. High concentrations of toxic contaminants in sediments have been associated with adverse biological effects in fish, including fin erosion, liver tumors and reproductive failures. Although some progress has been made toward limiting toxic pollutants, significant problems remain with regard to controlling the discharge of toxic substances. Without a tremendous commitment on the part of the State and federal governments in the form of financial assistance and pollution prevention, the contaminated sediment problem will remain largely unaddressed.

Participation by a full range of stakeholders, including cities, counties, tribes, storm water management utilities, and agricultural interests, has proven successful in the development and implementation of "watershed action plans." By December 1994, 101 of the more than 120 jurisdictions in the Sound had begun to implement stormwater control measures.[41] A 1995 survey by the Department of Ecology and the Authority show some local and nearshore improvements in water quality and habitat. Seventy-two percent of the jurisdictions have made progress in implementing stormwater programs and 20 percent have requested additional time to develop programs. In addition, nine cities are implementing programs to eliminate combined sewer overflows in order to reduce pathogenic pollution.

However, many of the CCMP's recommendations have gone unfunded and unrealized, including many of those related to habitat protection and other high priority programs. Implementation of the CCMP has also been hampered by political obstacles and the lack of political will to achieve its objectives. The political influence over the project could not have been more apparent than in the 1995 legislative session in Washington State. The Legislature declined to reauthorize the Puget Sound Water Quality Authority, thereby requiring that the Authority be dismantled on June 30, 1996. Because this result in 1995 flew in the face of public opinion, the 1996 Legislature enacted a "compromise" to avoid the criticism that it had abandoned Puget Sound. The Puget Sound program will be reconstituted as a new agency housed in the Governor's office and will be referred to as the Puget Sound Action Team.

The Authority which used to be governed by a board of 12 citizens appointed by the Governor, will be replaced by a board consisting of government agency representatives, advised by a citizen council. Citizens have clearly lost control in this turn of events. Once in a position to serve as a watchdog over government bureaucrats, now they have become powerless. While the staff of the Authority will carry on in this new structure, the very agencies that have resisted carrying out the Puget Sound Plan are now in charge of deciding which aspects of the Plan to fund, to delay, or to drop.

National Coastal Caucus

People for Puget Sound is a non-profit citizens group launched in 1991 to educate and involve people in protecting and restoring the land and waters of Puget Sound and the Northwest Straits. It seeks to eliminate contamination of our waters, to halt the destruction of natural habitats, and to sustain the Sound and Straits as a healthy source of people's livelihood, enjoyment and renewal. It plans to accomplish these goals by educating and involving communities in shared responsibility, by holding itself and its public officials accountable for carrying out commitments and enforcing laws and regulations, and by encouraging cooperation among diverse groups and interests throughout the region.

People for Puget Sound has served as a citizen watchdog over the agencies managing the Sound. Holding them accountable for implementation of the CCMP, the grassroots organization also lobbies the State Legislature for funding in order to achieve implementation of actions identified in the CCMP. Working together with local and regional groups, People for Puget Sound ensured that the Jobs and the Environment program was adequately funded in order to create jobs, such as restoring salmon stream habitats, for displaced timber workers.

People for Puget Sound has a very active educational program for children, an exciting and

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unique Adopt-a-Politician program to involve citizens in legislative activities and to ensure that they stay engaged, and a habitat assessment and restoration program. People for Puget Sound is also working to establish the proposed Northwest Straits Marine Sanctuary.

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San Francisco Estuary
in California

San Francisco Bay is perhaps the most highly modified major estuary in the world. If someone had sat down in 1849 and drawn up a plan to damage the Estuary as much as possible, s/he could hardly have done a better job. But the Bay area public understands the importance of a healthy Bay to the future of the region. In the next decade, we have a major opportunity to restore the health and biological diversity of the largest estuary on the West Coast.

—Barry Nelson, Executive Director
Save San Francisco Bay Association

Portrait of the Estuary

The San Francisco Estuary Program is examining the water quality and habitat problems of the Estuary, and the impact that the greater watershed area has on the system. The San Francisco Estuary is the largest estuary on the western seaboard of the Americas. It encompasses about 1,600 square miles of surface waters,[1] including the Sacramento-San Joaquin Delta and four embayments — the San Francisco, Suisun, and San Pablo Bays and the Carquinez Strait.

The watershed area covers 60,000 square miles —

San Francisco Estuary

Area of surface water	1,600 square miles
Area of watershed	60,000 square miles
Average depth	15 to 43 feet
Population	9.9 million people
Values	• Fisheries generate $159 million* • Tourists spend $3.9 billion • 20 million people rely on the Estuary system for drinking water
Threats	• Population growth and development • Freshwater diversion • Habitat loss and degradation • Pollutant loadings • Dredging
CCMP status	Approved in 1993

Designated as a "Nationally Significant" Estuary in 1987.

*State figure

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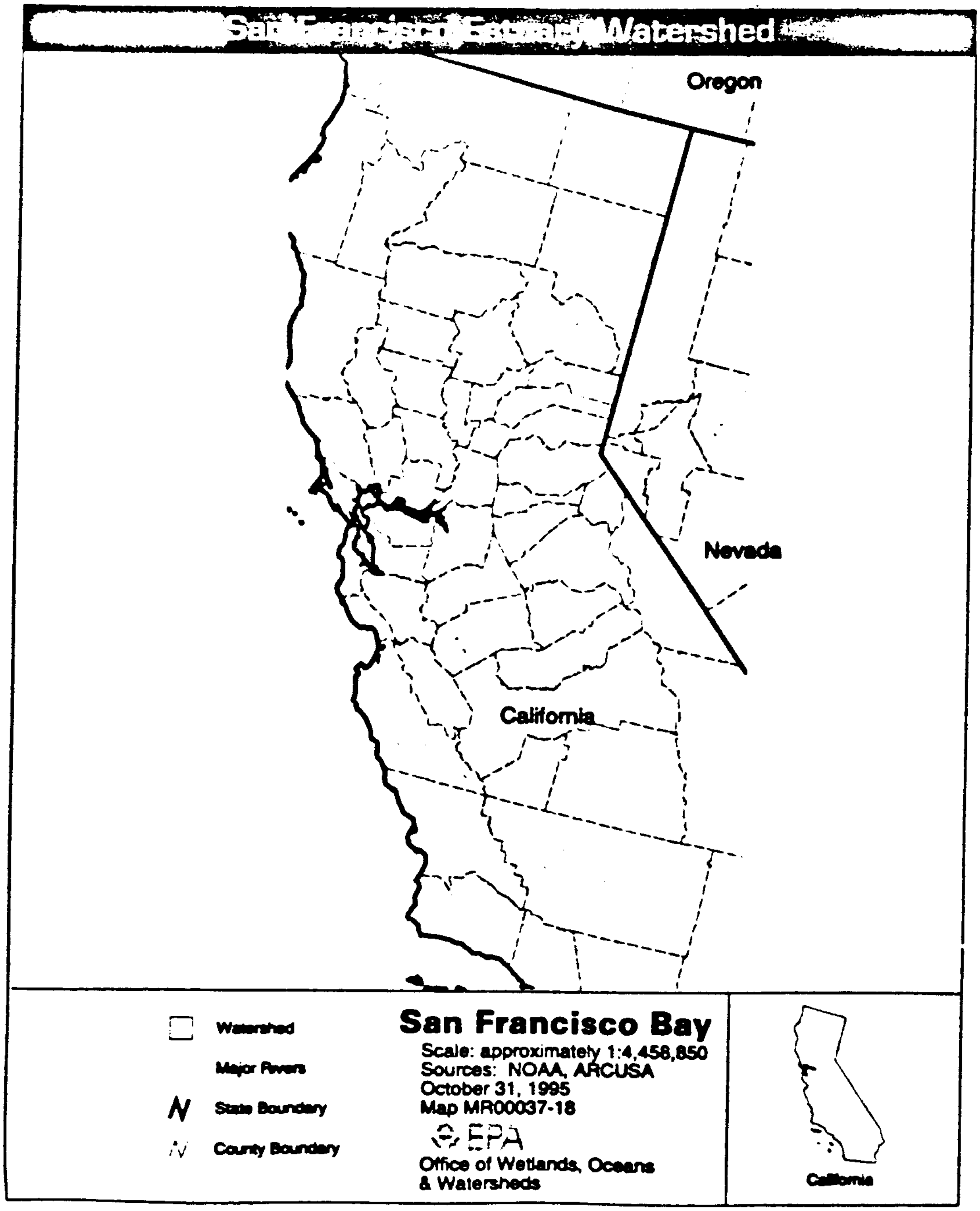
Watershed
Oregon
Nevada
California
Watershed
Major Rivers
State Boundary
County Boundary
San Francisco Bay
Scale: approximately 1:4,458,850
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-18
EPA
Office of Wetlands, Oceans
& Watersheds
California

40 percent of the total area of California.[2] It stretches across 12 counties — Alameda, Contra Costa, Marin, Napa, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Solano, Sonoma, and Yolo counties. It includes the cities of San Francisco, Oakland, Sacramento, Stockton, and San Jose, as well as the rich agricultural lands of the Central Valley. Approximately 9.9 million persons live within the watershed;[3] about 60 percent of this population resides in the San Francisco metropolitan area.[4]

The average depth of the San Francisco Estuary is 43 feet in the Central Bay and between 15 and 17 feet in the northern and southern portions of the Estuary. The Estuary's deepest point, located under the Golden Gate Bridge, is 360 feet.[5] The Bay-Delta system has a huge salinity range, from less than one part per thousand (ppt) in the Delta to 30 ppt in the Central Bay (the salinity of seawater is 35 ppt).[6] Consequently, different segments of the Estuary vary significantly in terms of the estuarine life they support.

The Sacramento-San Joaquin Delta is a triangular-shaped formation of land and water built by sediments at the confluence of the Sacramento and the San Joaquin Rivers. The Delta covers 1,150 square miles.[7] The Delta waters flow into the Suisun Bay, linking the Delta to the San Francisco Bay system. The Delta contains 57 low-lying islands and more than 700 miles of channels and sloughs, which feed the Estuary with freshwater from the Sacramento and San Joaquin Rivers.[8] Ninety percent of the freshwater entering the Bay-Delta drains from California's Central Valley; the remaining 10 percent originates from smaller rivers and streams flowing directly into San Francisco Bay.[9]

A diversity of habitats are found in the San Francisco Estuary and its watershed. These include open water habitats, intertidal mudflats, rocky shores, salt ponds, salt marshes, brackish marshes, freshwater marshes, riparian forests, and vernal pools.[10] Vernal pools are unique freshwater habitats which form when rain water pools in shallow depressions. They are home to more than 200 plant species, 91 percent of which are native only to California.[11]

Values of the Estuary

The San Francisco Estuary enriches the lives of millions of residents and tourists. Regional and State economies depend heavily upon the Estuary's aquatic resources for commercial fishing, boating, recreation, and tourism. Not only are the Estuary and its tributaries important for job creation, they also support drinking water supplies and agricultural production. Twenty million people, two-thirds of California's total population, rely on the Estuary system as a source of drinking water.[12] In addition, farmers use the area's freshwater to irrigate 4.5 million acres of agricultural land.[13] Finally, the San Francisco Estuary and its watershed area are invaluable to the many plant and animal species which have adapted to the estuarine ecosystem.

Recreation/Tourism

Sport fishing, bird watching, boating, swimming, hiking, and hunting are a few activities that attract Californians and tourists to the San Francisco Estuary. In 1990, visitors to the San Francisco area spent $3.9 billion on tourist-related activities, sustaining 66,000 jobs.[14] The region supports 290 shoreline parks, 200 duck clubs, 300 marinas, and about 500,000 recreational boaters.[15] Annual revenues generated by marina operations alone are estimated at $167 million.[16]

Recreational fishing in California, much of which is based in the San Francisco Estuary, provides a substantial revenue base for both State and local economies. In 1991, recreational fishing in California generated approximately $3.2 billion in economic output and employed nearly 40,000 people.[17] The average annual number of user-days devoted to recreational fishing in the San Francisco area is 4.4 million.[18] Recreational fish which are caught in the Estuary include chinook salmon, halibut, striped bass, starry flounder, sturgeon, brown rockfish, and surf perch. Other species which are caught in the rivers and streams of the Delta include American shad, steelhead trout, and bluegill.

Fisheries/Seafood

The San Francisco Estuary has historically provided valuable habitat for commercial fisheries in the Pacific region of the United States. In 1994, the combined market value of commercial finfish and

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shellfish landings in the Pacific region (excluding Alaska) totaled approximately $401 million.[19] Many of the commercially valuable species in the State also depend upon the health of the San Francisco Estuary for survival. In 1994, California's commercial finfish and shellfish landings totaled approximately 343 million pounds, valued at $159 million.[20]

The San Francisco Estuary supports over 130 fish species, of which Pacific herring holds the only great commercial value.[21] Chinook salmon, caught commercially in the ocean waters off northern California, used to provide a significant revenue base for the region. However, landings have dropped from 825,000 pounds in 1988, to 350,000 pounds in 1990.[22] Habitat modifications along the rivers of the watershed have contributed to the decline of salmon in the Estuary and its tributaries. Today, only 300 miles of the original 6,000 miles of in-stream habitat in the Central Valley are able to support spawning salmon.[23]

Most of the shellfish found in the San Francisco Estuary were introduced to the Bay and have adapted over time to the Estuary. Examples of these species include the soft shell clam, Japanese littleneck clam and the eastern oyster.[24] In the late 1800s, for example, the commercial oyster harvest totaled approximately 15 million pounds annually; for the past several years, however, there has been no oyster harvest from the Estuary due to water quality and habitat declines.[25] Other commercially valuable shellfish in the Estuary include the Bay mussel and the Dungeness crab.

Wildlife

The Estuary provides important habitat for millions of migrating and resident birds, fish, and other wildlife. Approximately 255 bird species, 81 mammal species, 30 reptile species, and 14 amphibian species live in the watershed area.[26] Many of these species depend on the open water and wetland habitats of the Estuary for spawning, nursing, and feeding grounds.

Waterfowl and shorebirds can be found in huge numbers in the San Francisco Estuary. Over 70 percent of the migratory shorebirds along the Pacific Flyway use the San Francisco Estuary as resting or wintering habitat.[27] However, since 1900, wintering bird populations have decreased by approximately 75 percent due to habitat losses and excessive hunting.[28] During certain seasons the Estuary provides essential habitat for over one million shorebirds.[29] About 34 species of shorebirds, such as stilts, plovers, avocets, and sandpipers, feed on insects and crustaceans in the tidal mudflats, marshes and shorelines of the Estuary.

Twenty-two wildlife species in the watershed are listed by federal or State agencies as threatened or endangered.[30] Most of these species depend on the wetlands of the Estuary and Delta for critical habitat. The federally endangered species living in the Estuary area include the bald eagle, California clapper rail, California least tern, salt marsh harvest mouse, the San Joaquin kit fox, San Francisco garter snake, Lange's metalmark butterfly, mission blue butterfly, and the Bruno elfin butterfly.[31] In addition, the Sacramento River winter chinook salmon run is threatened and the southern sea otter can no longer be found in the Estuary.

Threats to the Estuary

The daily activities of nearly 10 million people within the San Francisco Estuary watershed take a great toll on the Estuary's water quality and natural resources. Polluted urban stormwater, industrial discharges, municipal discharges, agricultural runoff, and habitat losses are threatening the integrity of this rich ecosystem.

The San Francisco Estuary Project identifies the primary threats to the Estuary system as land use/ population growth; freshwater diversion; and declining biological resources due to habitat loss, increased pollution, and dredging activities.[32] Another threat is the marine debris within coastal areas of the Bay and Delta which affects human activities and the health of wildlife populations.

Population Growth and Development

Almost one-third of California's population lives in the watershed of the San Francisco Estuary. Population projections show that by the year 2005, an estimated 12 million people will live in the Central Valley and San Francisco Bay counties.[33]

As more people move to the watershed area of the San Francisco Estuary, development within the coastal area continues to increase. To date, approximately 30 percent of the land in the nine counties

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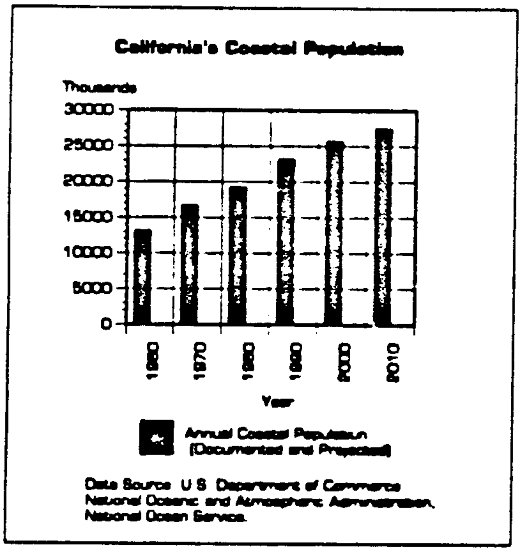

surrounding the San Francisco Estuary is urbanized.[34] Urbanization jeopardizes the salt marshes and freshwater wetlands which absorb stormwater, filter contaminants, and provide necessary spawning and nursery habitat for many of the fish and shellfish living in the Estuary. Replacing the natural soils, vegetation, and wetlands with impervious surfaces, such as pavement and roofs, allows greater concentrations of pollutants to enter the Estuary.

Freshwater Diversion

Over time, a number of water projects have occurred in the watershed, including the construction of flood control levees, water reservoirs, and dams, in order to provide freshwater for municipalities and agricultural producers. These projects divert approximately 16 million acre-feet of freshwater annually. In some years, this corresponds to a 50 percent reduction in the volume of freshwater reaching the Estuary.[35]

The two largest users of freshwater, the federal Central Valley Project and the State Water Project, extract 10 million acre-feet of water annually. Eighty-five percent of the water is diverted for agricultural uses and 15 percent is diverted for municipal, industrial and other uses, such as drinking water.[36] These water projects contribute to the economic growth of the region; but they also impair the estuarine ecosystem by increasing water salinity, changing water circulation patterns, altering habitat types, and affecting the survival rates of larval fish. During periods of drought in California, the negative environmental effects associated with water diversions are intensified.

Increased salinity levels in the Estuary reduce the overall biological productivity of the aquatic environment.[37] As less freshwater is delivered to the Estuary, saltwater gradually intrudes into historical freshwater habitats. Saltwater intrusion threatens the drinking water supply[38] and impedes the flushing capacity of the Estuary, making the retention of pollutants more likely.[39] Due to reduced levels of freshwater flow, zooplankton in the northern portions of the Estuary have experienced substantial declines.[40] Striped bass and salmon populations have also experienced declines, partially due to altered freshwater flows and water diversions which often kill fish eggs and juveniles.[41]

Despite these and other concerns, additional water diversion projects are being proposed that are expected to divert an additional 1.1 million acre-feet of water per year.[42] Water conservation and management measures need to be implemented and enforced to ensure the future health of the Estuary and its economic contributions to the region.

Habitat Loss and Degradation

Of the approximately 550,000 acres of original tidal wetlands in the San Francisco Estuary, only 44,371 exist today — a 92 percent loss.[43] Urban development, dredging activities, and hydrological changes in the tributaries are the chief causes of the destruction of Bay area wetlands. The ability of the aquatic ecosystem to support thriving wildlife and fish populations is severely reduced by habitat losses. The decline of wildlife populations throughout the Estuary demonstrates the impact of wetlands losses. Of the 32 species listed as in decline, 23 are wetlands-dependent species.[44]

Riverine habitat that has been altered for dam and levee construction is contributing to declines among anadromous fish in the watershed. For instance, the number of chinook salmon returning to spawn in tributaries is approximately 70 percent lower than historic levels.[45] In fact, the present-day

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commercial salmon fishery of the northern California coast relies on fish hatcheries for most of its salmon harvests.[46] However, these fish are usually genetically weaker and less able than wild fish to withstand environmental stresses, such as disease and temperature changes. The loss of riverine habitat and wetlands is also largely responsible for declining populations of striped bass, Delta smelt, longfin smelt, Sacramento splittail and California Bay shrimp.[47] Currently, the striped bass population is at its lowest level since the turn of the century.[48]

Pollutant Loadings

Nutrients, toxic contaminants, pathogens, and heavy metals enter the Estuary through polluted urban stormwater, industrial discharges, municipal discharges, agricultural runoff, and atmospheric deposition. The effects of these pollutants range from shellfish bed closures to health defects among the area's wildlife.

Polluted runoff and stormwater are the major carriers of pollutants to the Estuary and its tributaries. During rain events, stormwater delivers more contaminants to the Estuary than municipal and industrial discharges combined. It is estimated that stormwater carries 20 times more lead than point sources, as well as significant amounts of copper, nitrogen, phosphorus, animal waste, oil and grease residues.[49]

Pesticides from agricultural lands in the Central Valley and polychlorinated biphenyls (PCBs) are harming populations of mussels, clams, herons, and starry flounders in the Estuary.[50] Tissues of clams, mussels, and several species of fish and birds, especially those found near harbors and industrial waterways, have exceeded the State Maximum Allowable Residue Levels for DDT, PCB, and other heavy metals.[51]

In 1990, there were over 175 industrial point sources and over 85 municipal wastewater treatment plants discharging into the San Francisco, San Pablo, and Suisun Bays.[52] In 1992, the average volume of wastewater discharged in estuarine waters from chemical, metal finishing, oil refining, paper and other industries was 81 million gallons per day. In the same year, approximately 750 million gallons of wastewater from publicly-owned treatment plants flowed into the Bay and Delta each day.[53]

The heavy metals of greatest concern in the Estuary are arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, tin, and zinc.[54] Unusually high levels of toxic contaminants have been found in some fish and shellfish, especially striped bass and mussels. In 1986, California's Fish and Game Service initiated studies which revealed levels of selenium high enough to kill and deform waterfowl in San Pablo Bay and Suisun Bay.[55] In addition, levels of copper, lead, mercury, and nickel exceed State water quality standards in many portions of the Estuary.[56] According to the San Francisco Baykeeper, 322 tons of lead shot have been deposited into San Francisco Bay from the activities of one gun club alone during the past 30 years.[57] Toxic "hot spots" identified by the San Francisco Bay Water Quality Control Board of Oakland include a 250-acre site in Suisun Bay, a 10- to 50-acre site in Oakland's Inner Harbor, and a 250-acre site in the Central Bay.[58]

Dredging

Each year, about seven million cubic yards of sediment are dredged from places like Oakland Harbor, the Port of San Francisco and local marinas in the Estuary. One dredging project, Richmond Harbor's John F. Baldwin Channel, removed 2.7 million cubic yards of sediment, enough to fill five Olympic-sized swimming pools every day for one year. Maintenance projects alone generate approximately eight million cubic yards of sediment each year, making disposal a serious concern.[59]

Dredged sediments are deposited at one of the five aquatic or four upland disposal sites. The dumping of dredged materials seriously threatens the estuarine ecosystem by reintroducing previously-buried toxics into the water column, smothering bottom-dwelling organisms such as clams and crabs, and causing turbidity or clouding of the water. Dumping is only part of the problem. Dredging itself can permanently alter the natural bottom habitat that aquatic species are dependent upon, and cause changes in the salinity of the Estuary waters.

Additional Concerns

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. On September

17, 1994, volunteers cleared 565,501 pounds of marine debris from 480 miles of California's beach areas. Of the total amount of marine debris collected, 54.1 percent was plastic, 10.8 percent was metal, 18.5 percent was paper, and 16.6 percent was from other materials.[60]

Standards and monitoring procedures to protect swimmer safety vary widely throughout California. There were 415 beach closures and advisories in the San Francisco area in 1994. Some examples of beaches that issued closures and advisories in that year are Keller Beach, Oyster Cove, Baker Beach, and Ocean Beach.[61] These beaches were closed after heavy rainfalls and sewer overflows in order to protect swimmers from the harmful effects of bacteria and other pathogens.

The San Francisco Estuary Project

The San Francisco Estuary Project (SFEP) joined the National Estuary Program (NEP) in 1987.[62] In 1993, the Comprehensive Conservation and Management Plan (CCMP) for the San Francisco Estuary was approved by the United States Environmental Protection Agency (EPA).[63] A short time later, the Friends of the San Francisco Estuary, a non-profit public benefit corporation, was established to help coordinate implementation of the CCMP.

The SFEP process stressed the connection between environmental protection and economic viability by including economic incentives in long-term plans.[64] Governmental agencies along with 100 participants representing diverse interests collaborated on the development of management options to protect and restore water quality. Due to the vast array of competing uses of the Estuary, a consensus-based approach was necessary to ensure community-wide support of the project. The SFEP developed an estuary-wide strategy to coordinate research, enhance consistency, and reduce duplication.[65]

The CCMP describes 144 actions necessary for restoring and protecting the Estuary. The pollution section of the CCMP sets out sixteen specific action plans ranging from pursuing a mass emissions reduction strategy to developing environmental audit procedures for major users of toxics. Some of the tangible benefits of the pollution prevention activities are worthy of note. For example, a local petroleum refinery recently improved the efficiency of one of its sites and eliminated 70-90 percent of the chromium and lead in its wastewater by changing one chemical used in its cooling towers.[66] Another refinery recently agreed to change its practices in order to reduce discharges of selenium, a toxic chemical, into San Francisco Bay and to pay $2.2 million to settle a lawsuit alleging violations of the Clean Water Act.[67]

In the agricultural arena, the SFEP assists ranchers in reducing water pollution through the use of Best Management Practices, such as the installation of pens, livestock barriers, and fences designed to prevent cattle from trampling on sensitive vegetation and to reduce erosion.[68]

Habitat destruction is another major concern identified in the CCMP. The massive wetlands losses in the Estuary region led the SFEP to focus to a large degree on wetlands restoration projects.[69] Funding provided by the SFEP is being used in an attempt to restore the beneficial flood control functions of existing wetlands, as well as other functions and values.[70] Goals for better wetlands management within the watershed include protecting existing wetlands, restoring the ecological productivity of impaired wetlands, expediting an increase in wetlands acreage, and educating the public about wetland values. Unfortunately, habitat declines continue despite these and other efforts. Clearly, the success of these goals is dependent upon an increase in funding, additional economic incentives, and enhanced public resolve.

In addition to these projects, more than 70 monitoring projects, ranging from fish surveys to the identification of pollutant loadings, are underway. Outreach and education have also played a huge part in efforts to restore the Estuary. The SFEP has sponsored public forums, presentations, and tours to inform citizens about the values and key threats to the Bay-Delta region. However, in order for these strategies to be successful in the long-term, State and/or federal agency leadership must be strengthened, and a new infusion of funds must occur in order to ensure adequate implementation of the CCMP.

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National Coastal Caucus

Save San Francisco Bay Association (SSFBA) was founded in 1961 to protect open water, improve recreational opportunities, support wildlife conservation, beautify the shoreline, and promote resource planning. SSFBA has been actively involved in the SFEP serving on the Wetlands, Water Policy, Water Quality, and Management Committees.

SSFBA works with agencies like the Bay Conservation and Development Commission, the Army Corps of Engineers, and the Regional Water Quality Control Board that receive hundreds of applications each year for development projects that would irrevocably affect the Bay and the shoreline. As these applications are being processed, SSFBA works to ensure that the maximum public benefit is achieved and that the Bay's diminishing wetlands and other habitats are protected. It also serves as an important watchdog by reporting local Bay-related activities, protecting the Bay through legal means when necessary, educating the public, and encouraging citizen participation in Bay projects.

In 1994, the top priority of SSFBA's Restoring the Bay Campaign was protecting habitat in the reuse of closed federal military bases, acquiring habitat through the Land and Water Conservation Fund, and obtaining funds for restoration projects from the Regional Water Quality Control Board. Eight military facilities along the shoreline are expected to be closed in the next few years. Some of these bases were built partly on Bay fill and therefore displaced aquatic, tideland and/or wetlands habitat. The San Francisco Bay National Wildlife Refuge has identified important sites within these areas to be added to the refuge as protected areas, including the Alameda Naval Air Station and the Mare Island Naval Shipyard. However, opponents continue to argue that the sites should be reserved for economic development.

In 1995, SSFBA began to work on a project to enhance and restore 30,000 acres of wetlands that was funded through a grant from the Regional Water Quality Control Board. The San Pablo Baylands comprised one of the largest undeveloped tracts of former tidal wetlands in the entire state of California. The 30,000-acre Baylands were once extensive wetlands that were diked in the last century to create hay farms and salt ponds. The Partnership for the San Pablo Baylands is an entirely voluntary project that relies on the interest of landowners in the region to act as stewards of this valuable asset. The first phase involves a broad regional public education and outreach campaign. The outreach efforts will provide direct support for production and implementation of a wetlands enhancement plan. It will also develop a comprehensive inventory of educational materials and activities, including Baylands tours, videos and newsletters. The second element will employ an innovative approach known as Integrated Resource Management to create a plan that will enhance the management of multiple resources and attract the active support of landowners, citizens and government.

Another important victory for SSFBA was the recent agreement reached with environmental, agricultural and urban interests, and State and federal agencies, establishing new standards to protect the Bay from the effects of water diversion. This historic agreement which was the culmination of more than fifteen years of work by SSFBA, would strengthen environmental standards, protect endangered species, and create a $180 million Delta restoration fund. SSFBA also worked to find a solution to the dredging needs of the Port of Oakland in a project to use clean dredged mud to help restore 300 acres of tidal wetlands.

Through its Seafood Consumption Information Project, SSFBA has worked to persuade the State to conduct monitoring studies and post multi-lingual health advisories at Bay piers. As a result of this pressure, the State in December, 1994 found in the most comprehensive study to date, that sport fish in San Francisco Bay are so contaminated with PCBs, mercury, dioxin and pesticides that State health officials have warned against eating them more than twice a month. They have also advised that children under age six and pregnant or nursing women should not eat anything caught from the Bay."[1] SSFBA conducted their own survey of 93 pier fishers between the San Mateo and San Rafael bridges, and found that none of them had heard about the striped bass consumption advisory.

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San Juan Bay
in Puerto Rico

Portrait of the Bay

The San Juan Bay Estuary Program is examining the water quality and habitat problems of the San Juan Bay system and the impact that the greater watershed has on the estuary. San Juan Bay is located along the northeastern coast of the Commonwealth of Puerto Rico, approximately 1,000 miles southeast of Florida. The estuary system includes San Juan Bay proper and a number of smaller channels and lagoons, including San Antonio Canal, Condado Lagoon, Martin Pena Canal, San Jose Lagoon, Los Corozos Lagoon, Suarez Canal, Torrecilla Lagoon, and Pinones Lagoon.[1]

The greater watershed area of San Juan Bay encompasses 60 square miles (38,682 acres) and has an estimated population of 461,000 people.[2] The San Juan Bay watershed is the most populated area of Puerto Rico, which itself, has the greatest population density of any U.S. State or Trust Territory.[1] The major municipalities of the watershed are San Juan, Catano, Guaynabo, Carolina, Bayamon, and Loiza.

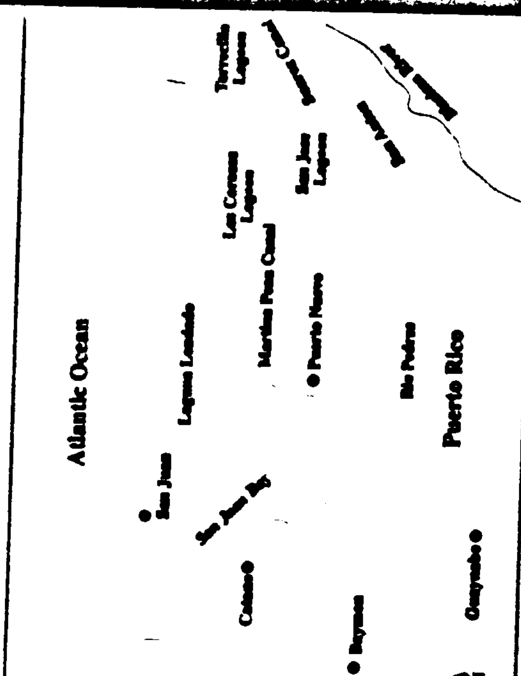
Freshwater draining from land intermixes with saltwater from oceans to create productive estuaries such as the San Juan Bay. The Bay receives its freshwater from the Puerto Nuevo, Rio Piedras Rivers and the Juan Mendez, San Anton, and Blasina

San Juan Bay

Area of watershed	60 square miles
Population	461,000 people
Values	• Fisheries generate $4.3 million*
	• Tourism generates over $1 billion*
	• Tropical ecosystem with "Critical Coastal Wildlife Areas"
Threats	• Pathogen contamination
	• Toxic contamination
	• Nutrient loadings
	• Habitat loss and degradation
	• Population growth and development
CCMP status	Final expected in 1998

Designated as a "Nationally Significant" Estuary in 1992.

*Figure for whole island



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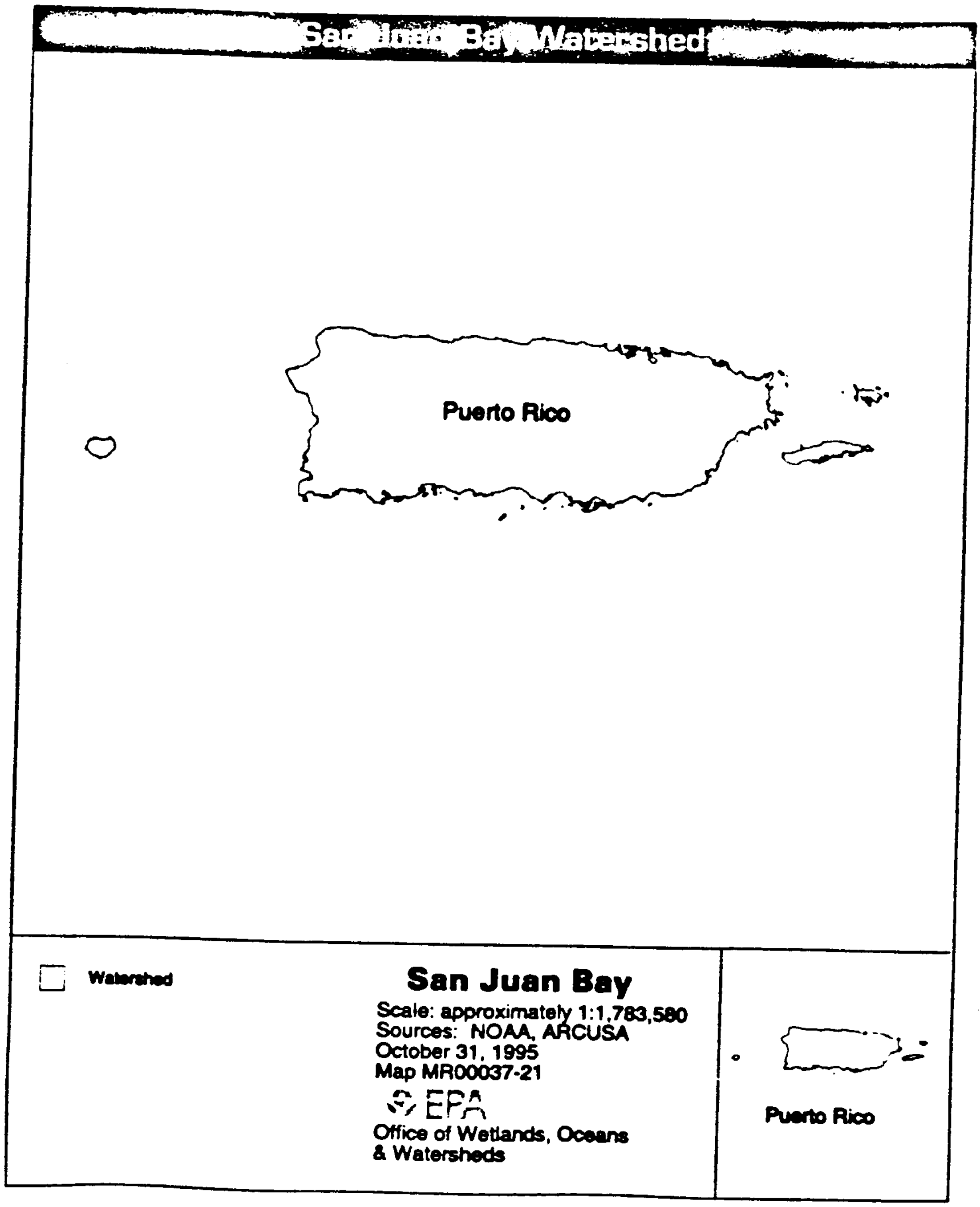
San Juan Bay Watershed
Puerto Rico
Watershed
San Juan Bay
Scale: approximately 1:1,783,580
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-21
EPA
Office of Wetlands, Oceans
& Watersheds
Puerto Rico

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Creeks.[4] The Estuary system has three connections to the Atlantic Ocean — Condado Lagoon and the northern portion of Torrecilla Lagoon on the eastern edge of the system, and San Juan Bay at the western edge of the system.[5] The limited flushing capacity and low tidal range characteristic of this estuary make it susceptible to the retention of harmful pollutants in the Bay.

The San Juan Bay system contains a variety of productive habitats. The predominant habitat types within the system include mangrove forests, coral reefs, seagrass beds, mudflats, marshes, sand dunes, and open water.

Values of the Bay

The San Juan Bay system is an irreplaceable natural, recreational, and commercial resource for Puerto Rico's residents and visitors. The lush habitats of the system provide year-round and wintering grounds for an abundance of birds, fish, and wildlife. The system's mangroves and coral reefs offer especially important breeding, nursery, and sheltering habitats for fish and shellfish. Tourism and water-based recreational industries generate significant revenue for the local communities of the Bay.

Recreation/Tourism

Puerto Rico promotes itself as "The Shining Star of the Caribbean" and is reputed for its beaches, boating, sailing, snorkeling, SCUBA diving, and sport fishing. According to the Puerto Rican Tourism Company, over one billion dollars in tourism-related revenues were generated from over two million visitors to the island in 1987.[6] The San Juan area was visited by an estimated 1.7 million visitors in 1992.[7]

Clean waters and a healthy environment are the foundations of San Juan's tourist economy. The coastal areas known to have the best water quality typically generate the greatest amount of tourism revenues.[8] The coastal waters just beyond San Juan Bay support a prosperous sport fishing industry. Saltwater anglers from across the world travel to San Juan in order to fish these marine waters, which have been dubbed "Blue Marlin Alley" because of the numerous world fishing records broken in them. Prized sport fish in these coastal waters include blue marlin, white marlin, dolphinfish, wahoo, Allison tuna, and oceanic bonito. Although these fish do not inhabit San Juan Bay, they do feed on smaller fish which use the estuary for spawning and nursery grounds.[9]

Fisheries/Seafood

The ocean waters surrounding Puerto Rico are too deep to attract large pools of commercially valuable fish. As a result, commercial fishing operations are conducted by small boats in the coastal waters and along beaches. In 1992, there were only 300 registered commercial fishermen in Puerto Rico.[10]

Despite the limited number of commercial fishermen in Puerto Rico, landings of commercial fish provide significant revenue for the local economies. In 1994, the landings for Puerto Rico's commercial fishery (including shellfish) totaled approximately 2.4 million pounds, and were valued at $4.3 million.[11] The most prominent species landed include silk snappers, yellowtail snappers, mackerel, lobsters, and conch.[12]

Wildlife/Habitat

As a tropical island ecosystem, the San Juan Bay system supports a greater diversity of habitat and living species than estuaries of the continental United States. A substantial number of bird species inhabit the estuarine area, including the yellow-shouldered blackbird, orange-fronted parakeet, black-whiskered vireo, bananaquit, herons, osprey and gulls.[13] Beaches and sand dunes in the area are used by leatherback, green, and hawksbill sea turtles for nesting grounds. In addition, manatees, dolphins, and whales can be found in the estuary.[14]

The Puerto Rican Department of Natural Resources has classified three areas within the San Juan Bay system as "Critical Coastal Wildlife Areas." The Constitution Bridge Mudflats, Torrecilla-Pinones-Vacia Talega Lagoon Complex, and Palo Seco Peninsula were designated as critical coastal wildlife areas based on the number of threatened and endangered species that rely on them.

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The Torrecilla-Pinones-Vacia Talega Lagoon complex alone contains more than 10,000 acres dominated by mangrove forests. This area contains the Pinones State Forest Natural Reserve, an area which supports a wide array of flora and fauna, but is most threatened by development projects.[15] In addition, the Palo Seco Peninsula, which was created in 1963 by dredged sands from the Bay, now provides essential habitat for mangroves and other valuable plant life.[16]

The Constitution Bridge Mudflats support the richest diversity of birds on the entire island.[17] Seagrass beds of the estuary provide essential habitat for juvenile fish and shellfish and trap pollutants and sediments which can damage coral reefs. Coral reefs are considered one of the most productive and diverse marine ecosystems on the planet. They cover a fraction of one percent of the Earth's surface but are home to a large percentage of all marine fish species.[18] Many of the commercially valuable fish of the San Juan Bay area rely on the corals, which are principally located around the Isla de Cabras. The potential use of coral communities in biomedical research and application is yet another argument for their protection.[19] For instance, it has recently been discovered that skeletons from stony corals may be useful agents in human bone grafts.[20] These areas, however, still await a comprehensive plan to define suitable measures for their protection.

Species listed as federally (U.S.) endangered which depend upon the San Juan Bay system include the West Indian manatee, green sea turtle, leatherback sea turtle, hawksbill sea turtle, roseate tern, and yellow-shouldered blackbird.[21] Other species which are listed as endangered by the Commonwealth of Puerto Rico and are found in the Bay system include the least tern, white-crowned pigeon, West Indian whistling duck, and ruddy duck.[22]

Threats to the Bay

At a quick glance, the San Juan Bay system appears to be a tropical paradise, complete with gorgeous beach areas, exotic wildlife species, and recreational diversions. In reality, however, this estuarine system has serious environmental problems ranging from toxic contamination to habitat degradation. The priority problems of the estuary which have been identified as the principal threats to the system are pathogen contamination, toxic contamination, and excessive nutrient loadings. Habitat destruction, population growth, and floatable debris also stress the Bay system.

Pathogen Contamination

Despite the availability of advanced (secondary) treatment technology for sewage treatment plants and federal grants during the 1970's and 1980's, to help meet the costs of upgrades, San Juan's major municipal plants continue only to perform primary treatment (solids are removed by screening and sedimentation) of sewage. Before 1985, these plants discharged the wastewater effluent directly into the Bay. Since then, these plants have dumped undertreated sewage in ocean waters through an outfall pipe. The San Juan Bay still receives direct discharges of untreated human sewage from nonsewered areas of the watershed, illegal sewer connections, municipal treatment plant bypasses, and boating waste.[23] As a result, San Juan Bay, local canals, and nearby ocean waters are impaired by pathogens.

Pathogens are disease-causing bacteria and viruses found in human and animal wastes. Pathogens in coastal waters pose risks to humans who eat contaminated fish and shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated waters or fish. For this reason, many beaches and shellfish beds are closed or restricted when water monitoring indicates that high levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

Direct discharges of sewage and illegal sewage connections to storm drains are some of most significant pollution problems in the San Juan Bay system. In some of the poorer neighborhoods of metropolitan San Juan, sanitary sewage disposal service is not provided. Along the Martin Pena Canal and San Jose Lagoon, human waste and garbage are dumped into local waters and onto bordering land. High tides and heavy rainstorms carry this waste, and the pathogens it contains, to other portions of the estuary.[24]

Another source of pathogen contamination in the Bay system is the illegal connection of sewage pipes to stormwater drains. Eliminating these illicit connections is a challenge to local officials because the task of identifying the connection points is difficult.

Raw sewage is responsible for fish and shellfish kills as well as human disease in the Martin Pena Canal and San Jose Lagoon system.[25] Scientists have made a direct connection between high concentrations of raw sewage and the incidence of Cigatuera, a disease causing severe gastrointestinal and nervous system disorders in human populations. Cigatuera is a naturally-occurring biotoxin found in tropical fish which reproduces more rapidly in areas where raw sewage concentrations are high.[26] Currently, poor water quality causes between 20,000 and 30,000 cases of Cigatuera each year in Puerto Rico and the Virgin Islands.[27]

Toxic Contamination

Unlike municipalities of the area, industries discharge their wastewater directly into the Bay system. Heavy metals, organic chemicals, and heated effluent are commonly found in these industrial discharges. Toxic chemicals also enter the Bay via illegal sewer connections to storm drains and stormwater carrying pesticides which have been applied to lawns and agricultural lands. Toxic chemicals which have been found in the Bay in excess of standard allowable levels include copper, lead, mercury, selenium, and zinc.[28] The San Juan Harbor is affected by these five heavy metals plus other chemicals, which include arsenic, beryllium, cadmium, chromium, cyanide, pesticides, polychlorinated biphenyls (PCBs), aluminum, thallium, silver, and nickel.[29]

In addition to organic chemicals and heavy metals, oil spills in the Harbor area of the Bay are additional sources of toxic pollution in the estuary. The U.S. Coast Guard estimates that between 1987 and 1990, the San Juan Bay area suffered from an average of 50 oil spills per year, at times, resulting in millions of gallons of oil spilled annually.[30] The effects of toxic discharges and oil spills wreak havoc on human and estuarine life, water quality, and habitat. Toxic levels of chemicals have been found in commercially valuable fish and in wildlife. Eating contaminated fish threatens human health. For the many people in the San Juan area who fish for subsistence, this risk is intensified since a heavy reliance on fish caught near the Bay shore increases the exposure to harmful contaminants, causing subsequent health problems. Endangered sea turtles in the area are deceived into eating floating tar balls resulting from oil spills.[31] Oil and chemical spills have led to beach closures in the area and an overall reduction in the number of beachgoers to the San Juan area.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to the estuary by urban stormwater, sewage treatment plants, power plant emissions, and other sources. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but also require a great amount of dissolved oxygen to decompose. Submerged aquatic vegetation is used as juvenile nursery grounds by fish and shellfish and hence, is vital to sustaining populations of these commercially valuable resources.

Habitat Loss and Degradation

Mangroves, seagrass beds, and coral reefs are the three prominent habitats of the San Juan Bay system. Mangroves are invaluable to the aquatic communities of the Bay — they provide shelter and nursery areas for young fish; guard shorelines against erosion and coastal storms; and filter harmful sediments and pollutants. The San Juan Bay area contains approximately 14,401 acres of mangrove forests, nearly 25 percent of the total mangrove coverage in all of Puerto Rico.[32]

Ongoing development activities are destroying the sensitive tropical habitats of San Juan Bay. Mangrove forests which hug shorelines are particularly affected by development and non-permitted, dredging activities in the San Juan area.[33] Near the

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San Jose Lagoon, mangrove cutting and residential development projects reduced the acreage of mangroves by 41 percent between 1937 and 1987.[14] In addition to modifications of near-shore habitats, changes in upland habitats, such as land clearing for urban and agricultural uses, exposes mangroves to more harmful contaminants.

Increasing levels of sediments, toxic contaminants, and nutrients harm seagrass and coral habitats by clogging the respiratory systems of corals and blocking essential sunlight needed by both seagrasses and coral reefs.[15] In addition, both corals and seagrass beds suffer from physical abrasion from boat anchors and certain fishing gear.[16]

Population Growth and Development

Toxic pollution, polluted runoff, and habitat destruction in the San Juan Bay are all human-induced problems. Thus, the increase in human population and human activity in the region, further jeopardizes the health of the natural system. The population in San Juan has grown significantly since the 1970's. Between 1970 and 1980 the towns within the San Juan Bay watershed grew in population by approximately 22 percent. Residential development alone increased by 36 percent during this period.[17] Corresponding commercial development has also increased the stress on the system. As long as the San Juan Bay area continues to attract visitors and residents, the impact of human activity on the main island (particularly in the low, flat areas of San Juan) will continue to increase. Therefore, stronger measures must be taken to ensure compliance with water quality standards and the preservation and protection of valuable habitat as development projects ensue.

Floatable Debris

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. The amount found in just one day was staggering — on October 8, 1994, volunteers cleared 115,240 pounds of marine debris from 40 miles of Puerto Rico's beaches. Of the total amount of marine debris collected, 44.5 percent was plastic, 29.7 percent was glass, 14.8 percent was metal, and 11 percent was from other materials.[18] Garbage slicks and beach wash-ups, in addition to the approximately 50 oil spills that occur each year in the San Juan area, result in negative impacts on the tourist economy as is evidenced by declining occupancy at hotels along affected shorelines.[19]

The San Juan Bay Estuary Project

The San Juan Bay Estuarine System was nominated to participate in the National Estuary Program (NEP) on April 16, 1992. It was the first and remains the only tropical estuary system to be included in the NEP. Thus, its nomination is ground-breaking in its effort to manage and protect some of the Earth's most biologically diverse marine habitat. On October 22, 1992 EPA accepted the nomination and designated San Juan Bay a "nationally significant" estuary.

San Juan Bay is also the first NEP to be established outside of the continental United States. As a result, the development of the SJBEP's Comprehensive Conservation and Management Plan (CCMP) has presented more challenges than those faced by other NEPs. For instance, it took about two years to actually establish the SJBEP office which is now located in San Juan.

A two-day Estuary Planning workshop occurred in June, 1993 in Old San Juan that brought together the stakeholders in the area to discuss water quality issues facing the Bay, as well as the administrative issues necessary to move the Program forward. Unfortunately, participation of citizens and local government agencies at the workshop was lacking. As a result, the establishment of the Citizens Advisory Committee (CAC) had to be postponed. A much more intensive effort needs to be made to expand the participation and representation of different categories of user groups in the Program, particularly from the citizen and environmental communities.

Although, the Management Conference Agreement and the First Year Work Plan were approved by EPA in 1994, it was not until April, 1995 that the

CAC was officially established. The program is in the process of preparing a preliminary draft CCMP to highlight more critical concerns for the Estuary.

The Management Conference and the Scientific and Technical Advisory Committees have been meeting regularly and recommending interim actions to protect the Bay. The limited tidal flushing capacity and the low tidal range characteristic of the San Juan Bay system make it susceptible to a contaminated sediment problem. As a result, a water quality and sediment sampling initiative is underway. Other characterization studies are being conducted to help in the development of an appropriate monitoring system. For instance, an Ecosystem Assessment project was established in May, 1995 to identify impacted habitats and species. A Hydrodynamic/Water Quality Mathematical Model is also being developed to evaluate proposals which could impact water quality of the Bay system. Other projects in the works include the development of administrative procedures to process solid waste dumping enforcement cases, as well as the enforcement of appropriate stormwater and wastewater hookups.

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Santa Monica Bay
in California

A healthy Santa Monica Bay is essential to the vitality and identity of Southern California. It is one of the most popular, but polluted coastal areas in the country. Between 50 million and 60 million visits are made to the Bay each year, and nine million people live within an hour's drive of the Bay. The population of Los Angeles County has increased by over 300 percent since 1940 and is predicted to grow another 30 percent by 2010. Our lifestyles have contaminated the Bay with DDT, PCBs, sewage, and toxic stormwater. Each of us must act individually and collectively now in order to save this precious resource

— Robert H. Sulnick, Executive Director
American Oceans Campaign

Portrait of the Bay

The Santa Monica Bay Restoration Project is examining the water quality and habitat problems of the Santa Monica Bay and the impact that the greater watershed area has on the estuarine system. Santa Monica Bay is located west of Los Angeles on the Pacific Coast of Southern California. It is bordered on the north by the Santa Monica mountains which, along with the Los Angeles coastal plain, dominate the physical terrain of the Bay region.[1] The Santa Monica Bay contains about 306 square miles of surface water, with depths reaching 1,640 feet, and a total water volume of about 6.8 trillion gallons.[2]

Santa Monica Bay

Area of surface water	306 square miles
Area of watershed	414 square miles
Maximum depth	1,640 feet
Population	3 million people
Values	• Fisheries generate $159 million* • Santa Monica Bay beaches generate $1.08 billion • Over 5,000 species inhabit the Bay area
Threats	• Habitat loss and degradation • Pathogen contamination • Conventional and toxic pollution • Floatable debris
CCMP status	Approved in 1995

Designated as a "Nationally Significant" Estuary in 1989.

*State figure

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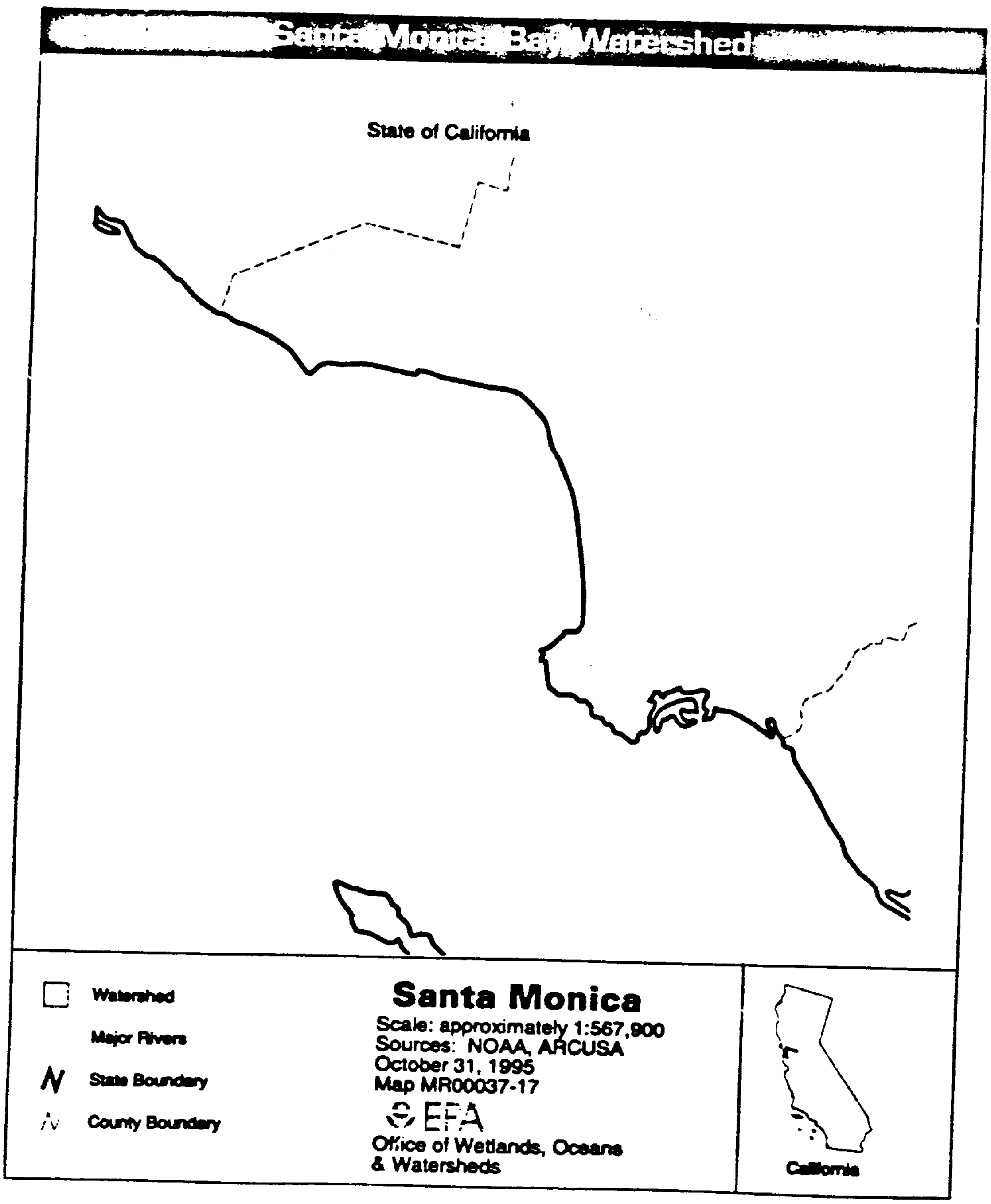
Santa Monica Bay Watershed
State of California
Watershed
Major Rivers
State Boundary
County Boundary
Santa Monica
Scale: approximately 1:567,900
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-17
EPA
Office of Wetlands, Oceans
& Watersheds
California

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Visitors and residents are attracted to the Mediterranean-like climate of the Santa Monica Bay: dry summer seasons and mild winter seasons. Rainfall averaged only 12 inches per year between 1983 and 1993.[3] The Bay offers a wide variety of natural habitats, ranging from rocky intertidal areas to coastal scrub (fire adapted, shrub-like plant communities).[4]

The Santa Monica Bay watershed encompasses a large number of highly populated communities including Beverly Hills, Calabasas, Culver City, El Segundo, Hermosa Beach, part of the City of Los Angeles, Malibu, Manhattan Beach, the Palos Verdes Peninsula, Redondo Beach, Santa Monica, and West Hollywood. About three million people live in the 414-square mile watershed area.[5] Griffith Park serves as the watershed's eastern border, with Point Fermin on the south and Ventura County on the west.

The Santa Monica Bay Restoration Project divides the study area of the Santa Monica Bay into three management regions: the wasteshed, the watershed, and the Bay. The wasteshed is the land area from which municipal wastes are collected before being treated and discharged into the Bay.[6] The 414-square-mile watershed receives water from 28 stream drainage basins, of which the Malibu Creek and Ballona Creek are the largest.[7] The combined area of the wasteshed and watershed is 1,380 square miles.[8]

The Bay's surface water is flushed relatively frequently, every three to four days.[9] Since it is an open embayment, the salinity of the Bay system ranges from 33.5 to 34.1 parts per thousand (ppt), close to the salinity of seawater (35 ppt).[10]

Values of the Bay

The Bay is the site of world-famous beaches, such as Malibu and Venice Beach, which draw great numbers of visitors to the Bay area each year. Santa Monica Bay provides a wealth of natural resources for residents and these visitors to enjoy. The Santa Monica Bay region includes a range of habitats including terrestrial, wetland intertidal, kelp bed, open water, and hard and soft bottom area.[11] Only a few thousand acres of wetlands remain in the watershed (riparian areas, lakes, ponds, coastal marshes, and lagoons). This area was once a vast, marshy system; but only a few hundred acres of coastal wetlands are found in the area today.[12] The few wetlands that remain trap nutrients and sediments that run off from the watershed before they reach Santa Monica Bay.

The shallow nearshore areas of Torrance and Redondo Beaches provide valuable nursery habitats for marine species such as California halibut and juvenile white sea bass. Hard bottom areas in the Bay provide habitat for giant kelp beds, fish and aquatic invertebrates.[13]

Recreation/Tourism

Tourism is the second largest industry in the Los Angeles Region, contributing $4.25 billion in payroll dollars per year to the regional economy, and supporting 437,000 full-time and part-time jobs.[14] A survey of visitors to Santa Monica Beach found that the daily recreational value per person was $18.36, using travel costs and parking fees as indicators.[15] The 1989 value, based on an attendance of 12.5 million visitors to Santa Monica Beach alone, is $229.7 million.[16] Visits to the various beaches in Santa Monica Bay total up to 60 million annually.[17] A calculation of $18 daily recreation value for 60 million individual visits results in a $1.08 billion annual recreation value for beaches of Santa Monica Bay.

Sport fishing is a booming industry throughout the Bay. Although statistics are not available specifically for the Bay, it is estimated that in 1989, sport fishermen made 5.5 million trips, worth about $536 million in gear and trip expenditures, to Southern California waters. Sport fisheries in the Bay include chub mackerel, barred sand bass, kelp bass, and California spiny lobster.[18] In addition, California grunion live in nearshore habitats and spawn along the shores of Southern California beaches in "grunion runs," attracting a wide number of spectators.

Santa Monica Bay is also a valuable educational resource. It is among the most frequented excursion sites for Los Angeles County school educational field trips, providing outdoor classrooms for students of all levels.[19]

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Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the Pacific Region (excluding Alaska) totaled approximately $401 million. In the same year, the State of California's commercial shellfish and finfish landings totaled about 343 million pounds, valued at $159 million.[20] Many commercially valuable species, notably California halibut and Northern anchovy, depend upon the health of Santa Monica Bay. Commercial fishing is prohibited in 62 percent of the Santa Monica Bay to protect local fish stocks which would otherwise be depleted by a combination of recreational and commercial fishing.[21]

Wildlife

The Bay's watershed is home to a diversity of species which use the Bay as spawning, nursery, and feeding grounds. To date, over 5,000 species have been identified, and more are still being discovered.[22] Wildlife found in the Bay's watershed include: invertebrates such as shrimp, crabs, clams, mussels, and sea urchins; birds such as egrets, herons, and sanderlings; and marine mammals such as seals and sea lions.[23]

Animals protected as rare, threatened, or endangered rely on habitats in the Santa Monica Bay watershed for survival. For instance, the California least tern and western snowy plover rely on beach areas in the Bay's watershed for nesting grounds; the California brown pelican relies on marine habitat in the area; the Belding's savannah sparrow relies on wetlands habitat in the Bay area; and the American peregrine falcon and California gnatcatcher rely on other watershed habitats for survival.[24]

Threats to the Bay

The water quality, habitat, and wildlife of Santa Monica Bay are under attack by many kinds of pollution, from a variety of sources. Some of the major threats to the Bay are: habitat loss and degradation, pathogen contamination, conventional and toxic pollutants, and floatable debris.[25]

Coastal pollution has contributed to the public's concerns about swimming in Santa Monica Bay. Although changes in weather may account for annual visitor fluctuations, beach attendance in Southern California declined by about 56 percent between 1983 and 1992.[26] Sewage spills and overflows from the Hyperion Sewage Treatment Plant in Los Angeles have resulted in beach closures and have raised public concern about beach pollution.[27] Pathogens carried to the oceans in storm drains are also a threat to human health.[28]

Habitat Loss and Degradation

The rapid urbanization and population growth in the Santa Monica Bay region have been key reasons for the impairment of Santa Monica Bay. The population of Los Angeles County has increased by over 300 percent since 1940,[29] to a 1990 estimate of nine million.[30] More people means an increased demand for land.

California has lost more than 91 percent of its wetlands, a higher percentage than any other State in the nation.[31] In the Santa Monica Bay region alone, 95 percent of the historic wetlands have been destroyed due to draining and filling activities for agriculture, flood control, port and oil development, and industrial and residential expansion.[32] With the destruction of these wetlands, many of the beneficial functions that wetlands provide are lost. Coastal wetlands serve as critical areas for spawning, nursing, and feeding of fish and shellfish. Many birds use these areas as nesting habitat. Coastal communities also benefit from wetlands. Wetlands filter pollutants carried in stormwater and urban runoff before they can reach waterbodies, absorb excess flood waters, and protect upland areas from coastal storms. In addition, wetlands are used by many people for recreational activities, such as bird watching and walking.

Historically, the Santa Monica Bay shoreline between the Pacific Palisades and Malaga Cove was composed of narrow beaches, rocky shores, sand dunes, and wetlands.[33] Destruction and development of these sensitive shoreline habitats over the last few decades has had serious financial consequences. Federal, State and local governments have constructed erosion control structures such as jetties and groins and have replenished beach sands at significant financial and environmental costs. These artificial structures also result in shoreline accretion and beach erosion at other points along the coast.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, polluted urban stormwater, agricultural runoff, boating waste, and individual septic systems. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who ingest contaminated waters. Gastroenteritis, hepatitis, and other diseases can result from contact with pathogens. For this reason, beaches and shellfish beds are closed or restricted when coastal water monitoring shows that standards for fecal coliform, total coliform, or enterococcus (indicators of pathogens) are exceeded.

Two large municipal wastewater treatment plants currently discharge treated sewage into the Bay: the Hyperion Treatment Plant (HTP) run by the City of Los Angeles and the Joint Water Pollution Control Plant (JWPCP) run by the Los Angeles County Sanitation District. About 85 percent of the municipal wastes discharged to the Bay originate from residential use which averages 100 gallons per day per capita.[34] The HTP and JWPCP are being upgraded from primary to secondary treatment to comply with biological treatment requirements that destroy bacteria and viruses (and break down organic compounds such as oil, grease, and some pesticides).

Until the mid-1970s, 800 million gallons of sewage receiving only primary treatment were dumped into the Bay each day,[35] degrading benthic communities, bottom-dwelling plants and animals. In 1993, HTP had a total daily flow of 330 million gallons of sewage — 166 million gallons of which received secondary treatment; while JWPCP had a total daily flow of 328 million gallons of sewage — 133 million gallons of which received secondary treatment.[36] Due to recent improvements in the efficacy of sewage treatment, benthic communities are making significant recoveries.[37] The contaminants discharged to the Bay from HTP and JWPCP have improved significantly as a result of increased source control, land disposal of sludge, improved sludge and primary treatment, and increased secondary treatment.[38]

Recreational boaters also discharge raw and chemically treated sewage into the Bay, especially into the popular marinas of King Harbor and Marina del Rey,[39] which together have about 7,500 berths.[40] Discharges are unlawful unless boats are at least three miles beyond the shoreline. Nevertheless, boaters continue to discharge because on-shore pumpout facilities are grossly inadequate.[41] The Santa Monica Bay Restoration Project received a grant in 1996 to survey pump-out facilities in the Bay which should lead to recommendations for reducing the sewage attributable to boats.

Conventional and Toxic Pollutants

Industrial sources discharging directly into the Bay include three power generating stations and one oil refinery along the coast. The generating stations take in about 238 billion gallons of seawater per day for cooling,[42] grinding up millions of fish larvae in the process. They discharge heated water and treated wastewater that is non-hazardous according to State and federal regulations.[43] The Chevron refinery, California's largest, produces up to 405,000 barrels of petroleum products and discharges petroleum processing wastewater, boiler water and cooling water that receives secondary treatment.[44] In addition, over 160 smaller commercial and industrial facilities discharge non-process wastewaters to storm drain channels that flow into the Bay.[45]

Urban stormwater is the leading source of pollution in Santa Monica Bay.[46] Toxic pollutants are contained in the stormwater which is delivered to the Bay. On dry days, 25 million gallons of stormwater and urban runoff are carried into Santa Monica Bay through storm drain outlets.[47] During heavy rains, 10 billion gallons of stormwater flow into the Bay through storm drains. The 5,000-mile storm drain network transports 30 billion gallons of stormwater and urban runoff through more than 200 outlets, ranging from 370-feet wide to an almost undetectable size.[48] A 1993 study conducted by the University of California at Los Angeles and American Oceans Campaign identified over 160 toxic chemicals, including known human carcinogens and

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mutagens. This pilot study included a review of five of the 64 major storm drains that empty into the Santa Monica Bay.[49] Stormwater is also a source of pathogens. The Santa Monica Bay Restoration Project has sponsored a health impact study to assess the risk of swimming near Bay storm drain outlets. The results will be released in the spring of 1996.[50]

Toxic pollutants are also contained in discharges from sewage treatment plants. Until the Clean Water Act's pretreatment program went into effect, many industries dumped untreated industrial wastes into sewer systems, which are not designed to treat such wastes. The pollutants passed through the sewer system into the ocean. Between 1940 and 1970, for example, sewer systems discharged 2,000 tons of DDT into the Santa Monica Bay near Palos Verdes.[51] As a result, 200 tons of DDT remain in the sediments of the Palos Verdes shelf. These historic discharges have accumulated in Bay sediments and contaminate aquatic species. In turn, they are ingested by organisms higher in the food chain, including humans.

Fisheries throughout the Bay are at risk from toxic contamination. The white croaker fishery was recently shut down due to concerns over possible toxic contamination.[52] As a result of DDT contamination in the Bay and its bioaccumulation in the food chain, Southern California's marine animals possess the highest levels of DDT poisoning in the world.[53] One meal of dover sole, Pacific sand dab, or white croaker caught by fishermen off the Bay's coast can expose the consumer to a dose of toxic chemicals equal to the amount a person would normally be exposed to in a lifetime.[54] Today, wastewater treatment facilities are required to enforce pretreatment standards for industrial facilities prior to discharge to the sewer system in order to remove toxic and conventional pollutants from the wastewater.

Marine vessels are a significant source of toxic pollutants given the 7,500 berths and hundreds of dry docks at Marina del Rey and King Harbor. Chemicals for the care of marine vessels contribute arsenic, chromium, copper, lead, mercury, PCBs, tributyl tin, and zinc.[55] Marine vessels are also a source of crude oil and refined petroleum products through tanker accidents, fueling, tank cleaning, bilge pumping, and improper disposal.[56] The U.S. Coast Guard estimated that an average of six petroleum product spills from recreational vessels and oil tankers occurred in Santa Monica Bay each year between 1973 and 1987, totaling almost 2,000 gallons of fossil fuels.[57]

Dredging contaminated materials presents other toxic pollution problems for the Bay. Dredging can stir up toxics and other contaminated materials and, when dumped at sea, can be carried back into the Bay by ocean currents. In the past, dredged materials were used for beach replenishment without testing for contaminant levels.[58]

No studies have been done of the Santa Monica Bay to determine the proportion of pollutants that fallout from air, but deposition is thought to be a significant source of lead, nickel, zinc, and PAHs.[59]

Floatable Debris

Trash and debris from beachgoers, marine vessels, and from urban runoff threaten estuaries and their wildlife inhabitants. Over 4,000 tons of trash are collected from Bay beaches annually.[60] The amount collected in just one day can be staggering — on September 17, 1994, volunteers cleaned 480 miles of California beaches. Of the 565,501 pounds of trash collected, 54.1 percent of plastic materials, 18.5 percent was paper, 10.8 percent was metal and the remaining 16.6 percent was other forms of trash.[61]

The Santa Monica Bay Restoration Project

The Santa Monica Bay Restoration Project joined the National Estuary Program in 1989. It seeks to address the following major problems: health risks associated with human contact with pathogen-contaminated water, seafood contamination, the loss of wetlands and living resources, and the impacts of pollution on the ecology and water quality of the Bay. The Project has encouraged cooperation among industry, the public sector, and environmental organizations.[62]

A draft action plan was developed in 1992. The final CCMP, with nearly 250 actions, was approved in March 1995. The Plan identified 74 priority actions costing about $67 million, 33 of which cost about $42 million and focus on the control of polluted urban runoff and stormwater.[63] The SMBRP initiated one of the nation's first permit programs to abate polluted stormwater into the Santa Monica Bay.[64] Current priority action items include: completing an epidemiological study of health risks to people swimming near storm drains; incorporating CCMP actions for stormwater control into a new county-wide NPDES permit for cities; improving the enforcement of water quality permits; reducing toxics from household and industrial sources; and restoring tidal influence of the Ballona Lagoon.

The Plan has a comprehensive monitoring framework to protect living resources. Recent steps have focused on making monitoring information more accessible to the public so that concerns over the health of the Bay can be more adequately addressed.[65]

Overall the SMBRP is renowned for respecting the public participation process and human health concerns that arise from multiple uses of the Bay. This has led to a comprehensive watershed approach to planning and implementation, engaging a wide range of stakeholders in efforts to protect and restore the Bay.[66]

California Senator Tom Hayden, Chairman of the California Senate Natural Resources Committee, although a participant on the Santa Monica Bay Restoration Project Oversight Committee, has also been a critic of the Plan. Thus far, the Project has spent almost $6.5 million in planning efforts; however, sources for the remainder of the $67 million needed for the priority actions have not been identified. Senator Hayden contends the $67 million would include the costs of further reports and studies when the findings of past research already make clear the kinds of actions that should be taken.[67]

Members of the environmental community believe that a significant part of the Bay's pollution problems result from the lack of enforcement by regulatory agencies, pointing out that in 1993-1994, the Los Angeles Regional Board cited only ten violations.[68] A stronger regulatory approach with fixed effluent limits and vigorous enforcement by regulatory agencies is needed. While 80 to 90 percent of the State's effluent flows to the ocean, only about five percent of the Water Resources Board's budget is allocated to ocean issues.[69] As is the case in several of the local NEPs, the Plan contains only those protective measures that all the stakeholders could agree upon, focusing on studies, planning, and education, rather than measurable pollution reduction goals and tough enforcement measures.

National Coastal Caucus

Environmental organizations focusing on the Santa Monica Bay have adopted different but complementary strategies. Heal the Bay is a non-profit coalition of people and organizations who are working to achieve swimmable and fishable coastal waters that meet the goals of the Federal Clean Water Act "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Founded in 1985, Heal the Bay informs publicly elected officials and the media about the Bay, the causes and effects of pollution, and the ways to deal with existing problems so that the Bay can begin the process of healing itself.

American Oceans Campaign (AOC) is a national non-profit organization dedicated to the protection and restoration of the world's oceans, estuaries, beaches and wetlands. AOC was founded in 1987 and is headquartered just a few blocks from Santa Monica Bay. AOC's approach to fulfilling its objective is to educate the public and decision-makers on the need to stop abusing the marine and coastal environments. AOC is committed to bring to the ocean debate diverse coalitions of local, regional, and national environmental organizations, elected officials, businesses, religious groups, labor, and other segments of society. American Oceans Campaign has a long history of working to ban oil and gas drilling off the nation's coast and to tighten restrictions on tankering. AOC has also joined with the City of Los Angeles and Unocal to establish a program for recycling used motor oil and to notify the public about this program. AOC also works to help disseminate information about products that can eliminate the need to change motor oil in cars, trucks, and boats and that may have a significant impact on the reduction of plastic debris entering the Bay.

Heal the Bay and American Oceans Campaign have a long tradition of working cooperatively with public entities and private businesses and industries to promote Bay restoration, as well as promoting educational efforts geared at the general public. Other groups, such as the Natural Resources Defense Council and Santa Monica Baykeeper have adopted a more litigious approach to Bay restoration. The permit to control stormwater and urban runoff illustrates how effectively the two strategies can work together.

Heal the Bay has worked intensively with many of the municipalities to bring about greater understanding and support for the NPDES stormwater permit for the L.A. region. It also launched a broad-based campaign to stencil storm drains to bring greater awareness to the public that what goes into the drains ends up in the Bay. AOC, along with scientists from UCLA, conducted a pilot study of five storm drains entering Santa Monica Bay that identified 160 toxic chemicals, including several known carcinogens and mutagens in the stormwater flow. AOC has also worked with the County of Los Angeles to develop the first-ever beach closure protocol which requires public notice about health risks posed by swimming in Santa Monica Bay due to toxic or bacterial contamination. NRDC has filed a number of lawsuits that have resulted in stringent court interpretations of existing stormwater controls and has, thereby, played a key role in shaping the new draft permit and in forcing the cities to focus on the issue of stormwater. The Baykeeper often serves as an investigative unit. With a 24-hour hotline, a cadre of volunteer inspectors, and a patrol boat, the Baykeeper gathers information about stormwater violations (along with other illegal discharges and activities such as unlawful fishing), and either deals with them directly, passes the information to the proper authority, or joins with lawyers to file a citizen suit.

American Oceans Campaign and Heal the Bay have been involved in the Santa Monica Bay Restoration Project since its inception. Members, Board Directors, and staff of both groups have served in numerous capacities in the development of the CCMP and in the monitoring of the interim actions and other steps taken to implement the plan. Currently, as part of the implementation phase, they serve on both the Santa Monica Bay Watershed Council and Oversight Committee.

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Sarasota Bay
in Florida

Humans, largely responsible for problems plaguing the Bay, have the power to solve the most pressing ones — but do they have the political will? I fear not. The political pressures on the National Estuary Program are such that they restrict the progress of the well-intentioned, good people who want to utilize scientific data now available to resolve the real problems of the Bay.

—Gloria Rains, Chairperson
MansSota-88

Portrait of the Bay

The Sarasota Bay National Estuary Program is examining the water quality and habitat problems of Sarasota Bay and the impact that the greater watershed area has on the estuarine system. Sarasota Bay is one of many subtropical estuaries situated along Florida's southwestern coast. The Sarasota Bay system is an elongated coastal lagoon extending for 56 miles from Anna Maria Sound in the north to Venice Inlet in the south.[1] Its width ranges from less than 300 feet in several narrows to no more than four and one-half miles at its widest point. The Intracoastal Water-

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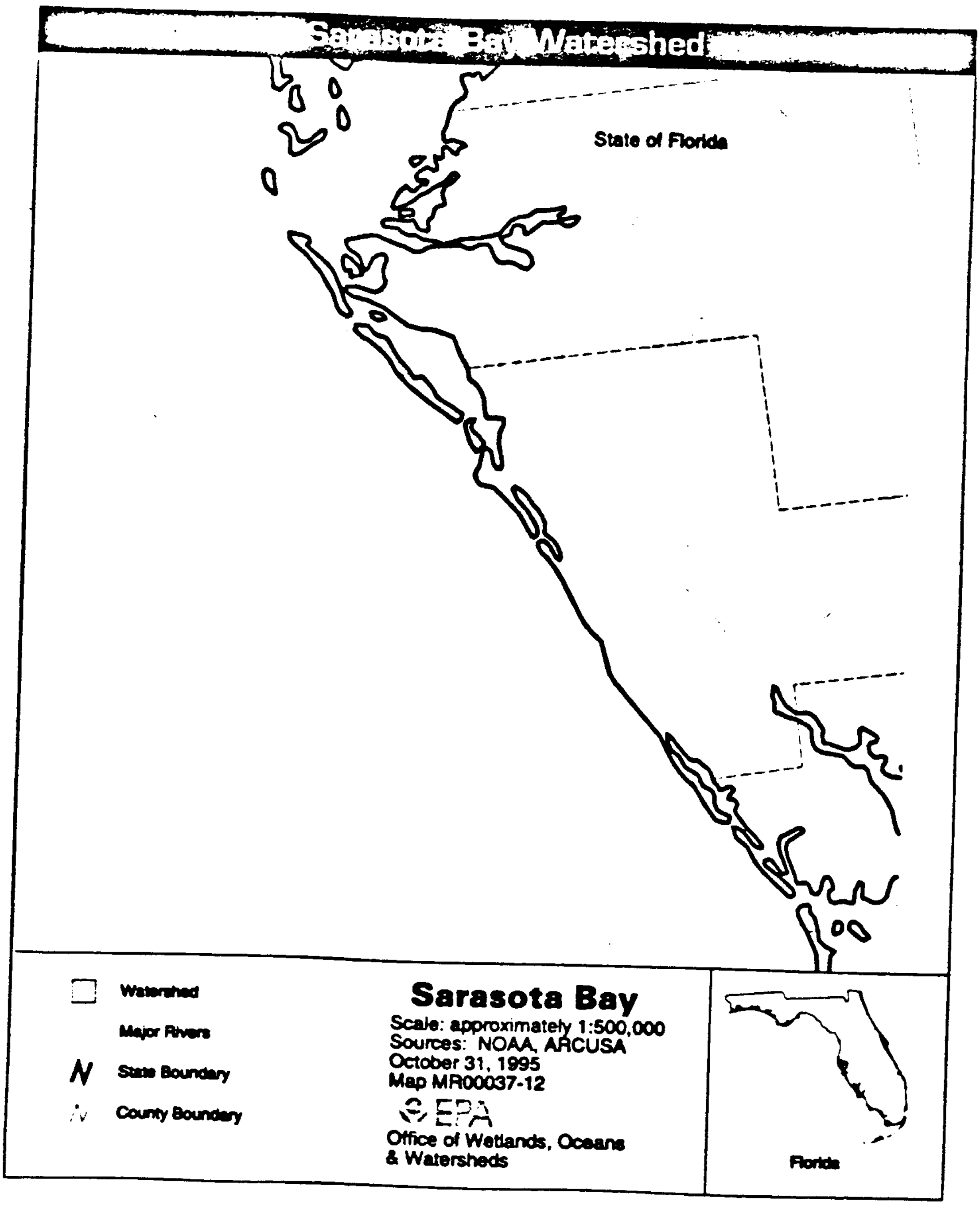
Sarasota Bay

Average depth	6 feet
Length	56 miles
Population	488,000 people
Values	• Sport fishing generates $3.5 billion in economic output* • Tourism generates $115 million • The federally threatened loggerhead sea turtle nests along the beaches
Threats	• Nutrient Loadings • Polluted urban stormwater • Toxic contamination • Habitat loss and degradation • Living resources declines
CCMP status	Approved in 1995

Designated as a "Nationally Significant" Estuary in 1988.

*State figure


Sarasota Bay Watershed
State of Florida
Watershed
Major Rivers
State Boundary
County Boundary
Sarasota Bay
Scale: approximately 1:500,000
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-12
EPA
Office of Wetlands, Oceans
& Watersheds
Florida

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way (ICW), a navigational channel nine to 12 feet deep, runs the entire length of the Bay. The average depth of the Bay is less than six feet.[2]

The Sarasota Bay watershed includes Sarasota County and part of Manatee County. Interstate-75 provides a rough eastern boundary for the greater watershed. Anna Maria, Bradenton, Bradenton Beach, Holmes Beach, Longboat Key, and Sarasota are the largest municipalities of the watershed area. The Sarasota Bay watershed has been one of the fastest growing areas in the nation. Since 1980, approximately 32 people per day have moved into Manatee and Sarasota Counties.[3] Approximately 488,000 people lived in the Sarasota and Manatee Counties in 1990. By 2010, it is projected that 688,000 people will live in both counties — a 41 percent growth rate.[4]

In Sarasota Bay, freshwater is delivered through nine major creeks and other smaller waterways. Stormwater provides a significant source of the estuary's freshwater. At its northern end, the Sarasota Bay system opens into Tampa Bay through Anna Maria Sound. To the west, the Bay connects to the Gulf of Mexico through four passages — Longboat Pass, New Pass, Big Pass and Venice Inlet.

Distinctive habitats of the Bay area include salt marshes, mangroves, freshwater wetlands, barrier islands, seagrass beds, oyster reefs, soft bottoms, and spoil islands. During the past 50 years, the abundance of shoreline and seagrass habitats in the area has been significantly reduced, primarily as a result of development. In the Sarasota Bay watershed, 28 percent of the land is used for urban purposes and 26 percent is used for agricultural production.[5] Of the nation's estuaries along the Gulf of Mexico, the Sarasota Bay watershed has the greatest percentage of urban land use.

Values of the Bay

Sarasota Bay brings enjoyment to the many residents and visitors of the region. Commercial and sport fishing, swimming, boating, water skiing, and wildlife observation are some of the popular activities of the estuary. In 1988, Bay-front property was appraised at almost $2 billion, and its value is increasing.[6] Many businesses are being opened to support the nature-related activities of the area.

These businesses, along with the fishing industries of the estuary, provide significant economic benefits for local communities. The Bay is home to one of the oldest commercial fishery centers in Florida, the Village of Cortez. Sarasota Bay also serves important ecological functions for a great diversity of wildlife which use the estuary and its habitats.

Recreation/Tourism

Tourism, the largest industry of the Sarasota Bay area, is closely linked to the estuary and its living resources. Through tourist uses, property tax revenues, and water-related recreation, Sarasota Bay generates over $115 million annually.[7] Although tourism is economically beneficial to the area, the resulting pressures are actually harming the estuarine system. Since tourism and the ecology of the Bay are inextricably linked, ensuring the sustainability of both is a key objective of the restoration effort.

The Bay area has 85 public beach and Bay access points and over 40 public boating ramps.[8] Use of the Bay for windsurfing, water skiing, jet skiing, and boating is so intense that it has created traffic problems and conflicts with swimmers in several portions of the Bay. Palma Sola Bay, Longboat Pass, Venice Inlet, New Pass, Big Pass, and the ICW near Phillippi Creek and Sister Key all suffer weekend congestion.

Sport fishing is an integral component of the local and State economies. In 1991, recreational fresh- and saltwater fishing contributed $3.5 billion to Florida's economy and employed nearly 58,000 people.[9] In the same year, over 2 million saltwater anglers spent a total of 22.6 million days fishing off the coast of Florida. One-third of the anglers were non-residents of the State. In 1991, approximately 30 percent of the nation's total saltwater fishing days occurred off the coasts of Florida.[10]

With its shallow depth and easy accessibility, Sarasota Bay provides recreational anglers with substantial opportunities to fish for spotted seatrout, sand trout, pinfish, sheepshead, Gulf kingfish, snook, and other fish species. Although only limited economic data on the Bay's recreational fisheries has been compiled, they are considered to be of equal or greater value than commercial fisheries in terms of primary economic impact.[11]

Fisheries/Seafood

In 1994, the combined market value of finfish and shellfish landings in the Gulf region totaled approximately $806 million. Many of the commercially valuable species in the Gulf region depend upon the health of the Sarasota Bay for survival. In 1994, the State of Florida's Gulf of Mexico and Atlantic Coast commercial finfish and shellfish landings totaled approximately 177 million pounds, valued at $239 million.[12]

In 1985, "dockside revenues" for Sarasota Bay's commercial fishing industry equaled approximately $950,000 — the retail value was much greater.[13] In Sarasota Bay, black (striped) mullet and spotted seatrout are two of the most commercially significant fish. In 1990, commercial landings for black mullet in Sarasota and Manatee Counties exceeded 3.1 million pounds, making it the largest commercial fishery of the two counties.[14] However, over the past four decades, annual commercial landings of black mullet and spotted seatrout in the Bay have declined by almost 50 percent.[15]

Historically, Sarasota Bay supported commercial harvesting of oysters, quahogs (hard clam), blue crabs, and bay scallops. Although oysters, quahogs, and stone crabs can still be found in the Bay, commercial shellfish harvesting in the Bay is limited to one small "conditionally approved" area off Longboat Key. Pollution, red tides, and pass closures are responsible for the severe deterioration of the Bay's once productive shellfish beds. Efforts are presently underway to restore the bay scallop population by relocating juveniles to areas of the Bay where seagrass has returned.

Wildlife

Approximately 1,400 plant and animal species inhabit Sarasota Bay and its bordering lands.[16] The Bay has a great diversity of bird species, including herons, egrets, ibis, bald eagles, white and brown pelicans, and various shorebirds. Many species of ducks use the estuary for wintering habitat.

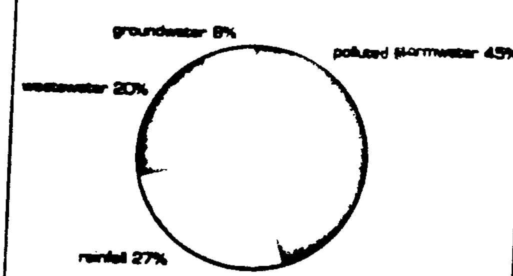
Sea turtles, manatees, and dolphins are some of the most celebrated wildlife inhabitants of the Bay. Sea turtles, including the federally-protected threatened loggerheads, nest on the beaches of the area. Endangered West Indian manatees populate the Bay from April to December and over 100 bottlenose dolphins are year-round residents of the Bay. The endangered wood stork and threatened piping plover, bald eagle, and green sea turtle also use Sarasota Bay and its neighboring habitats.

Threats to the Bay

Habitat modifications to meet the demands of a rapidly growing population and the resulting increases in pollution loadings have substantially altered the environment of Sarasota Bay. Many of the principal threats to Sarasota Bay are directly attributable to the population explosion in Florida. The area's population is expected to grow by 25 percent between 1992 and 1997.[17] Forty years ago, Sarasota Bay enjoyed a wide distribution of seagrass and its shores were thriving with thick mangrove forests. Bay scallops, finfish, and shellfish were abundant in the Bay and nearby Gulf of Mexico. Today, the Bay's fisheries, mangroves, and seagrasses are greatly reduced from 1950 levels. Recent restoration efforts and advancements in municipal and industrial wastewater technology are improving the health of the Bay. To continue the progress of restoring the Bay, the Sarasota Bay Project has developed initiatives to reduce nutrient loadings,

Sarasota Bay

Nitrogen Loading Sources for the Bay



Source: Sarasota Bay National Estuary Program.

stormwater pollution, habitat loss, wildlife declines, and to minimize the negative effects of population growth and increased development.

Nutrient Loadings

Nutrients, such as nitrogen and phosphorus, are introduced to Sarasota Bay by urban stormwater, wastewater treatment plants, septic system leachate, atmospheric deposition, and boater discharges. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As the algae grow, they not only block sunlight needed by the submerged aquatic vegetation of the Bay, but also require a great amount of dissolved oxygen to decompose. The decomposition process reduces the levels of oxygen needed by other aquatic life.

Nitrogen is the nutrient of greatest concern in Sarasota Bay. Nitrogen loadings have increased by 300 percent since the early stages of urbanization in the 1950's.[18] If steps are not taken to reverse the rate at which nitrogen is discharged into the Bay system, another eight percent increase in nutrient loadings is anticipated by 2015.[19]

Presently, stormwater and atmospheric deposition are the two leading sources of nitrogen loadings into Sarasota Bay, contributing 45 and 27 percent of the total load, respectively.[20] Reducing nitrogen levels carried by stormwater requires cooperation from landowners to decrease usage of harmful fertilizers and to change landscape designs so that runoff from residential lawns is minimized. Automobile exhausts and power plants emit significant amounts of nitrogen into the air. As it rains, nitrogen from the air eventually makes its way into the Bay.

As advanced treatment technologies for wastewater plants are installed, nitrogen loadings contributed by wastewater systems are diminishing. Centralized sewer systems in some areas of the watershed are simultaneously reducing pollution discharges into waterways and providing more water for irrigation through wastewater reclamation. The regrowth of 125 acres of seagrass in the central portion of Sarasota Bay is likely due to nitrogen reductions.[21]

Most of Sarasota County is served by smaller sewage treatment plants and 45,000 individual septic systems. Many of the smaller sewage treatment plants do not directly discharge into the Bay; instead, they discharge into the area's groundwater and are thus subject to weaker discharge safeguards. Septic systems remain a significant problem for the Bay since they are only regulated with respect to human health and not environmental quality.

Septic systems in the Phillippi Creek area of the watershed are a special concern. These systems contribute four times more nitrogen to the Bay than the City of Sarasota's wastewater treatment plant.[22] A sewer expansion project under review by Sarasota County would replace 8,500 of the 32,000 septic systems which currently feed into Phillippi Creek, and six old sewage plants.[23] Expanding the service area of the City of Sarasota's treatment plant to include areas near Phillippi Creek would ultimately reduce nitrogen loadings in the Creek by an estimated 31 percent.[24]

Polluted Urban Stormwater

Stormwater pollution is a significant threat to the health of Sarasota Bay. Each year, the Sarasota area receives an average of 58 inches of rain from about 100 storms.[25] During frequent storm events, a substantial amount of nutrients, heavy metals, organic chemicals, sediments, pathogens, and litter is carried by stormwater to the Bay and its tributaries. As the Sarasota Bay watershed becomes more urbanized, the problems associated with heavy rainfall heighten. By replacing natural soils and vegetation with impervious surfaces, such as pavement and roofs, the flow of stormwater and the concentration of pollutants are increased. The beneficial functions that natural lands perform, such as filtering contaminants and absorbing excess waters, are lost as the area becomes more urbanized.

Due to poor management practices of the past, stormwater continues to be directed into the region's creeks and bayous without any form of filtration, detention, or retention. As a result, these tributaries are more polluted than the Bay as a whole because they are more directly affected by the pollutants. Without improved stormwater management measures, these tributaries will continue to deliver polluted stormwater into the Bay, and estuarine areas affected by nutrient enrichment and contaminated sediments will be at greater risk.

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Toxic Contamination

The primary source of toxic chemicals in the Bay is stormwater, which picks up particles of heavy metals and organic chemicals and carries them to the Bay. The most commonly found heavy metals in the sediments of the Bay and its tributaries are lead, copper, zinc and cadmium.[26] Vehicle exhausts and brakes introduce lead and cadmium into the environment. Copper originates from anti-fouling paints used on boat bottoms and from some herbicides. The most prevalent pesticides which are found in the Bay include aldrin, DDT, dieldrin, heptachlor exopide, and chlorpyrifos.[27]

Five tributaries — Hudson Bayou, Cedar Hammock Creek, Bowlees Creek, Whitaker Bayou, and Phillippi Creek — have elevated levels of copper, lead, and zinc, that pose ecological risks to aquatic communities in the Bay.[28] Many toxins persist in the aquatic environment and over time, accumulate in the tissues of fish and shellfish. Shellfish sampled from Sarasota Bay contain levels of toxic contamination well above State averages.[29] Toxins are linked to reproductive and larval development problems in fish. Subsistence and recreational fishers put themselves at increased health risks from eating larger than average quantities of potentially contaminated fish and shellfish.[30]

Habitat Loss and Degradation

The loss of shorelines, seagrass, mangroves, and freshwater wetlands impairs the water quality and living resources of the Bay. Rapid development has significantly altered the habitats of the Bay. Bulkheads, seawalls, and rock revetments have been built along the coasts and natural shorelines have been artificially filled by spoils in the Sarasota Bay area. Only 22 percent of the Bay's shoreline remains in its natural state.[31]

Both tidal and freshwater wetlands serve critical functions for the estuary, its wildlife and coastal communities. Wetlands are important spawning and nursery areas for fish and shellfish, many of which are valuable commercial species. Wetlands also provide nesting and feeding grounds for waterfowl, shorebirds, mammals and reptiles. Mangroves and salt marshes prevent shoreline erosion and protect inland areas from coastal storms and tides. Finally, wetlands absorb flood waters, remove pollutants before the contaminants can reach the waters, provide places for recreation, and serve other beneficial purposes.

It is estimated that Florida lost over 9.2 million acres of its historic wetlands acreage between the 1780s and the 1980s — a 46 percent reduction. This represents the highest acreage loss of any state in the country.[32] Since the 1950s, significant amounts of Sarasota Bay's saltwater and freshwater wetlands have been destroyed.

Between 1950 and 1990, over 1,600 acres of the Bay's tidal wetlands were destroyed — a 39 percent loss.[33] An average of 40 acres of tidal wetlands were lost each year during this span. Mangroves are the predominant type of tidal wetland in Sarasota Bay; but, unlike the expansive stretches of mangroves which dominated the Bay shore in 1950, most of the remaining mangrove areas are small and fragmented. Dredge-and-fill activities, the construction of dikes in order to disrupt mosquito breeding, mangrove pruning and trimming, and the invasion of non-native plants (such as Brazilian pepper and Australian pine) are the chief causes of the significant loss of mangroves and salt marshes in the Sarasota Bay area.

Between 1975 and 1987, 1,900 acres of non-forested freshwater wetlands of the Sarasota Bay watershed were destroyed — a 35 percent reduction.[34] During these 12 years, 158 acres of non-forested wetlands were lost annually. In earlier years, most of the freshwater wetlands that were destroyed were converted to support agricultural uses. More recently, residential and commercial development are replacing once-existing, freshwater wetlands. The greatest freshwater wetland losses have occurred in the areas surrounding Hudson Bayou, Whitaker Bayou, Bowlees Creek, Cedar Hammock Creek, and Palma Sola Creek.[35]

Throughout the Bay, 30 percent of the historic coverage of seagrasses has been destroyed.[36] Dredge-and-fill activities to support waterside development; the construction of navigational channels; increased boater traffic, and pollution have all caused the declines of seagrasses in Sarasota Bay. Currently, seagrass beds account for 26 percent of the 33,000 acres of Bay bottom.[37] However, these remaining beds are not as productive as the seagrasses which covered the bottom prior to development activities. Restoring seagrass is important to the aquatic life of the estuary. Manatees and sea turtles feed on the seagrass, juvenile fish and shellfish use seagrass beds for nurseries and shelter, and dolphins rely on seagrass for nursery habitat. Reductions in nitrogen from wastewater discharges are helping to restore seagrasses in certain portions of the Bay. In Longboat Pass and New Pass, seagrass coverage is expanding.

Living Resources Declines

Human use of the estuary has disturbed the fragile balance of estuarine life. Human activities often come into direct conflict with animal life. Despite intense work to preserve the Bay's turtles, manatees, and dolphins and protect their habitats, heavy recreational use of the Bay and its beaches puts populations of these animals at risk. Colliding with boats is the leading cause of manatee deaths. Of the 19 manatees which died in the area between 1987 and 1991, nine were mutilated by boat propellers or died after colliding with boats. In addition, seven of the 19 were calves that researchers believe were separated from their mothers while fleeing from boats.[38] Only about 1,850 West Indian manatees remain in Florida waters.[39] During busy weekends, dolphins move to shallower waters to escape boating noise and reduce the risks of collisions. Seagrasses are important calving and nursery grounds for dolphins, just as beaches are vital habitat for turtle nesting. Losses or alterations of these habitats contribute to the decline of these animals.

Pollution is another major contributor to the losses among native plants and animals. Since the 1960s, pollution has contributed to drastic declines among scallop, hard-clam, and oyster populations, and to the closing of shellfish beds to harvest.[40] Declines in these shellfish populations alter the composition of aquatic life in the system. Some believe that this imbalance is triggering the increase in populations of stone crabs and other species.

Reduced fish stocks are a recent trend in Bay waters. Habitat losses are contributing to lower commercial landings in the area. For example, concrete seawalls have been built where mangroves once thrived and as a result, a large area of juvenile fish habitat no longer exists.

In Florida, the invasion of exotic plant species, which replace native species and destroy wildlife habitat, is a massive problem. Specifically, in Sarasota Bay, exotic species, such as Brazilian pepper and Australian pine, have doubled their coverage along the coastline since 1948.[41] Australian pines, which have a shallow root system and large canopy, frequently blow over during heavy storms and alter nearshore channel flow in the process. In addition, their roots often prevent turtles from nesting. Finally, carrotwood has also started to invade mangrove stands.

Additional Concerns

The accumulation of trash on estuarine beaches threatens the ecosystem and wildlife inhabitants. The amount found in just one day was staggering — on September 17, 1994, 1,267 miles of beach were cleared of 368,255 pounds of debris by volunteers in Florida. Of the total amount, 61.4 percent was plastic, 12.5 percent was metal, 11 percent was glass, and 15.1 was other materials.[42]

Florida does not have a state beach water quality monitoring program; however, the Department of Environmental Regulation has established bacteria standards for swimmer safety.[43] Sarasota County monitors 12 beaches quarterly for swimmer safety. In 1994, Sarasota County had two beach closures — both at Blind Pass Beach — which were caused by red tide. Manatee County has not adopted a water monitoring program for swimmer safety.[44]

The Sarasota Bay National Estuary Program

Sarasota Bay was formally designated as an estuary of "national significance" under the National Estuary Program (NEP) in 1988. A five-year workplan for developing a Comprehensive Conservation and Management Plan (CCMP) was approved by the Sarasota Bay National Estuary Program's

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Policy Committee in 1989. The structure of the Sarasota Bay National Estuary Program (SBNEP) consists of the Policy Committee, the Elected Officials Forum, the Management Committee, the Technical Advisory Committee, and the Citizens Advisory Committee. The SBNEP completed its "State of the Bay" report in January, 1990. In November 1995, the Environmental Protection Agency and the Governor of Florida approved the CCMP for Sarasota Bay. The approved plan outlines water quality improvement initiatives through additional wastewater treatment, stormwater controls, increased wetlands restoration, and pollution prevention activities.

By 1993, a compilation of studies that were completed over the past several years, and some new scientific research on the health of the Bay had been gathered and made available. Unfortunately, some questions exist regarding the accuracy, thoroughness, and timeliness of the data and the modeling that was conducted. For instance, although nitrogen is a significant problem for the health of the Bay, no studies were conducted on the atmospheric deposition of nitrogen oxide. After receiving numerous complaints some modeling, although inadequate, was eventually conducted.[43] Other studies included an assessment of fish and shellfish contamination, modeling of water circulation and pollutant loads, and evaluations of wetlands losses. The data from the research was used as a guide for the SBNEP in developing its CCMP and has assisted in determining the type and scope of necessary interim action projects. Some believe, however, that enough information had already existed to begin to address some of the most serious concerns of the Bay and that too much emphasis was placed on research as opposed to action.

One of the main purposes of the SBNEP was to establish working, coordinated partnerships among the federal, State and local agencies to address the threat of pollution in Sarasota Bay. To this end, the SBNEP has been quite successful. The level of civic involvement, of both citizens and local officials, has raised awareness and acceptance of the goals of the CCMP, as well as support for immediate action to protect and restore the Bay. Yet, it must be remembered that the Plan relies on acceptance by a wide number of political entities whose priorities may not always coincide with that of the Plan and who are reluctant to relinquish power to any central authority for implementation. A simple, yet telling, example of the political pressure is the change of emphasis on action between the draft CCMP and the final version — all language stating that agencies "shall" take specific actions was changed to "should" in the final version.

Wastewater and stormwater issues provide a good example of interagency cooperation under the SBNEP. County objectives for these issues coincide quite well with the goals of the CCMP. It is generally believed that stormwater reduction efforts and upgrading wastewater treatment plants, have been somewhat successful at reducing nutrient loadings into the Bay. The CCMP recommends using the excess capacity of the City of Sarasota's Advanced Wastewater Treatment Plant to service the inefficient and overburdened treatment plants of nearby communities, and to connect up failed septic systems that run adjacent to Phillippi Creek. County stormwater plans include the development and use of retention basins, detention ponds and the like to hold back waters that would normally discharge directly into tributaries of the Bay. Unfortunately, however, the SBNEP has yet to accomplish substantial gains in reducing nitrogen loading from septic systems.

The SBNEP has set a wetlands restoration goal of 29 acres per year. By 1995, the SBNEP had restored 75 acres of saltwater wetlands.[44] It has provided for demonstration projects to transplant seagrasses, re-establish scallops, and provide signs to reduce boat propeller scarring of underwater habitats. In addition, the Program experimented with an inexpensive artificial reef system to be used along existing sea walls lining the Bay. However, this proposal has proven to be extremely controversial. Although it provides additional reef habitat for fish, it has negative consequences. These consequences include disposing rubble into marine habitats to create the reef, forcing aquatic life to depend on artificial habitat, and losing on-site opportunities for education on the values of natural reefs, which can not be artificially duplicated.

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A Florida Yards & Neighborhoods Program was recently adopted to reduce pollution from individual homes. The SBNEP is recommending a 20 year commitment to this program at a cost of $200,000 per year. Its public education objectives include native plant selection, lawn maintenance reduction, shoreline management, mangrove conservation, and landscaping to reduce residential runoff. The anticipated results are a reduction in nitrogen loadings from over-fertilization of residential landscapes, water conservation, and habitat protection. However, since this is a strictly voluntary program with a relatively small budget — considering the amount of public outreach it must conduct to be effective — there is concern that there will be little impact and no clear way to measure its effectiveness.

The SBNEP also engages in hands-on educational projects. For instance, children and adults educate other citizens about the impact of individual actions by painting blue dolphins on storm drains with the statement "Dumping Here Pollutes Our BAY."

National Coastal Caucus

ManaSota-88, A Project For Environmental Quality 1968-2088, is a non-profit organization comprising more than 2,500 concerned members, all dedicated to the health and preservation of the environment. ManaSota-88 serves as an environmental watchdog organization for the two-county area of Manatee and Sarasota. It is actively engaged in a full range of advocacy and public education issues affecting both Sarasota and Tampa Bay.

Created in 1968, ManaSota-88 evolved from a major environmental health study sponsored by the U.S. Public Health Service, Florida State University, the University of Florida and the Sarasota and Manatee County Commissions. Manasota-88 functions primarily through working committees composed of citizen volunteers and public officials. A steering committee provides overall leadership and direction. The organization operates entirely through volunteer support and receives no contributions from the government or "special interest" groups.

Members, volunteers and staff of ManaSota-88 have served in numerous capacities in attempting to strengthen the development of the CCMP and in monitoring the interim actions and other steps taken to implement the Plan. In particular, they have served on the Citizens Advisory Committee and have served in an advisory capacity on other local government boards and commissions, such as the Southwest Florida Water Management District Board, Environmental Advisory Committee and Manasota Basin Board.

Spokespersons for ManaSota-88 present testimony on behalf of the organization in countless forums. ManaSota-88 educates its members, the general public and policymakers by promoting legislative initiatives, commenting on regulations, using the judicial process to enforce the law, initiating studies, and conducting research to help protect the Bay. For example, the organization works on federal legislation such as the Clean Water Act; State legislation such as the Mangrove Trimming & Preservation Act; local zoning decisions on such issues as protecting public resource lands and endangered species; and public right-to-know issues such as obtaining public records from the Port Authority on levels of airborne particulates in excess of State standards generated at their facility. In addition, ManaSota-88 has worked with the State Legislature to find economically viable solutions to dredging and port expansion projects. They have worked to assist the Legislature in coming up with a plan to determine and prioritize which ports merit allocation of funding. They have effectively argued that port expansion should not occur near aquatic preserves.

One of the most recent and important initiatives that ManaSota-88 has been involved with has been its outspoken opposition to the alternative fuel, Orimulsion. Orimulsion is a manufactured fuel that rapidly disperses in estuarine waters when spilled. The use of Orimulsion will cause other problems for the health of the Bay. It will increase nitrogen oxide emissions in the area by 10,000 tons or more per year. Emissions of other pollutants, including

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vanadium will also increase. ManaSota-88's efforts pulled the review process in the right direction and preserved its right to seek appellate court review.

The American Littoral Society (ALS) is a non-profit organization, founded in 1961 to encourage a better understanding of the marine environment and to provide a unified voice advocating for the protection of the delicate web of life along our coasts. The shore, its adjacent wetlands, estuaries, and coral reefs — the littoral zone — is the special area of interest and concern for the organization. ALS works to protect these resources by promoting marine education, accessing media coverage, and giving testimony at the local, state and national levels for legislation that furthers a cleaner marine environment.

The activities of ALS, as they relate to Sarasota Bay, include lectures, beachwalks, snorkeling trips, and Bay boat trips that emphasize the natural history and need for restoration of the Bay. The ALS has played a key role in the development of the CCMP. Specifically, the regional director of the Gulf/South Atlantic chapter serves on the Sarasota Bay National Estuary Project Citizens Advisory Committee and is a member of the Southwest Florida Water Management District Board, Environmental Advisory Committee.

ALS provides plenty of opportunities for activism. The organization runs a volunteer restoration project at Palmer Point, a 30 acre publicly-owned strip of barrier island located on north Casey Key and Siesta Key. Australian pine and Brazilian pepper are removed and replaced with native species grown by volunteers. ALS also conducts coastal cleanups, coastal strand and dune restoration, volunteer monitoring, seagrass planting, fish tagging and more. They organize outdoor field trips, such as seining, canoeing, camping, hiking, and diving, along the coastal strand. They also go whale watching, shark tagging, and otter trawling for marine specimens. ALS runs the nation's largest fish tag-and-release program. Over 10,000 fish are tagged annually. Tag and return data is sent to a computer at the National Marine Fisheries Center, Woods Hole Oceanographic Institution, Massachusetts. Those records help marine biologists learn more about fish migration and growth rates, among other things.

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Tampa Bay
in Florida

Once the State's most diverse and productive estuarine system, rapid urban and industrial development have significantly changed the character and ecology of Tampa Bay over the past 100 years, with habitat destruction and water quality degradation escalating during the last 30 of those 100 years. This profound loss of habitat has resulted in the complete collapse of our scallop and oyster fisheries, as well as major declines in bait and food shrimp, spotted sea trout and red fish.

—Peter Clark, President
Tampa BayWatch

Portrait of the Bay

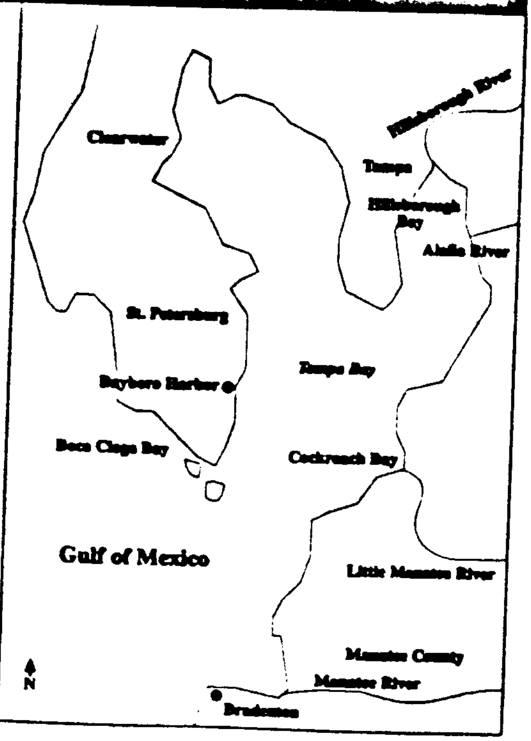
The Tampa Bay National Estuary Program is examining the water quality and habitat problems of Tampa Bay and the impact that the greater watershed area has on the estuarine system. Tampa Bay, located on Florida's Gulf coast, is the largest open-water estuary in the State. The Bay's water surface area measures approximately 400 square miles. The average depth of Tampa Bay is about 12 feet; however, this includes the depths of dredged shipping channels which are 43 feet deep.[1] Most of the Bay is relatively shallow.

Tampa Bay

Area of surface water	400 square miles
Area of watershed	2,200 square miles
Average depth	12 feet
Population	2 million people
Values	• Fisheries generate $239 million* • Sport fishing generates $3.5 billion in economic output* • Mangrove islands support 40,000 nesting pairs of birds
Threats	• Nutrient loadings • Toxic pollution • Habitat loss and degradation • Pathogen contamination • Floatable debris
CCMP status	Expected in 1996

Designated as a "Nationally Significant" Estuary in 1991.

*State figures



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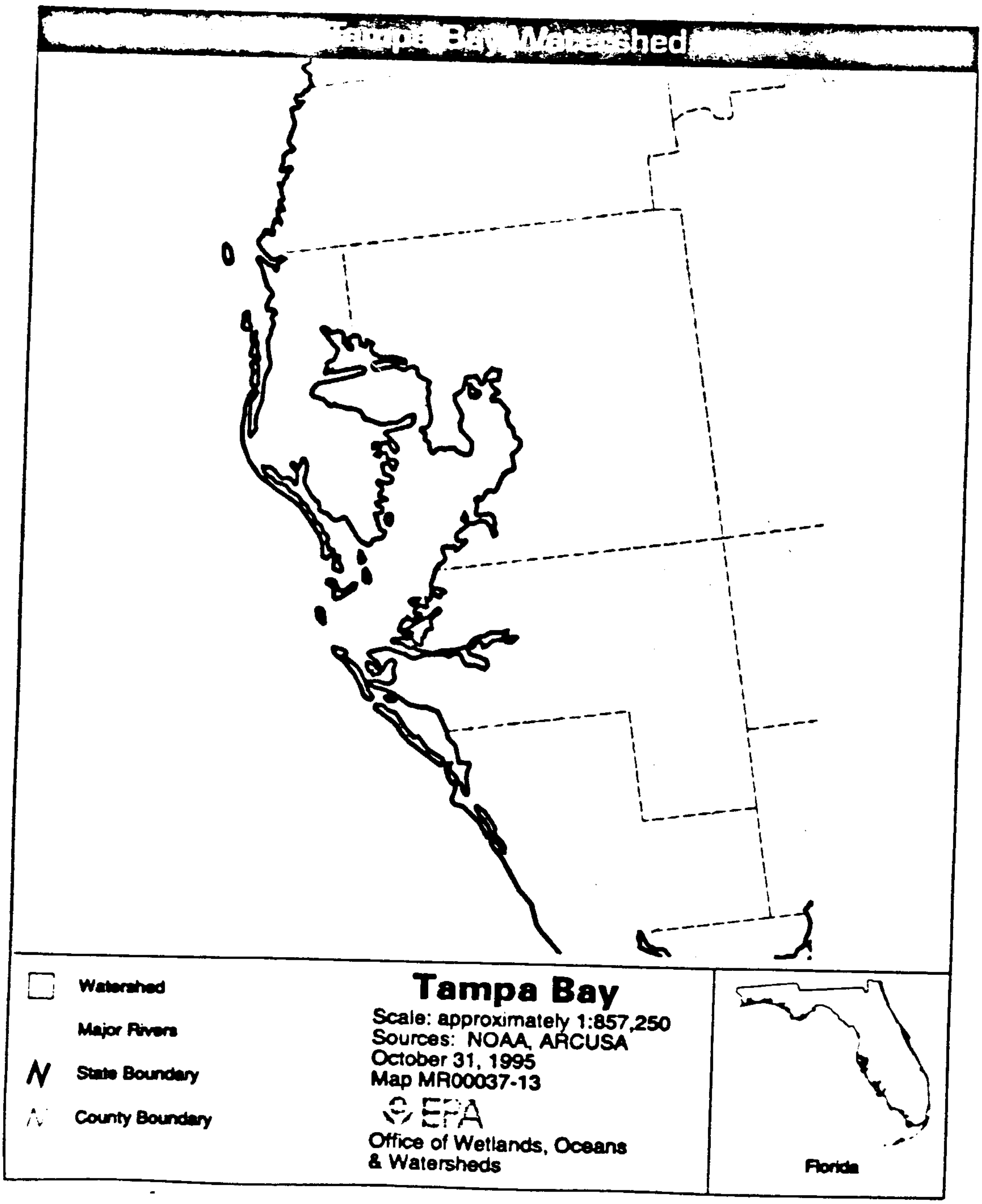
Tampa Bay Watershed
Watershed
Major Rivers
State Boundary
County Boundary
Tampa Bay
Scale: approximately 1:857,250
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-13
EPA
Office of Wetlands, Oceans
& Watersheds
Florida

The watershed of Tampa Bay covers approximately 2,200 square miles and extends into most of Pinellas, Hillsborough, and Manatee Counties and portions of Pasco, Polk, and Sarasota Counties.[2] In 1991, 40 percent of the land in the watershed was classified as agricultural land and 17 percent was classified as urban land.[3] The largest municipalities within the watershed are Tampa, St. Petersburg, Bradenton, and Clearwater. The population of the Tampa Bay area has increased 24 percent since 1970.[4] Currently, more than two million persons live in the watershed.[5] The combined population of Pinellas, Hillsborough, and Manatee Counties is projected to grow to 2.4 million by 2010 — a 20 percent increase from the current population.[6]

The Hillsborough, Alafia, Little Manatee, and Manatee Rivers are the major sources of freshwater for Tampa Bay. A number of smaller rivers and creeks also drain into the Bay. The estuary's major connection with the Gulf of Mexico is at the mouth of Lower Tampa Bay. Several passes and inlets also join the waters of the Gulf and the Bay.

Distinctive habitat types in the Bay system include submerged seagrasses, hard-bottom growth, soft-bottom habitat, salt marshes, mud flats, forested uplands, and open water. As a combined system, these habitats support a great diversity and abundance of wildlife. However, human-induced pressures, such as habitat alterations and pollution loadings, continue to jeopardize the living resources of the estuary.

Values of the Bay

With its inherent physical beauty, and economic and recreational values, Tampa Bay enhances the quality of life of its residents and visitors. Rich in natural resources, Tampa Bay is among the most productive estuarine ecosystems in the country. The estuary's mangroves sustain large nesting populations of sea and shorebirds; and its aquatic vegetation supports a diversity of benthic organisms.

The coastal communities of the Bay derive a number of benefits from the estuary. Four major tributaries within the watershed — the Hillsborough, Palm, Manatee, and Braden Rivers — provide drinking water for more than 750,000 residents in the estuary region.[7] The Bay and its surroundings, especially the ocean beaches, offer numerous tourist destinations. The Bay's three ports — Tampa, St. Petersburg, and Manatee — form an international trading hub. The Port of Tampa alone, contributes approximately $5.5 billion to the regional economy and supports an estimated 68,000 jobs.[8] Nonetheless, shipping operations in the Bay threaten the area's water quality and habitat. Thus, maintaining a proper balance between human usage and the health of the Bay's natural resources is the key to the estuary's future productivity.

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the Gulf of Mexico region totaled approximately $806 million.[9] Many of the commercially-valuable species in the Gulf region depend upon the health of Tampa Bay for their survival. In 1994, the State of Florida's commercial finfish and shellfish landings totaled 177 million pounds, valued at $239 million.[10]

Important commercial fisheries of Tampa Bay include black mullet and spotted seatrout. Tampa Bay fisheries have historically contributed to the economy of the region. In 1986, for instance, commercial fishermen landed about 35 million pounds of finfish and shellfish worth about $24 million in dockside revenues. Recently, however, the fishing industry has suffered from fish population declines. For example, between 1964 and 1990, finfish harvested at Tampa Bay Ports dropped by nearly 38 percent, from 17.6 million pounds to 11 million pounds.[12] Currently, there are bans prohibiting commercial fishing for red drum, menhaden, and herring in the Bay;[13] in addition, there is presently no approved commercial shellfish harvesting in Tampa Bay. The only shellfish which is approved for recreational harvest from Tampa Bay is the clam.[14] Water quality declines, overfishing, and habitat loss are the principal reasons for the Bay's decreased commercial fisheries production.

Recreation/Tourism

Tampa Bay and its surroundings are popular destinations for vacationers and residents in search of sunbathing, fishing, sailing, water skiing, diving,

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camping, and many other recreational opportunities. It is estimated that 50 million people visit Florida's beaches, spending up to $25 million each year.[15] In 1991, recreational fishing in Florida generated approximately $3.5 billion in economic output and employed over 58,000 people.[16] In 1991, over 2 million saltwater anglers fished off the coast of Florida.[17] One-third of the anglers were non-residents of Florida.[18]

More than 100,000 boats are registered in Pinellas, Hillsborough, and Manatee counties.[19] State parks and preserves are found along the Bay. In addition, the Egmont Key, Pinellas, and Passage Key National Wildlife Refuges are located at the mouth of the Bay. In addition to the residents that frequent these natural areas in their local region, approximately eight million tourists visit the Tampa Bay area each year.[20]

Wildlife

The variety of habitats found in Tampa Bay provide shelter and food for hundreds of animal species. Shrimp, bay scallops, seatrout, sea horses, manatees, and sea turtles are among the many species that rely on the Bay's seagrasses. Invertebrates thrive in the soft mud and sand along the Bay's bottom. In fact, each square meter of the Bay's soft-bottom contains an estimated one million invertebrates.[21] Oysters, fish, and invertebrates can be found using the Bay's oyster reefs and other hard-bottom grounds. Mangrove islands in the Bay provide nesting grounds for brown pelicans, roseate spoonbills, white ibis, reddish egrets, and other birds. These islands contain some of the most diverse and productive nesting colonies in North America, supporting approximately 40,000 nesting pairs of at least 25 bird species each season. Other animals found in Tampa Bay include Atlantic bottle-nose dolphins, sandpipers, and loggerhead, green, and Kemp's ridley sea turtles. Up to 200 West Indian manatees are residents of the Bay.[22]

Many of the species that inhabit the coastal areas of Florida are threatened and endangered. More than 25 percent of Florida's federally-protected endangered and threatened animal species depend on the State's wetlands.[23] The endangered green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, shortnose sturgeon, bald eagle, American woodstork, Florida salt marsh vole, rice rat, and West Indian manatee rely upon Florida's estuarine wetlands. Florida's loggerhead sea turtles and piping plovers are threatened species which depend upon estuarine wetlands in Tampa Bay and other parts of Florida.[24]

Threats to the Bay

During the past decade, efforts to restore natural habitats and upgrade wastewater treatment plants throughout the Bay have been extremely successful. However, many water quality problems remain. Stormwater and pollution running off urban and agricultural lands discharge a mixture of nutrients, bacteria, toxic chemicals, and trash into the Bay and its tributaries. Development in the region is replacing natural soils with impervious surfaces such as pavement and roofs, eliminating the filtering and absorbing capabilities of natural areas. Therefore, greater flows of water carrying higher concentrations of contaminants are reaching the Bay's waters. Fish and wildlife populations of the area are threatened by a combination of water quality impairments, habitat loss, and overfishing.

As the area's population continues to grow, the estuary's vitality will continue to be threatened. Thus, building upon recent environmental successes will be a challenge. The Tampa Bay Natural Estuary Program has identified nutrient loadings, toxic pollution, and habitat loss as among the priority problems facing the Tampa Bay system.

Nutrient Loadings

Nutrients such as nitrogen and phosphorus are introduced to the estuary by urban stormwater, agricultural runoff, leachate from septic tanks, sewage treatment plants, and atmospheric deposition from power plants and cars. Excessive levels of these nutrients stimulate the growth of algae in the Bay. As algae grow, they block sunlight needed by the submerged aquatic vegetation of the Bay. Thus, algal blooms cause declines among seagrass beds and subsequently bay scallop populations, which use seagrass as their primary source of habitat. In addition, as algal decomposition requires a great amount of dissolved oxygen, the process depletes oxygen levels — much-needed by other aquatic life — from the system. Low oxygen conditions (called hypoxia) can cause large fish kills.

Nitrogen is the nutrient of greatest concern to Tampa Bay. Stormwater is responsible for depositing almost one-half of the Bay's nitrogen loadings — urban stormwater alone accounts for 16 percent of the total nitrogen loadings. Twenty-eight percent of the nitrogen loadings come from atmospheric deposition; while 14 percent come from municipal and industrial point sources entering the Bay.[27] Previous deficiencies in wastewater treatment facilities have accounted for a large portion of past nitrogen loadings into the Bay system. The implementation of advanced wastewater treatment processes in the Bay's nine major public wastewater treatment facilities has effectively reduced nitrogen concentrations by as much as 90 percent. However, these facilities still dump approximately 28 billion gallons of effluent into the Bay yearly (including 440 tons of nitrogen).[26]

Toxic Pollution

When the Tampa Bay National Estuary Program began in 1991, toxic pollution was not considered one of the most pressing problems facing the Bay. However, subsequent research has found that toxic contaminants, such as heavy metals and pesticides, are a significant ecological concern for Tampa Bay. Of the nation's estuaries that border the Gulf of Mexico, Tampa Bay ranks among the highest in toxic chemical and pesticide concentrations.[27] Heavy metals found in elevated levels in Tampa Bay include cadmium, chromium, copper, lead, mercury, and zinc. Currently, due to high levels of mercury, fish consumption advisories exist for spanish mackerel and bluefish caught in Tampa Bay. The pesticides of greatest concern in Tampa Bay are DDT, mirex, dieldrin, endosulfan, and chlordane. Finally, polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs) are also present in the Bay.[28] All of these toxins can harm aquatic life in the Bay.

Particles of toxic metals and organic chemicals settle in the sediments of the Bay and its tributaries. These chemical contaminants persist in the system and are eventually consumed by aquatic organisms. Once consumed, these toxins accumulate in animal tissues and are passed throughout the food chain. Because of the persistent nature of these contaminants, chemicals and metals introduced to the system decades ago can have present-day effects on water quality, and wildlife and human populations. This is particularly problematic for subsistence fishers in urbanized waters.

The areas of the Bay system with the most significant concentrations of heavy metal contamination are found around urban centers, marinas, and ports, including Hillsborough Bay, the Port of Tampa, Boca Ciega Bay, and Bayboro Harbor.[29] Fish caught from the shipping channel have revealed cadmium, lead, and zinc levels high enough to cause biological impairments.[30] In addition, oysters in the Bay have revealed higher-than-average concentrations of lead, mercury, zinc, and arsenic when compared to oysters in other Gulf of Mexico estuaries. These contaminants are believed to be connected to reproductive and developmental deficiencies in Tampa Bay oysters.[31] Blue crabs, hardhead catfish, killifish, and red drum have also been found with biological impairments.

Pesticides are of particular concern in Cockroach Bay and Boca Ciega Bay. A survey of 200 nationwide sites revealed that oyster samples from Cockroach Bay had the third highest level of chlordane in 1988 and the fifteenth highest level of chlordane over a three-year period.[32]

Most toxic contaminants found in the Bay's sediments enter the Bay via stormwater discharges. In fact, stormwater carries an estimated 60 percent of the annual loadings of chromium, zinc, mercury and lead into the Bay.[33] Other sources of toxic contamination include atmospheric deposition and wastewater treatment plant discharges.

Habitat Loss and Degradation

According to the Tampa Bay Regional Planning Council, the Tampa Bay region is the third fastest growing urban area in the nation.[34] In an attempt to accommodate the growing population, development activities have escalated dramatically, causing significant habitat losses and water quality impairments in the Bay area. Shoreline, salt marsh, and

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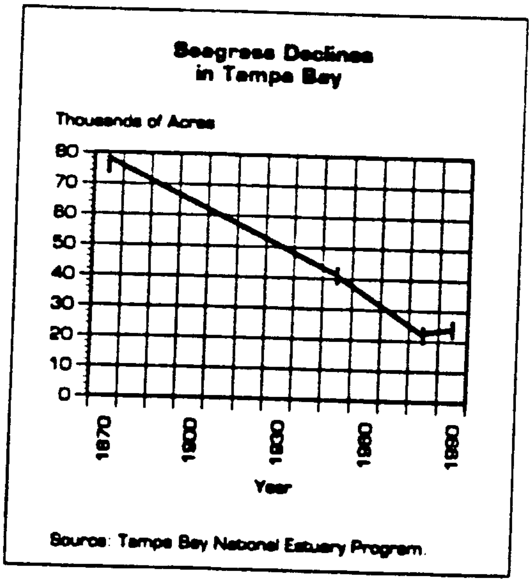

Source: Tampa Bay National Estuary Program.

seagrass habitats are the most severely affected by development activities.

Nearly 80 percent of the Bay's historical seagrasses have been destroyed.[35] In fact, between 1950 and 1982, seagrass coverage in the Bay decreased from 40,627 acres to 21,647 acres. However, aerial surveys show that seagrass coverage has been rebounding since 1982. For instance, about 4,000 acres of new seagrass beds sprouted between 1982 and 1992.[36] Stricter controls over pollution discharges and development activities are aiding in the restoration of seagrasses. In particular, nitrogen reductions in sewage treatment plant discharges have slowed the growth of algal blooms, which can prohibit sunlight needed for seagrass growth and productivity. Other causes of seagrass loss include dredging and filling seagrass beds for development projects, turbidity due to shipping channel dredging, and scarring of beds by boat propellers.

The area's mangroves and salt marshes are also at risk from development pressures. It is estimated that 9,700 acres, or 43 percent, of the original mangroves and salt marshes of the area were destroyed between 1950 and 1990.[37] Approximately 13,800 acres of mangrove forests and 4,600 acres of salt marsh remain in Tampa Bay.[38] Shoreline development projects, such as dredge-and-fill activities and seawall construction, plus the invasion of non-native vegetation, Brazilian pepper and Australian pine, are responsible for losses among these valuable wetlands.

Marshes and mangroves provide important habitat for birds, fish, and shellfish. In addition, these wetlands improve water quality by filtering pollutants, nutrients, and sediments before water carrying these contaminants is discharged into the estuary. Wetlands protect coastal communities from storms by collecting flood waters and providing buffers from strong tides.

Losses among life-sustaining habitats of the Bay threaten the productivity of the area's valuable wildlife resources. For example, declines in fish and shellfish populations are linked to diminishing spawning, feeding, nursing, and nesting habitats. As previously mentioned, bay scallop populations in the estuary are directly affected by the loss of seagrass beds, their primary source of habitat. The loss of seagrass habitat is also a chief reason for population and landing declines among spotted seatrout. Landings of one of the Bay's most popular sport fish, spotted seatrout plummeted from 487,000 pounds in 1950 to 67,000 pounds in 1990.[39]

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter estuaries through sewage treatment plant discharges, septic system failures, polluted urban stormwater, sanitary sewer overflows, agricultural runoff, and boating waste. Pathogens in coastal waters pose health risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogens. For this reason, beaches and shellfish beds are closed or restricted when water monitoring indicates high levels of fecal coliform and total coliform bacteria (indicators of pathogen contamination) are present in coastal waters.

During and immediately after heavy rain events, several of Tampa Bay's beaches and shellfish beds are routinely closed due to the threat of pathogen

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contamination. Not only does stormwater carry animal waste from lawns and pastures, but also it occasionally overloads municipal wastewater treatment plants, causing malfunctions that lead to the dumping of raw sewage into the Bay. During a severe rain event in August 1995, for instance, 15.6 million gallons of raw sewage were discharged into St. Petersburg canals that drain into the Bay.[40]

The local governments surrounding Tampa Bay use independent criteria to decide when swimming should be restricted. Many local health officials decide to close beaches when rainfall exceeds a certain limit, instead of actually monitoring for the presence of fecal coliform. The City of St. Petersburg's beach testing program is one of the most extensive in the State. St. Petersburg monitors its beach waters weekly and preemptively closes beaches following excessive rainfalls. In 1994, Maximo and North Shore beaches were closed 77 times, mostly due to the threat of pathogens following heavy rains. Hillsborough and Pinellas Counties test their beaches at least once a month.[41]

The monitoring of shellfish beds is conducted at least once a month and closures are determined by State standards. Currently, shellfish harvesting acres in Cockroach Bay are closed due to persistent pathogen contamination[42] and lack of funds for monitoring.

Floatable Debris

Trash accumulated on the beaches bordering Tampa Bay threatens the ecosystem and its wildlife inhabitants. On September 17, 1994, volunteers cleared 368,255 pounds of debris from an estimated 1,267 miles of Florida beaches. Of the total amount of debris collected, 61.4 percent was plastic, 12.5 percent was metal, 11 percent was glass, and 15.1 percent was other materials.[43]

Monofilament fishing line is a hazardous form of "debris" that has been harming the Bay's bird populations. Even a single piece of monofilament fishing line can claim the lives of multiple birds. In 1995, Tampa BayWatch surveyed 40 islands and gathered 45 pounds of monofilament fishing line and other entangling debris. Thirty dead birds were discovered in connection with the debris.[44] The elimination of this debris is critical to the recovery of the many threatened and endangered bird species which use Tampa Bay.

The Tampa Bay National Estuary Program

In 1991, the Tampa Bay National Estuary Program was established and charged with the responsibility of drafting a Comprehensive Conservation and Management Plan for the Bay. Congress designated Tampa Bay an estuary of "national significance," thereby incorporating it into the Clean Water Act's National Estuary Program. Since its inception, the Tampa Bay National Estuary Program (TBNEP) has been guided by a nine-member Policy Committee which is responsible for establishing the long-term plan to restore and protect the Bay. To accomplish this goal, the TBNEP brought together local, county, State and federal governments, as well as concerned citizens, to identify and address their concerns about Bay issues. The Tampa Bay Regional Planning Council, representing 43 local governments in the region, assists with the administration of the TBNEP.

Preliminary Action Plans were developed in January of 1995 as the framework for the Comprehensive Conservation and Management Plan (CCMP). To further enlist public comment, the draft CCMP — *Charting The Course* — was presented during four town meetings held in February and March of 1996. The TBNEP expects that the final CCMP will be approved by the Governor and the Administrator of the EPA by the end of summer, 1996. Once the plan is approved, the TBNEP will work to attain the consent of the Policy Committee for an inter-governmental "implementation agreement," which they hope to have signed by November, 1996.

To date, the TBNEP has raised more than one million dollars in grants for wetland restoration projects, habitat-enhanced shoreline demonstration projects, and atmospheric deposition research. The Program has also awarded more than $50,000 to community partners to advance smaller Bay restoration and improvement projects.

The decision to give local government officials high profile roles on the Management and Policy

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Committees of the Management Conference has been instrumental in ensuring their active participation in the planning process. The TBNEP also realized, from the outset, that close coordination with the Surface Water Improvement and Management (SWIM) Program, a program devoted to the restoration of waterways throughout Florida, would be critical to avoid duplication and ensure that there would be a single, unified management plan for the estuary. As a result, local government support for the TBNEP has been significant, especially compared to participation from other segments of the "stakeholder" population. Agricultural interests were slow to become involved in the early stages, while participation of the industrial groups has been mixed. Ongoing participation by broad based citizen groups and environmentalists has played a significant role in developing priorities for the TBNEP to begin implementation of the CCMP.

One of the lessons learned from the early stages of the Program is that the TBNEP tried to take on more issues than they were capable of coordinating. As a result, they were unable to address all the issues with the focus and resources necessary to adequately deal with the severity of the problems. Setting narrow priorities and limiting the overall number of issues is critical to the success of this type of broad-based watershed management initiative. However, in the process of narrowing priorities, it is critical that key information not get lost. The closure of the entire commercial shellfish industry in the Bay, does not appear in the draft CCMP until the 139th page in the document. The severity of this type of problem should not only be clearly highlighted as a major priority, but by so doing an issue like this would provide a tremendous opportunity to educate the public and motivate them into action.

Having learned from these lessons, the Program moved forward with some tremendous accomplishments. The TBNEP conducted extensive research on Bay water quality and habitat conditions. The results indicated that certain areas within the Bay have improved enough that they may now support the reintroduction of bay scallops.[45] As part of this effort, the TBNEP and Tampa BayWatch sponsor the "Great Bay Scallop Search" (in which volunteers snorkel the Bay's seagrass meadows searching for scallops) to assist in tracking long-term recovery trends. This data will provide a baseline for annual scallop surveys to record population trends. Homeowners along the Bay have also assisted in giving the scallops a head start. About 50 waterfront homeowners have agreed to allow the TBNEP to attach "scallop condos" to their docks to help them grow and survive in protective cages before they are released into the waters, where they are vulnerable to predators.

The TBNEP has had many other successes. Working with the Southwest Florida Water Management District, the Estuary Program has established preliminary nitrogen load reduction goals for the Bay. The Florida Yards & Neighborhoods Program was initiated by the TBNEP and has been applied throughout the region to educate landowners about preventing pollution in their communities. This program has encouraged residents, residential developers, and retailers to reduce fertilizer, pesticides, and water use by promoting and implementing environmental landscaping concepts.

Linking the commitments for action in the CCMP with appropriate regulatory programs also provides a strong incentive for TBNEP participants to follow through on implementation actions agreed to in the CCMP. Contaminated urban stormwater provides a good example because the permitting of discharges from municipal stormwater management systems is critical to protecting the future health of the Bay. Finally, to supplement the water quality and fisheries monitoring programs already being conducted by the local and state governments, the Tampa Bay NEP initiated two new monitoring programs in 1993. These two programs consisted of a benthic monitoring program to provide information on the health of bottom communities and the Great Bay Scallop Search monitoring program that uses citizen volunteers as mentioned above.

Tampa Bay's story shows a community rich in practical restoration experience with documented improvements in the Bay's resources due to habitat restoration action. However, capricious political trends have placed environmental restoration activities in serious jeopardy on a state-wide basis. Additionally, without federal and state support many local government programs and non-profit efforts will be rendered ineffective due to the lack of matching funds and other collateral support. Among the programs currently threatened by lack of State funding and political will is the SWIM program.

National Coastal Caucus

Tampa BayWatch is a non-profit environmental stewardship program devoted exclusively to the charitable and scientific purpose of restoring and protecting the marine and wetland environment of the Tampa Bay estuary. Tampa BayWatch employs trained professional staff to monitor and protect the Bay, and to coordinate public restoration and protection activities. The organization is currently operating under a grant to expand the TBNEP into the community via the Conservation Corps Network, which organizes citizens into a network to take on restoration projects. To date, Tampa BayWatch has recruited thousands of people from community groups, scout troops, and high schools to participate in monitoring and restoration activities, including: salt marsh plantings, shorebird nest site protection, storm drain marking, wildlife rescue, marine debris cleanups, and resource monitoring.

Members, staff, and the Board of Directors of Tampa BayWatch have played a key role in the development of the CCMP for the TBNEP. Specifically, it is the organization responsible for forwarding the nomination of Tampa Bay to the Governor for inclusion in the NEP process. In so doing, Tampa BayWatch helped develop the Nomination Package upon which the CCMP is based. In addition, the organization currently acts as co-chair of the Citizens Advisory Committee and sits on the Technical Advisory and Management Committees.

Tampa Bay is one of the few estuaries in the nation to have the benefit of actively managed water quality during the last 20 years, and restored natural habitat communities for the past 15 years. Because of this commitment, Tampa BayWatch is able to use this experience to document resource improvements resulting from management efforts, such as those of the TBNEP. Water quality has improved throughout the estuary to levels not seen since the 1960s. One example of how these improvements have translated into tangible benefits for the Bay is the natural recolonization of over 4,000 acres of subtidal seagrass beds, allowing the reintroduction of sensitive scallops in the Bay waters.

Tampa BayWatch is pleased with these successes but realizes much more work needs to be done. The organization and its committed public are a first line of defense against negative impacts to the Bay. Time and again, violations of environmental law are identified and reported by individuals who are routinely on the water. Tampa BayWatch provides a central clearing house for this information, passing it along to the appropriate authorities. The organization also ensures that environmental scientists are available to evaluate the information and follow up on enforcement actions.

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Tillamook Bay
in Oregon

Tillamook Bay is one of the really critical areas on the Oregon coast for salmon and a wide variety of migratory birds. It has experienced massive ecological changes over the past century, and still has some serious problems today. The National Estuary Program gives us an opportunity to work with the community to address those problems before they get worse and to begin taking steps to restore some key pieces of the natural system.

—Bruce Taylor, Executive Director
Oregon Wetlands Joint Venture

Portrait of the Bay

The Tillamook Bay National Estuary Project is examining the water quality and habitat problems of the Tillamook Bay system and the impact that the larger watershed area has on the estuary. Tillamook Bay is located in northwestern Oregon, about sixty miles west of Portland. The Bay's water surface area measures 11 square miles.[1] The Bay is approximately six miles long. Its maximum width is three miles;[2] and its average depth is a shallow six feet.[3]

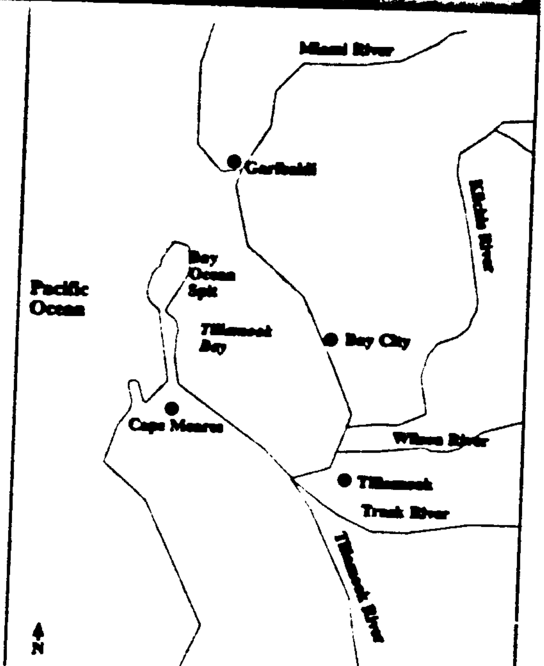
The watershed area of Tillamook Bay covers approximately 570 square miles, extending from the mountains of the Coastal Range to the Pacific Ocean.[4]

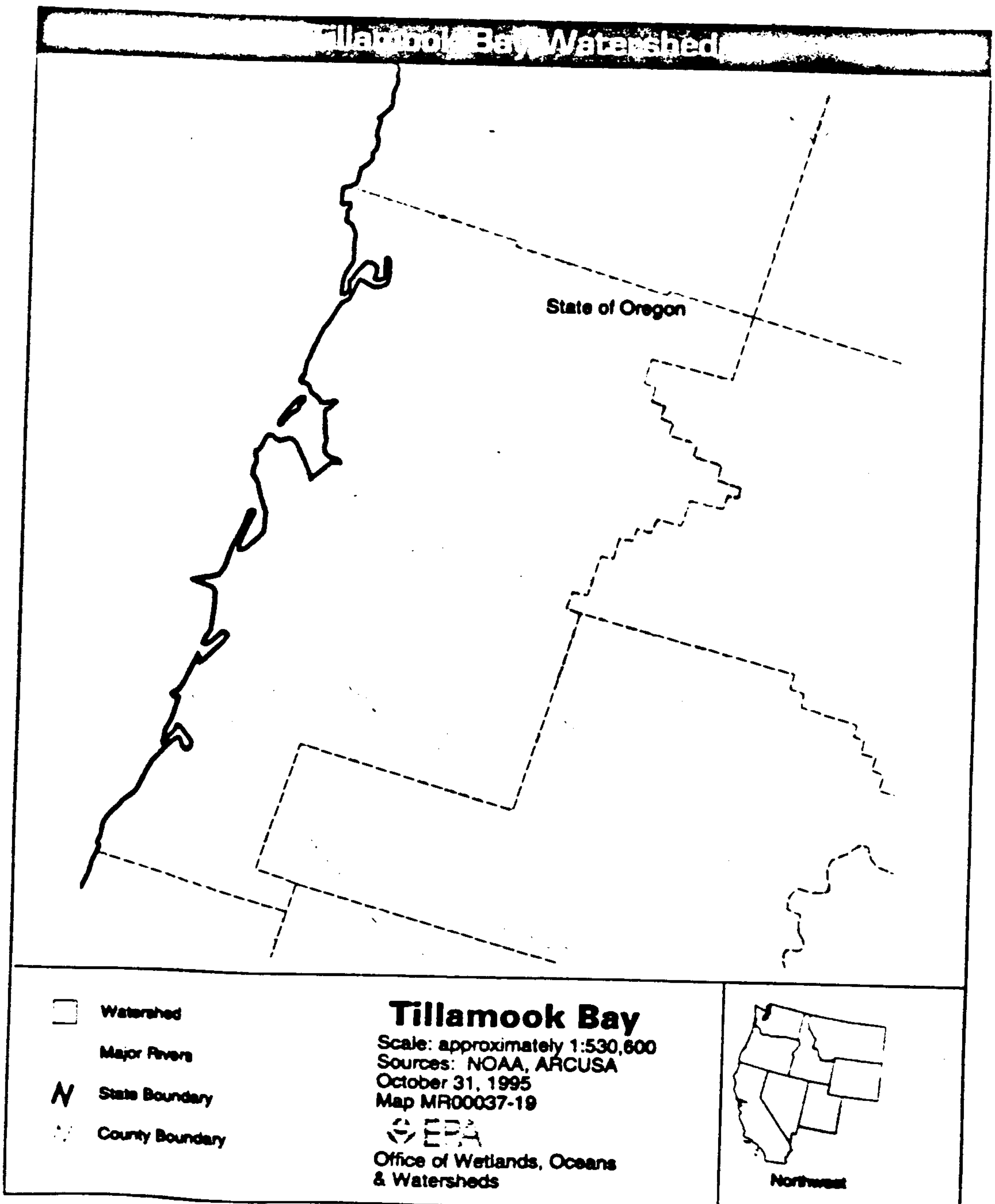
Tillamook Bay

Area of surface water	11 square miles
Area of watershed	570 square miles
Length	6 miles
Average depth	6 feet
Values	• Fisheries generate $86 million* • Sport fishing generates $940 million in economic output* • Important habitat for a variety of waterfowl, shorebirds and other wildlife
Threats	• Pathogen contamination • Sedimentation • Habitat loss and degradation
CCMP status	Final expected in 1998

Designated as a "Nationally Significant" Estuary in 1992.

*State figures




Tillamook Bay Watershed
State of Oregon
Watershed
Major Rivers
State Boundary
County Boundary
Tillamook Bay
Scale: approximately 1:530,600
Sources: NOAA, ARCUSA
October 31, 1995
Map MR00037-19
EPA
Office of Wetlands, Oceans
& Watersheds
Northwest

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Most of the watershed is located within Tillamook County; its largest municipalities are Garibaldi, Bay City and Tillamook. The combined 1994 population estimate for these three cities was 6,200 people.[5] Eighty-nine percent of the watershed is forested land, less than seven percent is agricultural, and less than two percent is urbanized.[6] With over 200 dairies in Tillamook County, milk and cheese production represent a significant portion of the local economy.[7] Unfortunately, the pollution caused by this industry is not currently compatible with the Bay's finfish, shellfish, and other natural resource-based industries.

Tillamook Bay's connection with the Pacific Ocean is limited to a narrow channel in the northwestern portion of the Bay. A four-mile long peninsula, called the Bayocean Spit, separates the Bay from the ocean and forms the western boundary of the Bay. Most of the freshwater entering the Bay is delivered by five rivers — the Miami, Kilchis, Tillamook, Wilson, and Trask Rivers.[8]

The Bay supports substantial acreage of intertidal flats. Up to 60 percent of the Bay's water surface area consists of these intertidal flats.[9] Salt marsh, mud flats, and seagrasses can be found in the estuary; eelgrass beds cover portions of the Bay's bottom.

Values of the Bay

Communities along the northern Oregon coast rely on the health and productivity of Tillamook Bay to help support their economies. Fishing, recreation, and tourism are key components of the local, natural resource-based economies. In addition, the wildlife, recreational opportunities, and natural appeal afforded by the Bay are attracting growing numbers of new residents to the area. Acknowledgment of the economic benefits derived from restoring the Bay and protecting its resources has increased the motivation of the community to develop a coordinated conservation strategy for this estuary.

Recreation/Tourism

The natural beauty of the Oregon coast and the variety of recreational pursuits it offers draw many visitors to Tillamook Bay each year. As the economies of Pacific Northwest communities diversify, the ecotourism sector is becoming more prominent in the Bay area. In Tillamook County, eight percent of the residents' personal earned income originates from the tourism industry.[10] Some of the most popular activities in the Bay area include sport fishing, hiking, camping, clam digging, bird watching, and boating.

In the State of Oregon, sport fishing is a particularly prominent and valuable recreational activity. In 1991, recreational fishing boosted Oregon's economy by approximately $940 million, and supported more than 15,000 jobs.[11] During the same year, 225,000 saltwater anglers spent over one million days fishing off the Oregon coast.[12] Thirty percent of the fishers were non-residents of the State.[13]

Each of the five major rivers within the watershed supports anadromous fish runs. Tillamook Bay and the Wilson and Trask Rivers are considered some of the State's best areas for salmon and trout fishing.[14] The widely reputed fall chinook runs and the summer steelhead catches lure significant numbers of sport fishers to the Bay each year. In addition to salmon and trout, surfperches, white sturgeon, green sturgeon, rockfish, and lingcod are caught in and near the Bay by anglers.[15] Also popular are the charter boat excursions from the Port of Garibaldi for salmon and groundfish fishing.

Fisheries/Seafood

In 1994, the combined market value of commercial finfish and shellfish landings in the Pacific region (excluding Alaska) totaled approximately $401 million.[16] Many of the commercially valuable species in the Pacific region depend upon the health of Tillamook Bay for survival. The State of Oregon's commercial finfish and shellfish landings in 1994 totaled approximately 246 million pounds, valued at $66 million.[17]

Tillamook Bay fisheries provide jobs for many residents in the area. The Bay's commercial fisheries are responsible for generating nine percent of the personal earned income in Tillamook County.[18] The Bay is reputed as the State's leading commercial shellfish producer, of which oysters and clams provide the greatest commercial landings.[19] In 1985, 300,000 pounds of oysters were caught from the Bay; the total State harvest was 424,000 pounds.[20] Between 1984 and 1994, 60 percent of Oregon's commercial clam harvest

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was caught in Tillamook Bay.[21] In 1994, over 150,000 pounds of clams were harvested from the estuary.[22]

Groundfish, coho salmon, chinook salmon, pink shrimp, and Dungeness crab are commercially caught in the nearby ocean waters. Since these species use the Bay and its tributaries for spawning and nursery habitat, the Bay's water quality and habitats are critical to the continued vitality of these fish and shellfish populations.

Wildlife

Overall, wildlife diversity in the Tillamook Bay watershed is typical of the Oregon Coastal Range, which ranks second in species diversity among the State's ten ecological provinces. Native species regularly using four selected habitat types (estuaries, coniferous forests, riparian, and marshes) include 256 bird species and 61 mammal species.[23] The salt marshes, mudflats, eelgrass beds, and open waters of Tillamook Bay provide some of the most important areas along northern Oregon's coastline for shorebirds and waterfowl. The Bay area contains over one-quarter of coastal Oregon's entire wintering waterfowl population.[24] It is one of three estuaries in Oregon where wintering brant can be found.[25] It is also among the six most important estuaries north of San Francisco Bay for migratory shorebirds along the Pacific Flyway.[26]

The Pacific Harbor seal is the most common marine mammal inhabitant of the estuary. California sea lions and orca whales can occasionally be observed in the Bay. Stellar sea lions can sometimes be observed on Seal Rock, which is part of the Three Arch Rocks National Wildlife Refuge, a few miles southwest of the Bay.

Tillamook Bay provides valuable habitat for a number of threatened and endangered animal species. For example, the endangered California brown pelican and the threatened bald eagle, Aleutian Canada goose, western snowy plover, and marbled murrelet use the estuary. The Bayocean Spit is one of the most populated breeding areas for the snowy plover in the State.[27] In addition, the marbled murrelet feeds at the mouth of the Bay and nests in at least one of the watershed's forests.[28]

Threats to the Bay

The rural character of Tillamook Bay's watershed has spared it from many of the pollution problems affecting other Pacific Coast estuaries. Nonetheless, fish and shellfish populations have been declining and habitat has been disappearing along the Bay. Communities near the Bay are planning to address three major threats to the future vitality of the estuary and its natural resources. These priority environmental problems are pathogen contamination, sedimentation, and loss of living resources/loss of habitat.

Pathogen Contamination

Pathogens are disease-causing microorganisms found in human and animal wastes which enter the Bay primarily through runoff from agricultural lands, sewage treatment plant discharges and raw sewage overflows, septic systems, and boating wastes. Pathogens in coastal waters pose risks to humans who eat contaminated shellfish or who recreate in beach waters. Gastroenteritis, hepatitis, and other diseases can result from the ingestion of pathogen-contaminated waters. For this reason, in some states, beaches and shellfish beds are closed or restricted to both recreational and commercial shellfish harvesting when water quality monitoring indicates elevated levels of fecal coliform bacteria (an indicator of pathogen contamination) are present in coastal waters.

The Oregon Health Department has the authority to post notices and close beaches if sewage spills pose public health risks. However, Oregon's bay and ocean beaches are not regularly monitored to ensure that water quality is safe for swimming and water contact sports,[29] and posting does not often, if ever, occur. Recently, the Oregon Department of Environmental Quality required the City of Garibaldi to post notices in an area subject to overflows of raw sewage. The Oregon Department of Environmental Quality does conduct monitoring for purposes of shellfish bed classification.[30] Tillamook Bay is sampled 10 times a year at 16 different stations for fecal coliform bacteria, salinity and temperature.[31]

High concentrations of bacteria frequently lead to shellfish harvest closures in the Bay. Currently, there are no "approved" commercial shellfish harvest areas in all of Tillamook Bay. Thus, all harvest areas have at least partial restrictions on harvesting. The Main Bay and Cape Meares portions of the Bay are "conditionally approved," meaning they are rou-

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tinely closed following heavy rain events.[33] Shellfish harvesting is prohibited in the large southeastern and southern portions of the Bay known as Upper Bay, and for the area around Garibaldi.[35] These prohibited areas comprise over 20 percent of the Bay.[34] Typically, shellfish harvesting is prohibited 50 to 90 days a year due to suspected pathogen contamination.[35] Recreational harvesting for clams is allowed, but is subject to occasional red tide advisories.

Four small municipal wastewater treatment plants and extensive dairy production in the Tillamook Bay watershed are thought to be significant sources of the Bay's bacterial contamination. The area supports over 23,000 dairy cows which generate a cumulative 3 million tons of manure and urine annually.[36] Some dairy farmers are trying to minimize pollutant loading into the Bay by building structures, such as manure sheds and storage tanks. These facilities assist in restricting the concentrations of animal waste running off agricultural lands and into tributaries of the Bay. Unfortunately, many of these facilities also overflow, releasing waste into the Bay and its tributaries.

Most, if not all, dairy farms engage in the practice of spraying liquid manure on lands in amounts that exceed levels which plant life can uptake and use. Often the amounts are so great that they actually kill plants and trees. Due, in part, to the installation of tile drains in diked pastures which were formerly wetlands, this manure is carried quickly to waterways that drain into the Bay.[37] Since a study conducted by the Oregon Department of Environmental Quality identified animal waste as a major source of pollution for the Bay, local government agencies and the Tillamook County Creamery Association together have attempted to improve management practices.[38]

Sedimentation

As a result of the massive amount of sediment entering the estuary, the water volume of the Bay has decreased by 35 percent from historical levels.[39] Increased inputs of sediment also inhibit the productivity of the estuary's salt marshes, mud flats, and seagrasses. Sediments can smother aquatic plants and increase turbidity in the water, blocking sunlight needed for the growth of eelgrass beds.

Between 1918 and 1951, five major fires roared through the watershed area resulting in the destruction of forested habitat and the overall decline of the watershed's environmental health.[40] These fires caused massive shoreline erosion problems, and subsequently, greater loadings of sediments into the Bay and its tributaries. Since then, forestry and agricultural practices throughout the watershed have led to further erosion of stream and river banks. In addition, the natural flooding of rivers and the breaching of the Bayocean Spit have delivered more sediments to the estuary.

Mass wasting, a process in which landslides dump immense amounts of sediment into surrounding rivers and streams, is the leading cause of sedimentation in the Tillamook Bay system. The improper construction and inadequate maintenance of roads built to access lands for salvage logging practices is the primary cause of mass wasting. Another cause of sedimentation in Tillamook Bay is the high rate of erosion from steep slopes of cleared forest lands.[41] The reforestation of previously clear-cut areas is helping to lower the rates of sediment delivery into the Bay, but much more needs to be done to address this problem.

In 1952, the Bayocean Spit was breached by the Pacific Ocean. Gravel and sediments from the peninsula buried important tidal flats and altered the hydrology of the Bay.[42] The construction of jetties at the mouth of the Bayocean Spit is suspected to have altered the transport of sand needed to maintain the Spit and may have contributed to the breach.[43]

Habitat Loss and Degradation

As forests and pasture lands dominate the Tillamook Bay watershed, the problems faced by more urbanized lands are minimal in this estuary. To support agricultural production in the watershed, upland and freshwater wetlands have been converted to farm and pasture lands. In addition, tidal wetlands of the watershed have been diked. It is estimated that approximately 72 percent of the historical intertidal habitat has been lost to agriculture and other development activities.[44] These modifications have seriously harmed the ecology of the Bay and its watershed and are negatively impacting wildlife populations and diversity. Declining runs of salmon and trout are a particular concern.

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The degradation of aquatic habitats in the Tillamook Bay watershed has harmed steelhead, chum, and coho salmon runs in the rivers. Today, Tillamook Bay's coho salmon stocks are declining at a faster rate than any other watershed's coho stocks in northern Oregon.[45]

Additional Concerns

Trash accumulated on estuarine beaches threatens the ecosystem and its wildlife inhabitants. On September 24, 1994, volunteers cleared 23,064 pounds of marine debris from 135 miles of beach area in Oregon. Of the total amount of marine debris collected, 66 percent was plastic, 14.5 percent was paper, 7.7 percent was metal, and 11.8 percent was from other materials.[46]

Toxic contamination and excessive loadings of nitrogen and phosphorus are other potential problems facing Tillamook Bay. However, more studies need to be conducted in order to reach any conclusions on their effect on the water quality of the Bay.

Tillamook Bay National Estuary Project

In the Spring of 1992, Tillamook Bay was designated as an estuary of "national significance" under the National Estuary Program of the Clean Water Act. Due to a lack of funding, the program suffered some initial delays in getting off the ground. However, by June, 1994 the Tillamook Bay National Estuary Project (TBNEP) had been established and the Management Conference Agreement and the start-up activities were completed. The TBNEP is a joint local, State and federal effort that is charged with coming up with a comprehensive plan to address the environmental problems of and to test possible solutions for Tillamook Bay and its watershed. The TBNEP has begun conducting research and gathering the data needed to produce its draft Comprehensive Conservation and Management Plan (CCMP) for the Bay. The target date for approval of the CCMP by the Governor and the Administrator of the EPA is July, 1998.

There are several committees responsible for feeding information into the Plan, including a Policy Committee, Management Committee, Scientific/Technical Advisory Committee, Finance Committee and Citizen Involvement Strategy Advisory Committee. Since it is a community-based initiative, all public and private agencies, organizations and individuals interested in the welfare of the Bay are involved in managing the Project. The TBNEP has encouraged many local residents to participate in the preservation of the estuary by sponsoring outreach and education programs, as well as training seminars, for area teachers. The Project has made strides in helping the public to understand that by preserving the watershed, the economies of the local communities which depend on the Bay are also protected. However, some citizens find participation in the Project difficult because the political power of the county is dominated by the dairy industry. There is growing concern about whether there will be a consensus to change the status quo.

In the early stages of the program, the TBNEP focused on providing the funding to research the many gaps of information regarding the Bay's ecology. Several projects conducted during the first year were interagency efforts focused on the technical characterization of the Bay and its watershed. Interagency coordination has been particularly effective in habitat inventory and watershed analyses.

One of the most recent projects is a Historical Reconstruction Study to focus on the physical changes in various characteristics of the watershed, such as: plant communities, stream flow patterns, and factors affecting the rate at which sediments reach the Bay.[47] The Study will provide information about how human activities and physical processes have changed the character and values of key resources in the Bay. In addition, a water circulation model has been developed to determine movements of sediments and bacteria throughout the watershed. Other projects include a watershed analysis and several fishery research projects including the development of a coho task force, salmonid habitat restoration maps, expanded coho spawning survey, and aquatic inventories. In October of 1995, over 50 percent of the stream miles in the Bay's watershed were surveyed by the Oregon Fish and Wildlife Service and Department of Forestry.[48] A Geographic Information System (GIS) computerized mapping program is also being utilized to document trends in land use and resource changes in the watershed.

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National Coastal Caucus

Northwest Environmental Advocates (NWEA) is a 27-year old membership organization focused on water quality and wetlands protection in Oregon and Washington. NWEA is involved in litigation to force the States to perform Total Maximum Daily Loads (TMDLs) on waterbodies with unsafe levels of pollution. NWEA's interest in Tillamook Bay is primarily in developing regulatory controls on the disposal of manure and in establishing a program to restore former wetlands through dike breaching.

The Oregon Wetlands Joint Venture is a coalition of private conservation, waterfowl, and agricultural organizations and State and federal resource agencies. Direction is provided by the Steering Committee, made up of representatives of private, non-profit organizations. The coalition serves as a statewide umbrella for actions in Oregon under two larger, regional wetland habitat restoration initiatives — the Pacific Coast Joint Venture and the Intermountain West Joint Venture. Overall, the Joint Venture's mission is to create partnerships among agencies and organizations for projects to restore and enhance wetlands on public and private lands. Although Joint Venture has not previously been involved in projects in the Tillamook Bay region, its involvement in the NEP process demonstrates a commitment to wetlands habitat restoration in the watershed area of the Bay. The Joint Venture coalition encourages wetlands acquisition, or placing sensitive habitat into permanent protection to ensure long-term habitat protection. With a prospective project for 1996 involving continued wetlands restoration in the Tillamook Bay region, Oregon Wetlands Joint Venture intends to encourage the TBNEP to heighten its emphasis on wetlands restoration.

Oregon Wetlands Joint Venture has been a participant in the Tillamook Bay NEP since the project's inception. The Joint Venture's executive director serves as the "environmental interests" representative on the NEP's Management Committee and has participated on a number of subcommittees involved in developing NEP budgets and work plans, evaluating grant requests, and developing strategies for the draft CCMP.

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CHAPTER 7

Recommendations to Strengthen National Estuary Program

Congress established the National Estuary Program (NEP) under section 320 of the Federal Water Pollution Control Act (commonly called the Clean Water Act) in its 1987 Amendments to the Act. The conference report for the 1987 Amendments stated that Congress was setting a "national policy to maintain and enhance the water quality in estuaries and provide for the biological integrity of these waters"[1] by creating the National Estuary Program. One of the main objectives of the NEP is to address the many complex issues — such as habitat destruction, pollution, resource management and land-use planning — that have contributed to the deterioration of the nation's estuaries.

As the NEP has expanded from six to 28 estuaries, several recommendations for improving the Program have been developed by representatives of citizens' groups who are active participants in their local estuary program. This coalition of grassroots activists, called the National Coastal Caucus (NCC), has suggested ways to improve the Program through legislative means. A collaborative effort has developed between the NCC and a number of dedicated members of Congress and their staff to propose legislative improvements to the National Estuary Program.

In recent years, several administrative actions to strengthen the Program have been taken by the Environmental Protection Agency. To reflect these changes, the legislative proposal has been regularly updated.

In each Congress since 1991, Representatives Rosa DeLauro (D-Connecticut) and Nita Lowey (D-New York), and Senators Joseph Lieberman (D-Connecticut) and Christopher Dodd (D-Connecticut) have introduced the Water Pollution Control and Estuary Restoration Act. This bill has incorporated legislative recommendations advocated by the National Coastal Caucus. In the 102nd Congress, H.R. 5070 was supported by 50 bi-partisan co-sponsors. The Senate counterpart to H.R. 5070 was S. 2831. During the 103rd Congress, H.R. 1720 was co-sponsored by over 60 Representatives. In addition, a significant portion of its Senate counterpart, S. 815, was accepted by the Senate Environment and Public Works Committee in its version of the bill to reauthorize the Clean Water Act, S. 2093. In the 104th Congress, H.R. 1917 was introduced on June 22, 1995. The Senate version will be introduced in 1996.

The National Coastal Caucus believes that adoption of these suggestions by Congress would improve the National Estuary Program and help to ensure the implementation of restoration plans, active citizen participation, and efficient coordination of all stakeholders during the planning process. Not only would these proposals enhance the environmental health of estuaries, they would also create jobs in coastal communities through expanded infrastructure investments.

Key recommendations for improving the National Estuary Program:

- ***Require implementation of approved Comprehensive Conservation and Management Plans (CCMPs).*** Section 320(f)(2) of the Clean Water Act explicitly states that approved CCMPs shall be implemented. However, in actuality, many approved estuary plans are not being sufficiently implemented due to funding constraints and a lack of political will among local, State, and federal elected officials. During the nomination and development of CCMPs, local and State officials are intensely involved in the planning process. In addition, the Governor must concur with the Plan before the EPA Administrator approves the CCMP. Due to their involvement throughout the development of the plan, elected officials should be supportive of the restoration efforts highlighted in the Plan and should

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not be allowed to excessively delay the implementation phase. Further, citizens should be given a mechanism to ensure that officials are held accountable for the actual implementation of CCMPs. This will maximize the benefits of local citizens' investment of time and the nation's investment of resources that are expended during the planning process.

Local estuary restoration programs have been generally successful at identifying water quality problems and raising public awareness about the importance of protecting the estuary. However, it is essential that the National Estuary Program extend beyond identifying problems to implementing solutions. In order for this to occur, a stronger federal commitment must be made to the NEP. Section 320 of the Clean Water Act should be amended to clarify that implementation of approved estuary conservation and management plans is a non-discretionary duty of the Environmental Protection Agency, and a "set-aside" of federal financial assistance should be provided to aid in implementing plans.

• ***Assure funding to implement CCMPs.*** Due to State budget shortfalls and diminishing federal financial support, many States have been unable to implement their approved CCMPs. The Clean Water Act should include a funding mechanism to ensure that States are provided federal assistance to properly implement, monitor, and enforce CCMPs. Otherwise, the federal funds expended on crafting the plans will have been unwisely spent since actions to actually improve the estuary would not result. Approved estuary restoration plans represent the conclusions of a consensus-based process involving key stakeholders, and therefore should receive priority consideration for funding. Providing funds for implementation rewards the timely development of strong CCMPs that have garnered the full support of the community. Federal funding also provides incentives for states to undertake the more politically difficult task of putting the planning elements into practice. The most obvious source of federal monies for CCMP implementation funds is the Clean Water Act's State Revolving Loan Fund (SRF) program; however, current appropriation levels are severely inadequate to meet the growing demand for funding. The SRF should be increased to a minimum of $5 billion per year with a specific set-aside for implementation of Comprehensive Conservation and Management Plans.

• ***Increase citizen involvement.*** In many of the local programs, citizen participation in the development of CCMPs has been inadequate and inconsistent. The National Estuary Program would be strengthened by requiring citizen participation, and specifically representation by environmental organizations, in all aspects of the CCMP process. Rather than have citizens appointed primarily to the Citizens Advisory Committee, citizen representatives should also hold positions on other committees, including the Management and Policy Committees. In some cases, financial assistance to ensure full citizen participation on these committees might be necessary. In addition, public hearings should be held on a regular basis throughout the life of the program. The active recruitment of citizens to participate in the development of CCMPs will assist in building the public's commitment to take actions for restoration.

The Water Pollution Control and Estuary Restoration Act has been endorsed by over 150 local, regional, and national environmental organizations, labor organizations, and industry groups. The hopes of improving the National Estuary Program, restoring our productive coastal waters, creating jobs, and investing in clean water infrastructure projects are the major benefits which have brought this diverse coalition together.

End Notes

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Conclusion

American Oceans Campaign and the National Coastal Caucus are encouraged by federal, state, and local efforts to restore and protect the ecological integrity of the 28 "nationally significant" estuarine ecosystems around the nation. With the lessons learned and the accomplishments made by each local Estuary Program, a viable model has been created which can be used to assist future watershed planning efforts.

For the bounty of life they produce and nourish; the economies they boost and support; and the aesthetic qualities and recreational opportunities they offer; estuaries are a symbol of life and sustenance. It is not too late to halt the environmental abuse we have wrought on many of these priceless systems by way of pollution, habitat destruction, and coastal development. Nor is it too early to protect the more pristine estuaries from the levels of degradation faced by more urbanized ones. The situation is dire; yet with greater support to replenish these vital links between land and sea, the wealth and productivity of estuaries will be ensured for generations to come. The question that remains is whether or not we as a nation have the political will to fully fund and implement plans to revitalize our "nationally significant" estuaries and their living resources.

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The National Coastal Caucus ("NCC") was established by American Oceans Campaign in February of 1991 to provide an organized framework for like-minded groups to work together on issues of mutual concern. While recognizing that much of the important work of protecting our coasts, estuaries and oceans is best accomplished at the local and state levels, the NCC believes that the federal government's influence is also extremely important. Indeed, the concept of the NCC evolved out of the need to build and reinforce relationships among local, state and federal players.

Since its inception, the NCC has worked to strengthen the federal Clean Water Act ("CWA"). In doing so, it has supported other national coalition-building initiatives, such as the Clean Water Network. The NCC's work complements the work of the Network on a full range of CWA issues and has filled a void by focusing on the National Estuary Program, which previously lacked a major grassroots constituency. The following people and organizations participate in the NCC:

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Glossary of Terms

Algae Simple rootless plants that grow in bodies of water.

Anadromous Fish Those fish, such as salmon, that spend part of their life cycle in the ocean and return to freshwater streams and rivers to spawn.

Anoxia The absence of oxygen.

Bayou A marshy or sluggish body of water that is a tributary to another body of water.

Bioaccumulation The process by which some persistent contaminants accumulate through the food chain and become biologically magnified. That is, contaminants concentrate as they travel via digestive processes up to higher levels of the food chain.

Biological Oxygen Demand The amount of oxygen used by organic matter in water. High levels of BOD can remove oxygen needed to support fish and other aquatic life.

Brackish A combination of saltwater and freshwater, common to coastal wetlands and estuaries.

Bycatch Fish and other marine life caught incidentally while fishing for something else.

Combined Sewer Overflow (CSO) A pipe that discharges untreated wastewater during storms from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport, store, or treat the increased flow caused by stormwater.

Commercial Landing The quantity of fish or shellfish brought ashore by a commercial fishing operation.

Dredging The mechanical removal of sediment from the bottom of canals, rivers, or harbors.

Ecosystem A natural community of living organisms interacting with one another and with their physical environment, such as an estuary, rain forest or salt marsh. Damage to any part of a complex system may affect the whole. A system as complex as an estuary can also be thought of as the sum of many interconnected ecosystems such as the rivers, wetlands and bays.

Effluent The liquid waste that flows out of a facility or household into a waterbody or sewer system. For example, the treated liquid discharged by a wastewater treatment plant is the plant's effluent.

Estuary A partially enclosed, coastal water body where fresh water empties into and mixes with saltwater.

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Eutrophication
Inundation of a marine environment with nutrients, leading to excessive growth of phytoplankton, algae, or vascular plants, and often depletion of oxygen.

Floatable Debris
Garbage and trash which is dumped or is carried into the ocean. Also known as marine debris.

Habitat The environment on which an animal or plant depends for various stages of its life cycle.

Heavy Metals
Metallic elements, such as lead, mercury, silver, cadmium, copper, chromium and zinc, which have relatively high atomic weights and may be toxic at high concentrations.

Hypoxia A state of low oxygen concentration relative to the needs of aerobic species.

Inlet A short, narrow waterway connecting a bay or lagoon with the ocean.

Intertidal Area
The area between high and low tide levels. The alternate wetting and drying of this area makes it a transition between land and water and creates special environmental conditions.

Mangrove Forest
A community of salt-tolerant trees, with associated shrubs or vines and other organisms, that grows in a zone roughly coinciding with the intertidal zone along protected tropical and subtropical coasts.

Marine Debris
See Floatable Debris.

Marsh A wetland where the dominant vegetation is non-woody plants such as grasses and sedges, as opposed to a swamp where the dominant vegetation is woody plants like trees.

Nonpoint Source Pollution
Pollution that enters water from dispersed and uncontrolled sources (such as surface runoff) rather than through pipes. Nonpoint sources (e.g., forest practices, agricultural practices, on-site sewage disposal, and recreational boats) may contribute pathogens, suspended solids, and toxicants. While individual sources may seem insignificant, the cumulative effects of nonpoint source pollution can be significant. Also known as polluted runoff.

Pathogen An agent such as a virus, bacterium or fungus that can cause disease in humans.

Point Source
Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

Pollutant A substance that adversely alters the physical, chemical, or biological properties of the environment. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

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Polycyclic or Polynuclear Aromatic Hydrocarbons (PAHs)
A class of complex organic compounds, some of which are persistent and cancer-causing. These compounds are formed from the combustion of organic material. PAHs are commonly formed by forest fires and by the combustion of gasoline and other petroleum products.

Primary Treatment
A wastewater treatment method that uses settling, skimming, and chlorination to remove solids, floating materials, and pathogens from wastewater. Primary treatment typically removes about 35 percent of biochemical oxygen demand and less than half of the metals and toxic organic substances.

Runoff Water that is not absorbed into the ground and hence which flows into streams or other bodies of water, or into a drain or sewer.

Seagrass A flowering plant that lives underwater and provides habitat for aquatic life.

Secondary Treatment
A wastewater treatment method that usually involves the addition of biological treatment to the settling, skimming, and disinfection provided by primary treatment. Secondary treatment may remove up to 90 percent of biochemical oxygen demand and significantly more metals and toxic organic material than primary treatment.

Sediment Material suspended in or settling to the bottom of a liquid, such as sand and mud.

Septic System
A system of tanks and porous pipes in which sewage is decomposed by anaerobic bacterial action and usually filtered by soil.

Submerged Aquatic Vegetation (SAV)
Plants that grow for the most part under water.

Tidal Flat Level, muddy surface bordering an estuary that is alternately submerged and exposed to the air by changing tidal levels.

Turbidity A cloudy condition in water caused by suspended silt or organic matter.

Watershed A geographic area in which water, sediments and dissolved materials drain to a common outlet — to a point on a larger stream, lake, underlying aquifer, estuary or ocean.

Wetlands Critical ecosystems, commonly called marshes, bogs, and swamps. Wetlands function naturally to preserve environmental quality by controlling floods and filtering contaminants from water. In addition, wetlands provide essential habitat for fish and wildlife.

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Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems

A User's Guide

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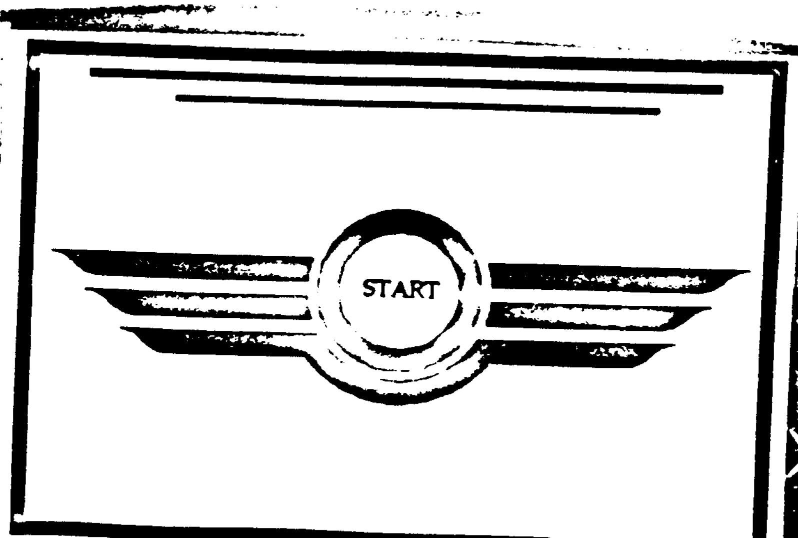

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INVESTIGATION OF INAPPROPRIATE POLLUTANT ENTRIES INTO STORM DRAINAGE SYSTEMS

A User's Guide

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NOTICE

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under contracts 68-03-3255 and 68-C9-0033 for Foster-Wheeler Enviresponse, Inc. and under cooperative agreement CR-816862 for the Urban Waste Management and Research Center of the University of New Orleans. Although it has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document, it does not necessarily reflect the views of the Agency and no official endorsement should be inferred. Also, the mention of trade names or commercial products does not imply endorsement by the United States government.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs to provide an authoritative, defensive engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The purpose of this User's Guide is to provide guidance to municipalities for investigating non-stormwater entries into storm drainage systems. Contaminated non-stormwater entries into storm drainage systems have been shown to contribute substantial levels of contaminants to the Nation's waterways. These entries may originate from many diverse sources including sanitary wastewaters from leaky or directly connected sanitary sewerage and from poorly operating septic tank systems, washwaters from laundries and vehicle service facilities, and many types of industrial wastewaters that are discharged to floor drains leading to the storm drainage or from direct industrial wastewater connections to the storm drainage system. Conventional pollution control programs may be ineffective if these pollutant sources are not identified and corrected.

This User's Guide will be useful to municipalities in conducting required studies as part of their stormwater discharge permit activities, in addition to other interested users. It will enable users to identify the type and to estimate the magnitude of non-stormwater pollutant entries into storm drainage systems and to design needed pollution control activities. An associated demonstration project (Pitt and Lalor publication pending) describes the development and testing of the procedures presented in this User's Guide.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

ABSTRACT

This User's Guide is the result of a series of EPA sponsored research tasks to develop a procedure to investigate non-stormwater entries into storm drainage systems. A number of past projects have found that dry-weather flows discharging from storm drainage systems can contribute significant pollutant loadings to receiving waters. If these loadings are ignored (e.g., by only considering wet-weather stormwater runoff), little improvement in receiving water conditions may occur with many stormwater control programs. These dry-weather flows may originate from many sources, the most important sources may include sanitary wastewater or industrial and commercial pollutant entries, failing septic tank systems, and vehicle maintenance activities. After identification of the outfalls that contain polluted dry-weather flows, additional survey activities are needed to locate and correct the non-stormwater entries into the storm drainage systems.

This User's Guide contains information to allow the design and conduct of local investigations to identify the types and to estimate the magnitudes of these non-stormwater entries.

This report was submitted in partial fulfillment of contracts numbered 68-03-3255 and 68-C9-0033 and cooperative agreement CR-816862 under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from October 1, 1990 to September 30, 1992, and work was completed as of September 30, 1992. This report was prepared under subcontract to Foster-Wheeler Enviresponse, Inc. of Edison, New Jersey, and the Urban Waste Management and Research Center of the University of New Orleans.

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ACKNOWLEDGMENT

This User's Guide contains information that has been developed and tested in a number of separate research reports investigating inappropriate pollutant entries into storm drainage systems. Many case studies were reviewed during early parts of this research to identify the most appropriate methods of investigation. Information that was obtained from these cities is gratefully acknowledged.

Valuable technical assistance concerning industrial dry-weather discharges was provided by Mark Miller and Tom Meinholtz (Triad Engineering, Inc.) who were supported by Kevin Weiss of the NPDES Branch, Permits Division, Office of Water, of the EPA through the Cadmus Group, Inc. Early report guidance was also provided by Gene Driscoll (Woodward Clyde Consultants), also supported by the Permits Division, Office of Water, of the EPA. Dan Murray, of the Center of Environmental Research Information, Cincinnati, Ohio, EPA, also provided support for the publication of this Guide.

Richard Field, Chief of the Storm and Combined Sewer Pollution Control Program, EPA, was the Project Officer for this project and provided much valued direction during this research. Michael Brown and Marie O'Shea of his staff, along with Ramjee Raghavan at Foster Wheeler Enviresponse, Inc., also provided important project assistance. Darwin Wright of the Office of Research and Development, EPA is gratefully acknowledged for his suggestion to work with the University of New Orleans, Urban Waste Management and Research Center to conduct EPA stormwater research activities. Helpful comments from the report reviewers are also gratefully acknowledged.

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SECTION 1

INTRODUCTION

Current interest in illicit or inappropriate connections to storm drainage systems is an outgrowth of investigations into the larger problem of determining the role urban stormwater runoff plays as a contributor to receiving water quality problems. Urban stormwater runoff is traditionally defined as that portion of precipitation which drains from city surfaces exposed to precipitation and flows via natural or man-made drainage systems into receiving waters. An urban stormwater drainage system also conveys waters and wastes from many other sources. For example, Montoya (1987) found that slightly less than half the water discharged from Sacramento's stormwater drainage system was not directly attributable to precipitation. Sources of some of this water can be identified and accounted for by examining current NPDES (National Pollutant Discharge Elimination System) permit records, for permitted industrial wastewaters that can be discharged to the storm drainage system. However, most of the water comes from other sources, including illicit and/or inappropriate entries to the storm drainage system. These entries can account for a significant amount of the pollutants discharged from storm drainage systems (Pitt and McLean 1986).

The U. S. Environmental Protection Agency's (EPA's) Office of Research and Development's Storm and Combined Sewer Pollution Control Program and the Office of Water's NPDES Program Branch have supported the development of this User's Guide for the investigation of inappropriate entries to storm drainage systems. This User's Guide is designed to provide information and guidance to local agencies by meeting the following objectives of:

1. Identifying and describing the most significant pronounced sources of non-stormwater pollutant entries into storm drainage systems.

2. Describing an investigative procedure that will allow for the determination of whether significant non-stormwater entries are present in a storm drainage system, and then to identify the particular source, as an aid to the ultimate location of the source.

The background study prepared in conjunction with this User's Guide (Pitt and Lalor publication pending) examined three categories of non-stormwater outfall discharges: pathogenic/toxicant, nuisance and aquatic life threatening, and clean water. The most important category is outfall discharges containing pathogenic or toxic pollutants. The most likely sources for this category are sanitary or industrial wastewaters. The outfall analysis procedure described in this User's Guide has a high probability of identifying all of the outfalls in this most critical category. High probabilities of detection of other contaminated outfalls are also likely when using these procedures. After identification of the contaminated outfalls, their associated drainage areas are then subjected to a detailed source identification investigation. The identified pollutant sources are then corrected.

ROLE OF DRY-WEATHER FLOWS IN URBAN STORMWATER RUNOFF ANALYSES

The EPA's Nationwide Urban Runoff Program (NURP) highlighted the significance of pollutants from illicit entries into urban storm drainage (EPA 1983). Such entries may be evidenced by flow from storm drain outfalls following and during substantial dry periods. Such flow, frequently referred to as "baseflow" or "dry-weather flow", could be the result of direct "illicit connections" as mentioned in the NURP final report (EPA 1983), or could result from indirect connections (e.g., leaky sanitary sewerage contributions through infiltration). Many of these dry-weather flows are continuous and would therefore also occur during rain induced runoff periods. Pollutant contributions from the dry-weather flows in some storm drains have been shown to be high enough to significantly degrade water quality because of their substantial contributions to the annual mass pollutant loadings to receiving waters.

Dry-weather flows and wet-weather flows have been monitored during several urban runoff studies. These studies have found that discharges observed at outfalls during dry weather were significantly different from wet-weather discharges. Data collected during the 1984 Toronto Area Watershed Management Strategy Study (TAWMSS) monitored and characterized both stormwater and baseflows (Pitt and McLean 1986). This project involved intensive monitoring in two test areas (one a mixed residential and commercial area, and the other an industrial area) during both warm and cold weather and during both wet and dry weather. The annual mass discharges of many pollutants were found to be dominated by dry-weather processes.

During the mid-1980s, several individual municipalities and urban counties initiated studies to identify and correct illicit connections to their storm drain systems. This action was usually taken in response to receiving water quality problems or information noted during individual NURP projects. Data from these studies indicate the magnitude of the cross-connection problem in many urban areas. From 1984 to 1986, Washtenaw County, Michigan dye-tested 160 businesses in an effort to locate direct illicit connections to the County stormwater drainage. Of the businesses tested, 61 (38 percent) were found to have improper storm drain connections (Schmidt and Spencer 1986). In 1987, the Huron River Pollution Abatement Program dye-tested 1067 commercial, industrial, and tax exempt businesses and buildings. A total of 154 (14 percent) were found to have improper connections to storm drainage (Washtenaw Co. 1988). Commercial car washes and other automobile related businesses were responsible for the majority of the illicit connections in both studies. Discharges from commercial laundries were also noted. An investigation of outfalls from the separate storm drain system in Toronto, Canada revealed 59 percent with dry-weather flows. Of these, 84 (14 percent of the total outfalls) were identified as grossly polluted based on the results of a battery of chemical tests (GLA 1983). In 1987, an inspection of the 90 urban stormwater outfalls draining into Inner Grays Harbor in Washington revealed 29 (32 percent) flowing during dry weather (Pelletier and Determan 1988). A total of 19 outfalls (21 percent) were described as suspect based on visual observation and/or anomalous pollutant levels as compared to those expected in typical urban stormwater runoff characterized by the EPA 1983 NURP report.

CURRENT LEGISLATION

With additional data now available, the Clean Water Act of 1987 contained provisions specifically addressing discharges from storm drainage systems. Section 402 (p) (3) (B) provides that permits for such discharges:

i. May be issued on a system or jurisdiction-wide basis.

ii. Shall include a requirement to effectively prohibit non-stormwater discharges into the storm drains, and

iii. Shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system design and

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engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

In response to these provisions, the EPA issued a final rule to begin implementation of section 402(p) of the Clean Water Act on November 16, 1990 (40 CFR parts 122, 123, and 124 National Pollutant Discharge Elimination System Permit Regulations for Storm Water Discharges, Federal Register, Vol. 55, No. 222). A screening approach which includes chemical testing of outfalls or storm drainage with dry-weather flow (defined by a 72-hour antecedent dry period), was adopted. The parameters to be tested are a combination of several pollutants of concern and "tracers" that may be used to help identify contaminated outfalls and predict the source of illicit discharges.

Section 122.26 (d) (1) (iv) (D) of the rule applies specifically to this User's Guide. The EPA requires an initial screening program to provide a means of detecting high levels of pollutants in storm sewerage. The protocol of this User's Guide seeks to determine whether or not non-stormwater flows are causing problems (e.g. pathogenic, toxic, aquatic life threatening, nuisance), and to provide additional detail with respect to the source. It accomplishes this by outlining an effective screening methodology to identify storm drainage system outfalls contaminated by illicit or inappropriate discharges and to determine specifically how the likely sources can be identified. This protocol is supported by a research report (Pitt and Lalor publication pending) containing the results of a demonstration project using these procedures and much more detailed information.

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SECTION 2

OVERVIEW

POTENTIAL DRY-WEATHER DISCHARGE SOURCES

This User's Guide is directed to the identification and location of non-stormwater entries into storm drainage systems. It is important to note that for any effective investigation of pollution within a stormwater system, all pollutant sources must be included. Prior research has shown, that for many pollutants, stormwater may contribute the smaller portion of the total pollutant mass discharged from a storm drainage system. Significant pollutant sources may include dry-weather entries occurring during both warm and cold months and snowmelt runoff, in addition to conventional stormwater associated with rainfall. Consequently, much less pollution reduction benefit will occur if only stormwater is considered in a control plan for controlling storm drainage discharges. This User's Guide contains a protocol to identify sources of inappropriate entries to storm drainage systems. The investigations presented in this User's Guide may also identify illicit point source outfalls that do not carry stormwater. Obviously, these outfalls also need to be controlled and permitted.

Table 1 summarizes the potential sources of contaminated entries into storm drainage systems, along with their likely flow characteristics. The following subsections summarize these sources.

Residential and Commercial Sources

The most common potential non-stormwater entries, which have been identified by a review of documented case studies for commercial and residential areas are:

- Sanitary wastewater sources:
  - sanitary wastewater (usually untreated) from improper sewerage connections, exfiltration, or leakage
  - effluent from improperly operating, or improperly designed, nearby septic tanks
- Automobile maintenance and operation sources:
  - car wash wastewaters
  - radiator flushing wastewater
  - engine de-greasing wastes
  - improper oil disposal
  - leaky underground storage tanks
- Irrigation sources:
  - lawn runoff from over-watering
  - direct spraying of impervious surfaces
- Relatively clean sources:
  - infiltrating groundwater
  - water routed from pre-existing springs or streams
  - infiltrating potable water from leaking water mains

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TABLE 1. POTENTIAL INAPPROPRIATE ENTRIES INTO STORM DRAINAGE SYSTEMS

Potential Source:	Storm Drain Entry		Flow Characteristics		Contamination Category		
	Direct	Indirect	Conti-nous	Inter-mittent	Patho-genic/Toxic	Nuis-ance	Clear
Residential Areas:							
Sanitary Wastewater	X	x	X	x	X	x	
Septic tank effluent		X	X	x	X	x	
Household chemicals	x	X		X	X		
Laundry wastewater	X			X		X	
Excess landscaping watering		X		X	x	x	X
Leaking potable water pipes		X	X				X
Commercial Areas:							
Gasoline filling station	X	x		X	X		
Vehicle maintenance/repair	X	x		X	X		
Laundry wastewater	X		X	x	x	X	
Construction site de-watering		X	X	x		X	
Sanitary wastewater	X	x	X		X		
Industrial Areas:							
Leaking tanks and pipes	x	X	X	x	X		
Miscellaneous process waters[1]	X	x	X	x	X	x	x

Note: X: most likely condition
x: may occur
blank: not very likely

[1] see Table 2 for industrial examples

- Other sources:
  - laundry wastewaters
  - non-contact cooling water
  - metal plating baths
  - dewatering of construction sites
  - washing of concrete ready-mix trucks
  - sump pump discharges
  - improper disposal of household toxic substances
  - spills from roadway and other accidents
  - chemical, hazardous materials, garbage, sanitary sludge landfills and disposal sites

From the above list, sanitary wastewater is the most significant source of bacteria and oxygen demanding substances, while automobile maintenance and plating baths are the most significant sources of toxicants. Waste discharges associated with the improper disposal of oil and household toxicants tend to be intermittent and low volume. These wastes may therefore not reach the stormwater outfalls unless carried by higher flows from another source, or by stormwater during rains.

Industrial Sources

There are several types of industrial dry-weather entries to storm drainage systems. Common examples include the discharge of cooling water, rinse water, other process wastewater, and sanitary wastewater. Industrial pollutant sources tend to be related to the raw materials used, final product, and the waste or byproducts created. Guidance on typical discharge characteristics associated with common industries is given in Sections 4, 5, and 6.

There is also a high potential for unauthorized connections within older industries. One reason for this is that at the time of an industry's development, sanitary sewers may not have been in existence, since early storm drains preceded the development of many sanitary sewer systems. Also a lack of accurate maps of sanitary and storm drain lines may lead to confusion as to their proper identification. In addition, when the activities within an industry change or expand, there is a possibility for illicit or inadvertent connections, e.g., floor drains and other storm drain connections receiving industrial discharges which should be treated before disposal. Finally, industries processing large volumes of water may find sanitary sewer flow-carrying capacity inadequate or sanitary sewers located too far away, leading to improper removal of excess water through the storm drain system.

Continuous processes, e.g., industrial manufacturing, are important potential sources because any waste streams produced are likely to be constantly flowing. Detection of dry-weather discharges from these sources is therefore made easier, because the continuous and probably undiluted nature of these discharges is more discernable, e.g., odors produced will be stronger and colors more intense along with their tracer constituents being more concentrated and more readily detected by sampling.

Intermittent Sources

The presence of regular, but intermittent, flows will usually be a good indication of contaminated entries to the storm drains, and can usually be distinguished from groundwater infiltration flows. However, as drainage areas increase in size, many intermittent flows will combine to create a continuous composite flow. Examples of possible situations or activities that can produce intermittent dry-weather flows are:

- Wash-up operations at the end of a work shift, or job activity.
- Wash-down following irregular accidents and spills.
- Disposal of process batches or rinse water baths.

- Over-irrigation of lawns.
- Vehicle maintenance, e.g., washing, radiator flushing, and engine de-greasing.

Industries that operate on a seasonal basis, e.g., fruit canning and tourism can be a source of longer duration intermittent discharges.

Direct Connections to Storm Drains

Direct connections are defined in this Guide as physical connections of sanitary, commercial, or industrial piping (or channels) carrying untreated or partially treated wastewaters to a separate storm drainage system. These connections are usually unauthorized. They may be intentional or may be accidental due to mistaken identification of sanitary sewerlines. They represent the most common source of entries to storm drains by industry.

Direct connections can result in continual or intermittent dry-weather entries of contaminants into the storm drain. Some common situations are:

- Sanitary sewerlines that tie into a storm drain.
- Foundation drains or residential sump-pump discharges that are frequently connected to storm drains. While this practice may be quite appropriate in many cases, it can be a source of contamination when the local groundwater is contaminated, as for example by septic tank failures.
- Commercial laundries and car wash establishments that may route process wastewaters to storm drains rather than sanitary sewers.

Infiltration to Storm Drains

Infiltration into storm drains most commonly occurs through leaking pipe joints and poor connections to catch basins and manhole chimneys but can also be due to other causes, such as damaged pipes and subsidence.

Storm drains, as well as natural drainage channels, can therefore intercept and convey subsurface groundwater and percolating waters. In many cases, these waters will be uncontaminated and have variable flows due to fluctuations in the level of the water table and percolation from rainfall events.

Underground potable water main breaks are another potential clean water source to storm drains. While such occurrences are not a direct pollution source, they should obviously be corrected.

Groundwater may be contaminated, either in localized areas or on a relatively widespread basis. In cases where infiltration into the storm drains occurs, it can be a source of excessive contaminant levels in the storm drains. Potential sources of groundwater contamination include, but are not limited to:

- Failing or nearby septic tank systems.
- Exfiltration from sanitary sewers in poor repair.
- Leaking underground (and above-ground) storage tanks (LUST) and pipes.
- Landfill seepage.
- Hazardous waste disposal sites.
- Naturally occurring toxicants and pollutants due to surrounding geological or natural environment.

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Leaks from underground and above-ground storage tanks and pipes are a common source of soil and groundwater pollution and may lead to continuously contaminated dry-weather entries. These situations are usually found in commercial operations such as gasoline service stations, or industries involving the piped transfer of process liquids over long distances and the storage of large quantities of fuel, e.g., petroleum refineries.

INVESTIGATION METHODOLOGY

Applying the methodology presented in this User's Guide will determine if a storm drain outfall (and drainage system) is affected by pronounced non-stormwater entries. In many cases, the information to be collected by using this methodology will also result in a description of the most likely sources of these discharges.

Several aspects of this methodology were derived from the experience of many municipalities that have previously investigated inappropriate entries into storm drainage systems.

The methodology establishes priorities to identify the areas with the highest potential for causing problems. The investigative procedures then separate the storm drain outfalls into three general categories (with a known level of confidence) to identify which outfalls (and drainage areas) need further analyses and investigations. These categories are outfalls affected by non-stormwater entries from: (1) pathogenic or toxic pollutant sources, (2) nuisance and aquatic life threatening pollutant sources, and (3) unpolluted water sources.

The pathogenic and toxic pollutant source category should be considered the most severe because it can cause illness upon water contact or consumption and significant water treatment problems for downstream consumers, especially if the pollutants are solubla metal and organic toxicants. These pollutants may originate from sanitary, commercial, and industrial wastewater non-stormwater entries. Other residential area sources (besides sanitary wastewater), e.g., inappropriate household toxicant disposal, automobile engine de-greasing, and excessive use of chemicals (fertilizers and pesticides) may also be considered in this most critical category.

Nuisance and aquatic life threatening pollutant sources can originate from residential areas and aside from raw sanitary wastewaters may include laundry wastewaters, lawn irrigation runoff, automobile washwaters, construction site dewatering, and washing of concrete ready-mix trucks. These pollutants can cause excessive dissolved oxygen depletions, and algal growths, tastes and odors in downstream water supplies, offensive coarse solids and floatables, and noticeably colored, turbid or odorous waters.

Clean water discharged through stormwater outfalls can originate from natural springs feeding urban creeks that have been converted to storm drains, infiltrating groundwater, infiltration from potable waterline leaks, etc.

Figure 1 is an outline of the major topics presented in this User's Guide, and Figure 2 is a simplified flow chart for the detailed methodology. The initial phase of the investigative protocol includes the initial mapping and field surveys. These activities require minimal effort and result in little chance of missing a seriously contaminated outfall. The initial activities are followed by more detailed watershed surveys to locate and correct the sources of the contamination in the identified problem areas. After corrective action has been taken, repeated outfall field surveys are required to ensure that the outfalls remain uncontaminated. Receiving water monitoring should also be conducted to analyze water quality improvements. If expected improvements are not noted, then additional contaminant sources are likely present and additional outfall and watershed surveys are needed.

MAPPING & PRELIMINARY WATERSHED EVALUATION (SECTION 3)

1) Identify receiving waters.
2) Locate all outfalls and associated drainage areas.
3) Compile data on land uses within drainage areas.

SELECTION OF TRACER PARAMETERS (SECTION 4)

1) Select physical and chemical parameters to measure.
2) Determine suitable analysis techniques and number of samples required.
3) Develop library of potential local source flow characteristics.

INITIAL FIELD SCREENING SAMPLING ACTIVITIES (SECTION 5)

1) Conduct outfall screening survey for intermittent and continuous flows.

DATA ANALYSIS TO IDENTIFY PROBLEM OUTFALLS AND FLOW COMPONENTS (SECTION 6)

1) Simple procedures using checklists for typical major flow components.
2) More detailed analyses utilizing library of data on potential source flows will quantify flow components.

WATERSHED SURVEYS TO CONFIRM AND LOCATE INAPPROPRIATE POLLUTANT ENTRIES TO THE STORM DRAINAGE SYSTEM (SECTION 7)

1) Conduct drainage surveys using tracer parameters in critical watersheds.
2) Use flow mass balances, dye studies, smoke tests, and T.V. surveys in isolated drainage areas.

CORRECTIVE TECHNIQUES (SECTION 8)

1) Educate public/industry and enforce with ordinances, zoning, etc.
2) Disconnect illicit direct connections.
3) Wide spread entries may require regional solutions or designation of storm drainage system as a CSO.

Figure 1. Outline of major topics presented in this User's Guide

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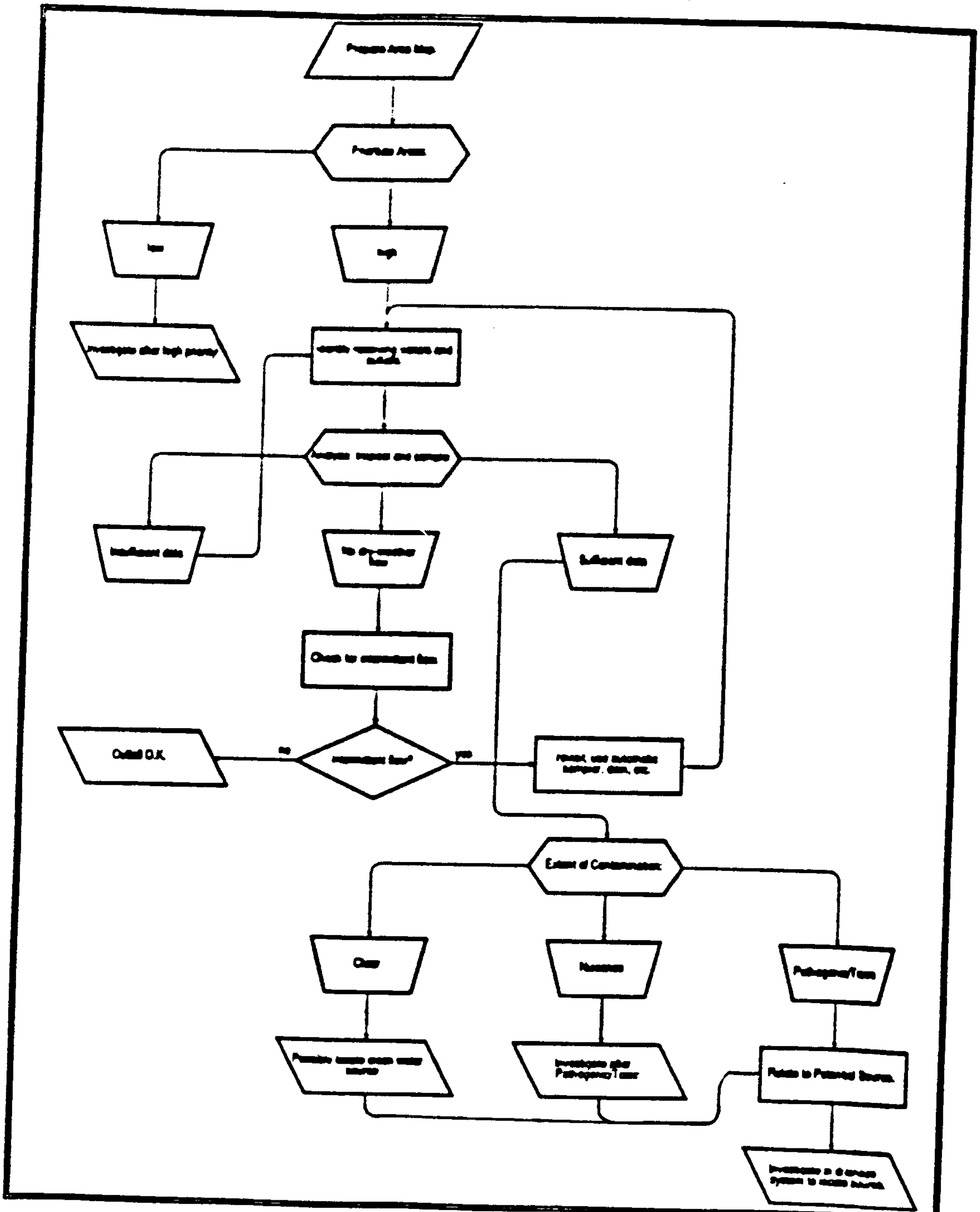

Figure 2. Flow chart for investigation procedures.

RECOMMENDATIONS

This User's Guide should be used as part of a comprehensive stormwater management plan which addresses all sources of stormwater pollution. Correction of pollutant entries identified by use of only this User's Guide is unlikely to achieve a significant improvement in the quality of stormwater discharges or receiving waters.

A municipality will need to plan their investigation of inappropriate entries to a storm drainage system to suit local conditions. This User's Guide describes the issues in sufficient depth and provides examples to enable the design of a local investigation. Greater detail and the results of a comprehensive demonstration of these procedures will be given in a supporting research report by Pitt and Lalor (publication pending).

The full use of all of the applicable procedures described in this User's Guide is likely to be required for successful identification of pollutant sources. Attempting to reduce costs, for example by only examining a certain class of outfalls, or using inappropriate testing procedures, will significantly reduce the utility of the testing program and result in inaccurate data. Also cursory data analyses is likely to result in inaccurate conclusions.

During investigations of non-stormwater entries to storm drainage systems, consideration should be given to any economic and practical advantages of designating the storm drainage system as a combined sewer systems and applying end-of-pipe combined sewer overflow (CSO) control-treatment.

It is also recommended that the methodology (appropriately modified) be applied to other types of sewerage systems, such as combined and separate sanitary sewerage systems, to locate inappropriate entries, e.g., untreated or toxic industrial wastewaters/wastes or infiltration/inflow (I/I) in separate sanitary sewers.

It is recommended that this User's Guide be updated and refined by incorporating experience gained in its application. Incorporation of information from a wide variety of test locations (e.g., lake and large river receiving waters, tidal receiving waters, areas experiencing long dry periods, areas having short summers, areas having unusual groundwater characteristics, etc.) will improve the testing and data analyses protocols described.

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SECTION 3

MAPPING AND PRELIMINARY WATERSHED EVALUATION

PURPOSE

An investigation of non-stormwater entries into a storm drainage system needs to proceed along a systematic path of action, which investigates areas from high to low potential for causing problems, and focuses in from general outfall screening to pin-pointing pollutant sources.

A mapping and evaluation methodology, as detailed in this section, is required to identify the areas to investigate and to provide a basis to prioritize the areas by potential to contribute non-stormwater entries into the storm drainage system.

The data collected in this phase is important as it forms the basis for the rest of the more detailed investigations, described in the subsequent sections of this User's Guide.

MAPPING

To make this exercise as economical and productive as possible, full advantage should be taken of any existing and available information. Data gained from existing sources will need to be supplemented with information obtained by field investigations. The following summarizes the information required, likely data sources, and how to obtain the information.

Receiving Waters and Storm Sewer Outfalls

The receiving waters and stormwater drainage outfalls must be identified and accurately located on appropriate maps. However records of all outfalls are hard to locate, and even for those that can be found, the locations of the outfalls may not be accurate. It is therefore important that the field survey described in Section 5 be used to supplement the data collected during this initial stage. As noted in Section 5, it can take three visits to a drainage area to find all (or almost all) outfalls.

Possible sources of documented information include:

- City records, drainage maps, and storm drain maps.
- Previous surveys, e.g., sanitary sewer infiltration/inflow (I/I) and sewer system evaluation survey (SSES) studies.
- Topographic maps.
- Existing GIS (Geographic Information System) data.
- Pre-development stream locations.
- Drainage department personnel having knowledge of the area.
- Aerial surveys.

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Drainage Area for Each Outfall

The drainage area for each outfall must be determined and marked on the map. This will enable known potential pollutant source locations to be assigned to the correct outfall. Sources for this information are storm drain maps and topographical maps. These should be at least 1" = 200' scale and have no greater than 5 ft contour intervals (depending on the steepness of the area).

Land Uses for Each Outfall Drainage Area

Local planning departments should have detailed zoning maps of the area. These maps should designate residential, commercial, and industrial land uses in each of the outfall drainage areas. In addition, local revenue departments should have lists of business licenses for the entire municipality, but they may not be usefully sorted. The public health department should know where septic tanks are used. Aerial photographs can provide useful information to identify and or confirm land use areas. Historical land uses, especially landfills and industrial areas, should also be noted.

An effective way to obtain this information is to examine the municipality's zoning maps and to drive to the critical areas to conduct inspections. The land uses of most interest are all industrial, most commercial, and some municipal activities. The activities in the commercial areas of most concern include vehicle related activities (sales, parts, service, or repair), laundry or dry cleaning (including hospitals and hotels), and restaurants. The municipal activities of most concern include but are not limited to: landfills, bus barns, airports, and sanitary wastewater treatment facilities.

Table 2 can be used to identify the local industries in each drainage area most likely to contribute non-stormwater entries into the storm drainage system. The categories considered in this table include loading and unloading of dry bulk or liquid materials, outdoor storage or processing, water usage (cooling and process waters), dust or particulate generating processes, and illicit or inadvertent industrial connections. The likelihood of an industry producing dry-weather or wet-weather discharges in each of these categories was rated on the basis of high, moderate, or low potential and not applicable if there was no relationship evident.

The industrial categories listed in Table 2 were defined according to the 1987 Standard Industrial Classification Manual codes (SIC code). The industries were classified according to six main categories. The category for "Primary Industries" includes facilities involved in the production of food products and other basic goods. The category of "Material Manufacturing" includes those industries producing materials such as lumber, paper, glass, and leather. Similarly, the "Chemical Manufacturing" category includes those industries making products such as plastics, paints, detergents, fertilizers, pesticides, and other related substances. "Transportation and Construction" primarily concerns the discharge of contaminants from building or other types of outdoor development. The "Retail" category includes establishments engaged in the selling of merchandise or offering merchandise related services. Finally, all other industries which did not fit into any of the above classifications were placed into a "General" category. Those industries which are not specifically listed should have characteristics resembling the industries of the major groups with which they are classified by SIC code.

Investigators should take care to include any area where the land use has a potential to contribute pollutant sources to a storm drainage system. As stated above, these land uses may not be covered by Table 2. Some common examples of land use areas to be included are given below:

- Landfill areas can be a source of leachate and polluted runoff.
- Airports have a high potential for fuel spillage. Aircraft deicing agents, and other maintenance operations, produce wastewaters that may be discharged into the storm drainage system.

TABLE 2. SOURCES OF INDUSTRIAL NON-STORMWATER ENTRIES INTO STORM DRAINAGE SYSTEMS

Industrial Categories / Major Classifications / SIC Group Numbers		Loading/Unloading: Dry Bulk	Loading/Unloading: Liquids	Outdoor Storage/ Processing	Water Usage: Cooling	Water Usage: Process	Particle Generating Process	Illicit/ Inadvertent Connections
Primary Industries								
20	Food & Kindred Products							
201	Meat Products	H	L	H	H	H	L	H
202	Dairy Products Processing Industry	H	H	NA	H	H	NA	H
203	Canned & Preserved Fruits & Vegetables	H	H	H	H	H	M	H
204	Grain Mill Products	H	H	L	H	H	H	H
205	Bakery Products	H	M	NA	NA	H	M	L
206	Sugar & Confectionery Products	H	M	NA	L	M	H	L
207	Fats & Oils	H	H	NA	M	H	NA	M
208	Beverages	H	H	NA	H	H	M	L
21	Tobacco Manufactures	H	M	NA	NA	M	H	M
22	Textile Mill Products	H	L	NA	H	H	M	H
23	Apparel & Other Finished Products Made from Fabrics & Similar Materials	H	L	NA	NA	M	M	L
Material Manufacture								
24	Lumber & Food Products	H	L	H	NA	M	H	L
25	Furniture & Fixtures	H	M	NA	NA	L	M	L
26	Paper & Allied Products	H	H	H	H	H	H	H
27	Printing, Publishing, & Allied Industries	H	M	NA	NA	M	H	L
31	Leather & Leather Products	H	H	L	L	H	H	H
32	Stone, Clay, Glass, & Concrete Products	H	M	H	L	H	H	L
33	Primary Metal Industries	H	M	H	H	H	H	H
34	Fabricated Metal Products	H	H	L	H	H	H	H
37	Transporation Equipment	L	H	L	H	H	L	H

(continued)

TABLE 2. (continued)

Industrial Categories Major Classifications SIC Group Numbers	Loading/Unloading Dry Bulk	Loading/Unloading Liquids	Outdoor Storage/ Processing	Water Usage Cooling	Water Usage Process	Particle Generating Process	Illicit/ Inadvertent Connections
Chemical Manufacture							
28 Chemicals & Allied Products							
281 Industrial Inorganic Chemicals	H	H	NA	H	H	H	H
282 Plastic Materials & Synthetics	H	H	L	H	M	L	H
283 Drugs	L	L	NA	H	M	L	L
284 Soap, Detergents, & Cleaning Preparations	H	H	NA	H	H	H	H
285 Paints, Varnishes, Lacquers Enamels & Allied Products	H	H	NA	L	H	H	L
286 Industrial Organic Chemicals	H	H	NA	H	H	H	M
287 Agricultural Chemicals	L	L	NA	H	L	L	L
29 Petroleum Refining & Related Industries							
291 Petroleum Refining	L	H	H	H	L	NA	H
295 Paving & Roofing Materials	H	H	H	NA	M	M	L
30 Rubber & Misc. Plastic Products	H	H	NA	H	H	H	M
Transportation & Construction							
15 Building Construction	M	L	H	NA	L	H	L
16 Heavy Construction	M	L	H	NA	L	H	L
Retail							
52 Building Materials, Hardware Garden Supply, & Mobile Home Dealers	H	L	H	NA	L	NA	L
53 General Merchandise Stores	H	M	L	NA	L	NA	L
54 Food Stores	H	H	NA	NA	M	L	L
55 Automotive Dealers & Gasoline Service Stations	H	H	H	NA	M	L	M
56 Apparel & Accessory Stores	H	L	NA	NA	L	NA	L
57 Home Furniture, Furnishings and Equipment Stores	H	L	L	NA	L	NA	L
58 Eating & Drinking Places	H	M	NA	NA	M	NA	M
Other							
Coal Steam Electric Power	H	L	H	H	L	H	L
Nuclear Steam Electric Power	NA	L	NA	H	L	NA	NA

NOTE: H: High potential M Medium potential L Low potential NA: Not applicable

- Government facilities, such as military bases, may store or use polluting materials and have large vehicle maintenance facilities.
- Agricultural impacts are likely to be greater for wet-weather flows, but practices such as irrigation and drainage tiles may also produce dry-weather flows.

Finally, it is necessary to identify and locate existing permitted discharges to streams and storm drainage. The National Pollutant Discharge Elimination System (NPDES) permits, administered by most states or, if not, by the EPA Regional Offices, contain this information for the facilities currently having discharge permits. Only a small fraction of all industries have NPDES permits, as most have no direct wastewater discharges to waters of the United States. Pretreatment programs for municipal sewage treatment plants would also contain additional industrial information.

Other Relevant Information and Features

It is important that investigators be aware of any relevant features or information which may be specific to their drainage area and not included specifically in the above subsections of this User's Guide. Examples of some items that need to be included are discussed in this subsection.

Information on pre-development streams and springs, which may have been routed into the storm drainage system, will aid in the identification of natural uncontaminated or contaminated dry-weather flows.

Information regarding depth to the water table will be helpful. If the water table is well below the storm drain invert at all times, then groundwater infiltration may be less important as a potential source of dry-weather flow. However, the accumulation of percolating shallow groundwater will still occur in storm drainage fill material and be a potential source of some infiltration water. Groundwater conditions for the study area may be available from special studies conducted by the USGS (U.S. Geological Survey), the state water agency, or other sources. Utility construction and repair crews and earth moving companies should know of areas having shallow groundwater. Local I/I and SSES studies also include information concerning shallow groundwater. Well log data collected during drilling of water supply wells, and information from geotechnical investigations, may also be useful.

Areas serviced by sanitary sewerage and areas serviced by septic tanks should be determined in order to identify the areas most likely to have direct connections and infiltration sources, respectively. Either local health, sewerage, utility, environmental, or public works departments should have information on the location of these areas.

Older residential areas with failing infrastructure (especially sanitary sewerage in poor condition), and high density residential areas with septic tanks, should be designated as areas with a high potential for pollutant entries into the storm drainage system.

PRELIMINARY WATERSHED EVALUATION

The above activities should produce maps with complete descriptions of the drainage areas, including outfall locations, NPDES permittees, critical land uses, drainage boundaries for each outfall, city limits, major streets, streams, etc. The investigators need to classify drainage areas by their potential for causing non-stormwater entries. This mapping information, together with the information to be obtained as described in Sections 4 and 5 and analyzed as described in Section 6, will form the basis to rank the drainage areas in order of priority for further detailed drainage area investigations (Sections 7 and 8).

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The investigation of non-stormwater entries will have a cost associated with it, which will increase with the drainage system size and complexity, and with the number of sources being investigated. All pollutant sources, including both wet- and dry-weather pollutant entries, will need to be controlled to have an effective improvement in the quality of the stormwater system discharge. Pitt and McLean (1986) noted that even with the removal of directly connected non-stormwater entries, stormwater originating from industrial and commercial land uses has a high probability of having unacceptable pollutant loads. It would therefore be prudent, at an early stage in the investigation, to review the costs of the investigation and corrective action versus the cost for treatment of the stormwater system discharge. The classification of the storm drainage system as a combined sewer, and subsequent treatment of the flow, may prove to be a more economical and practical alternative. An appropriate time for such a review would be after the mapping and field screening activities to avoid complex, costly, and time consuming drainage system investigations into inappropriate non-stormwater entries, and instead direct resources to pollution control.

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SECTION 4

SELECTION OF TRACER PARAMETERS

INTRODUCTION

The detection and identification of inappropriate entries requires the quantification of specific characteristics of the observed outfall baseflow. The characteristics of most interest should be relatively unique for each potential flow source. This will enable the presence of each flow source to be noted, based on the presence (or absence) of these unique characteristics. The selected characteristics are termed tracers, because they have been selected to enable the identification of the sources of these waters.

One approach presented in this User's Guide is based on the identification and quantification of clean baseflow and contaminated components. If the relative amounts of potential components are known, then the importance of the baseflow can be determined. As an example, if a baseflow is mostly uncontaminated groundwater, but contains 5 percent raw sanitary wastewater, it would be a likely important source of pathogenic bacteria. Typical raw sanitary wastewater parameters (e.g., BOD$_5$ or suspended solids) would be in low concentrations and the sanitary wastewater source would be difficult to detect. Fecal coliform bacteria measurements would not help much because they originate from many possible sources. Expensive specific pathogen measurements would be needed to detect the problem directly.

The ideal tracer should have the following characteristics:

- Significant difference in concentrations between possible pollutant sources;
- Small variations in concentrations within each likely pollutant source category;
- A conservative behavior (i.e., no significant concentration change due to physical, chemical or biological processes); and,
- Ease of measurement with adequate detection limits, good sensitivity, and repeatability.

In order to identify tracers meeting the above criteria, literature characterizing potential inappropriate entries into storm drainage systems was examined. Several case studies which identified procedures used by individual municipalities or regional agencies were also examined. Though most of the investigations resorted to expensive and time consuming smoke or dye testing to locate individual illicit pollutant entries, a few provided information regarding test parameters or tracers. These screening tests were proven useful in identifying drainage systems with problems before the smoke and dye tests were used. The case studies also revealed the types of illicit pollutant entries most commonly found in storm drainage systems.

This list of potential illicit sources (see Section 2) led to a search for information regarding the chemical and physical characteristics of these specific flows. This search yielded typical characteristics for sanitary wastewater, septic tank effluent, coin-operated laundries and car wash effluents as well as potable water and "natural waters". This information, along with specifics obtained from case studies, provided the basis for selecting parameters for further study. Specific analyses will be needed to identify the characteristics of local potential inappropriate entries and uncontaminated water sources, as described in this section.

CANDIDATE PARAMETERS

Many different candidate parameters were evaluated before the suggested list was developed (Pitt and Lalor publication pending). It is recommended that the initial field screening effort (in the absence of known commercial and industrial activities in the watershed) include at least:

- Placement of outfall identification number.
- Outfall discharge flow estimate.
- Floatables, coarse solids, color, turbidity, oil sheen, and odor characteristics of discharge and/or receiving nearfield water.
- Other outfall area characteristics, e.g., stains, debris, damage to concrete, corrosion, unusual plant growth, or absence of plants.
- Water temperature.
- Specific conductivity.
- Fluoride and/or hardness concentrations.
- Ammonia and/or potassium concentrations.
- Surfactant concentration and/or fluorescence.
- Chlorine concentration and pH.

If commercial or industrial activities occur in the drainage area, then it is important to add additional parameters (e.g., a toxicity screening procedure and specific metallic and organic toxicant analyses) to the above list.

Most of the screening effort items listed above can be obtained at the outfall location using field procedures. It is much easier, more cost-effective, and much more accurate to collect samples in the field for later laboratory analyses. Analyzing multiple samples for the same parameter is much more efficient than trying to analyze a single sample for many parameters, especially under adverse field conditions.

The selection of the analysis procedures and equipment will depend on many conditions, most notably the expected concentrations in the uncontaminated baseflows and in the potential non-stormwater discharge flows, along with the needed probabilities of detection at the minimum contamination level. A description of the techniques developed as part of this study to help in the selection of the analytical procedures is given later in this section. Other factors affecting procedure selection include ease of use, analytical interferences, cost of equipment, training requirements, and time requirements to conduct the analyses.

Physical Inspection

Estimates of outfall flow rates, and noting the presence of oil sheens, floatables, coarse solids, color, odors, etc. will probably be the most useful indicators of outfall problems. Physical observations of outfall conditions have been noted in case studies to be very useful in determining the significance of contaminated dry-weather flows. There has been a good correlation between storm drains judged contaminated after physical inspection and those judged contaminated after chemical tests at several case studies (e.g., Inner Grays Harbor, Washington, Beyer, et al. 1979 and Pelletier and Determan 1988; Fort Worth, Texas, Falkenbury 1987 and 1988 and Moore and Hoffpauir 1988; and Toronto, Ontario, GLA 1983).

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Odor--

The odor of a discharge can vary widely and sometimes directly reflects the source of contamination. Industrial dry-weather discharges will often cause the flow to smell like a particular spoiled product, oil, gasoline, specific chemical, or solvent. As an example, for many industries, the decomposition of organic wastes in the discharge will release sulfide compounds into the air above the flow in the sewer, creating an intense smell of rotten eggs. In particular, industries involved in the production of meats, dairy products, and the preservation of vegetables or fruits, are commonly found to discharge organic materials into storm drains. As these organic materials spoil and decay, the sulfide production creates this highly apparent and unpleasant smell. Significant sanitary wastewater contributions to a dry-weather flow will also cause pronounced and distinctive odors.

Color--

Color is another important indicator of inappropriate discharges, especially from industrial sources. Industrial dry-weather discharges can have various colors. Dark colors, such as brown, gray, or black, are most common. For instance, the color contributed by meat processing industries is usually a deep reddish-brown. Paper mill wastes are also brown. In contrast, textile wastes are varied. Other intense colors, such as plating-mill wastes, are often yellow. Washing of work areas in cement and stone working plants can cause cloudy dry-weather discharges. Potential dry-weather sources causing various colored contaminated waters from industrial areas include process waters (slug or continuous discharges), equipment end work area cleaning water discharged to floor drains, and spills during loading operations (and subsequent washing of the material into the storm drains).

Turbidity--

Turbidity of water is often affected by the degree of gross contamination. Dry-weather industrial flows with moderate turbidity can be cloudy, while highly turbid flows can be opaque. High turbidity is often a characteristic of undiluted dry-weather industrial discharges, such as those coming from some continual flow sources, or some intermittent spills. Sanitary wastewater is also often cloudy in nature.

Temperature--

Temperature measurements may be useful in situations where the screening activities are conducted during cold months, or in areas having industrial activity. It may be possible to identify an outfall that is grossly contaminated with sanitary wastewater or cooling water during cold weather and possibly to conduct a rough heat balance. Both sanitary wastewater and cooling water could substantially increase outfall discharge temperatures. Elevated baseflow temperatures (compared to baseflows at other outfalls being screened) could be an indicator of substantial contamination by these warmer source flows.

Floatable Matter--

A contaminated flow may also contain floatables (floating solids or liquids). Evaluation of floatables often leads to the identity of the source of industrial or sanitary wastewater pollution, since these substances are usually direct products or byproducts of the manufacturing process, or distinctive of sanitary wastewater. Floatables of industrial origin may include substances such as animal fats, spoiled food products, oils, plant parts, solvents, sawdust, foams, packing materials, or fuel; whereas floatables in sanitary wastewater include fecal matter, sanitary napkins, and condoms.

Deposits and Stains--

Deposits and stains (residue) refer to any type of coating which remains after a non-stormwater discharge has ceased. They will cover the area surrounding the outfall and are usually of a dark color. Deposits and stains often will contain fragments of floatable substances and, at times, take the form of a crystalline or amorphous powder. These situations are illustrated by the grayish-black deposits that contain fragments of animal flesh and hair which often are produced by leather tanneries, or the white crystalline powder which commonly coats sewer outfalls due to nitrogenous fertilizer wastes.

Vegetation--

Vegetation surrounding an outfall may show the effects of intermittent or random non-stormwater discharges. Industrial pollutants will often cause a substantial alteration in the chemical composition and pH of the discharge. This alteration will affect plant growth, even when the source of contamination is intermittent. For example, decaying organic materials coming from various food product wastes could cause an increase in plant life. In contrast, the discharge of chemical dyes and inorganic pigments from textile mills could noticeably stunt plant growth, as these dry-weather discharges are often acidic. In either case, when the industrial pollution constituent in the flow ceases, the vegetation surrounding the outfall will continue to show the effects of the contamination.

In order to accurately judge if the vegetation surrounding an outfall is normal, the observer must take into account the current weather conditions, as well as the time of year in the area. Thus, flourishing or inhibited plant growth, as well as dead and decaying plant life, are all signs of pollution or scouring flows when the condition of the vegetation beyond the outfall contrasts with the plant conditions near the outfall. It is important not to confuse the adverse effects of high storm-induced flows on vegetation with highly toxic dry-weather intermittent flows. Poor plant growth could be associated with scouring flows occurring during storms.

Damage to Sewerage/Outfall Structure--

Sewerage structural damage is another readily visible indication of both continual and intermittent industrial dry-weather discharge contamination. Cracking, deterioration, and spalling of concrete or peeling of surface paint, occurring at an outfall are usually caused by severely contaminated discharges, usually of industrial origin. These contaminants are usually very acidic or basic in nature. For instance, primary metal industries have a strong potential for causing sewerage structural damage because their batch dumps are highly acidic. However confusion is possible due to the effects poor construction, hydraulic scour, and old age may have had on the condition of the outfall structure or sewerage system.

Chemical Parameters

Chemical tests are needed to supplement the above described physical inspection parameters. Chemical tests are needed to quantify the approximate components of a mixture at the outfall. In most cases, dry-weather discharges are made up of many separate source flows (e.g., potable water, groundwaters, sanitary wastewater, and automobile washwaters). Statistical analyses of the chemical test results can be used to estimate the relative magnitudes of the various flow sources (as described in Section 6 of this Guide).

Specific Conductivity--

Specific conductivity can be used as an indicator of dissolved solids. Specific conductivity measurements can be conducted with relative ease in the field, while dissolved solids measurements must be made in a laboratory.

The literature indicates that variation in specific conductivity measurements between water and wastewater sources could be substantial enough to indicate the source of dry-weather flow in the storm drainage system. Specific conductance was judged to be a reliable and quick field indicator of general outfall contamination in Toronto (GLA 1983). Observed levels ranged from 25 to 100,000 μS/cm (microSiemens per cm). Specific conductivity levels less than 1000 μS/cm indicated significant levels of rainwater in the drainage. Specific conductivity can be measured quickly, easily and cheaply. For these reasons, it was selected as a parameter for further study.

Fluoride--

Fluoride concentration should be a reliable indicator of potable water where fluoride levels in the raw water supply are adjusted to consistent levels and where groundwater has low to non-measurable natural fluoride levels. It is common practice for communities to add fluoride to municipal waters to improve dental health. Concentrations of total fluoride in fluoride treated potable waters are usually in the range of 1.0 to 2.5 mg/L.

Fluoride measurements have often been used to distinguish treated waters from natural waters. During the Allen Creek drainage study (Schmidt and Spencer 1986), the fluoride concentrations of dry-weather flows at outfalls were undetectable after most of the known improper connections to storm drains were eliminated. Very few of these improper connections were of sanitary wastewater to the storm drainage. Apparently, most of the non-stormwater discharges were treated potable water.

Hardness--

Hardness may also be useful in distinguishing between natural and treated waters (like fluoride), as well as between clean treated waters and waters that have been subjected to domestic use.

The hardness of waters varies considerably from place to place, with groundwaters generally being harder than surface waters. Natural sources of hardness are limestones which are dissolved by percolating rainwater made acid by dissolved carbon dioxide. Information regarding the average hardness of potable water as well as local groundwater and surface waters should be readily available wherever a public water supply system exists.

Ammonia/Ammonium--

As part of the nitrogen cycle, ammonia is produced by the decay of organic nitrogen compounds. Ammonia may then be broken down, forming nitrites and nitrates. The presence or absence of ammonia (NH_3), or ammonium ion (NH_4^+), has been commonly used as a chemical indicator for prioritizing sanitary wastewater cross-connection drainage problems. Correlations between elimination of improper sanitary wastewater cross-connections into storm drainage and reduced numbers of storm drainage outfalls with ammonia present were noted in Fort Worth (Falkenbury 1987 and 1988; Moore and Hoffpauir 1988). During studies in Toronto (GLA 1983), more "problem" storm drain outfalls had high ammonia concentrations (>1 mg/L) than any other single parameter, except TKN. During the Huron River (Michigan) study (Washtenaw Co. 1987 and 1988; Murray 1985), ammonia levels were found to be greater at all "problem" storm drain outfalls than at control locations. However, the Allen Creek (Michigan) Drainage study (Schmidt and Spencer 1986) reported that with 92 percent of the improper non-stormwater entries to storm drains eliminated, the ammonia concentrations did not change significantly (all were about 0.44 mg/L). However, very few of these cross-connection eliminations were for sanitary wastewater. Ammonia should be useful in identifying sanitary wastes and distinguishing them from commercial water usage.

Potassium--

Large increases of potassium concentrations have been noted for sanitary wastewater compared to potable water during studies in California (Evans 1968), Virginia (Hypes, et al. 1975), and Brussels, Belgium (Verbanck, et al. 1990). These potassium increases following domestic water usage suggest its potential as a tracer parameter.

Surfactants and Fluorescence--

Surfactants are discharged from household and industrial laundering and other cleaning operations. In the United States, anionic surfactants are commonly used in detergents and account for approximately two thirds of the total surfactants used. Anionic surfactants are commonly measured as Methylene Blue Active Substances (MBAS). In raw sanitary wastewaters, surfactants generally range from 1 to 20 mg/L, while natural waters usually have surfactant concentrations below 0.1 mg/L.

Large concentrations of surfactants are found in sanitary wastewater, but some researchers (Alhajjar, et al. 1989) have reported that they are not found in septic tank effluent. Surfactants can be totally degraded in the septic tanks. During the Allen Creek drainage study (Schmidt and Spencer 1986; Washtenaw County Drain Commissioner 1984; and Washtenaw County Statutory Drainage Board 1987), surfactants (as MBAS) decreased significantly after most of the improper non-stormwater entries to storm drains were eliminated. Surfactants can be used to identify sanitary or laundry wastewater cross-contamination in storm drainage systems. They may also be of use in distinguishing between infiltrating septic tank effluent and other washwaters from domestic or commercial cleaning operations.

Water fluorescence is also an indicator of detergent residue in waters. Most detergents contain fabric whiteners which cause substantial fluorescence. Fluorescent indicators remain after sanitary wastewater treatment in septic tanks. Fluorescence in contrast to MBAS may be useful in distinguishing between sanitary wastewater contamination and septic tank effluent.

pH--

The pH of most uncontaminated baseflows, as well as sanitary wastewater, is usually quite close to neutral (pH of 7). Therefore, Ph will probably not serve as an indicator of sanitary cross connections. However, pH values may be extreme in certain inappropriate commercial and industrial flows or where groundwaters contain dissolved minerals. If unusual pH values are observed, then the drainage system needs to be carefully evaluated. Very few of the stormwater outfalls tested during dry-weather in Fort Worth (Falkenbury 1987 and 1988; Moore and Hoffpauir 1988) had pH values either below 6 or above 9. None of the Toronto (GLA 1983) "problem" outfalls were reported to have extreme pH values.

Chemicals (acidic and alkaline) released into storm drains by chemically-oriented industries are frequently the cause of pH fluctuations which can range from 3 to 12.

Industries that commonly release low pH (acidic) dry-weather discharges include (but are not limited to) textile mills, pharmaceutical manufacturers, metal finishers/fabricators, as well as companies producing resins, fertilizers and pesticides. Wastes containing sulfuric, hydrochloric, or nitric acids are common industrial sources of low pH discharges.

Many industrial wastes contain high pH (alkaline) chemicals such as cyanide, sodium sulfide, and sodium hydroxide. High concentrations of these contaminants are found in discharges from soap manufacturers, textile mills, metal plating industries, steel mills, and producers of rubber or plastic.

Total Available Chlorine--

Chlorine can be present in water as free available chlorine and as combined available chlorine (usually as chloramines). Both types can exist in the same water and be determined together as the total available chlorine. Chlorine is not stable in water, especially in the presence of organic compounds. Tests of clean potable water during the demonstration project (Pitt and Lalor publication pending) found that total available chlorine only decreased by about 25 percent in 24-hours during an aerated bench-scale test. However, the chlorine demand of contaminated water can be very large, with chlorine concentrations decreasing to very small values after short periods of time. Chlorine therefore cannot be used to quantify flow sources because of its instability, but the presence of chlorine in baseflow waters (very unlikely) could indicate a significant and very close potable water flow source.

Other Chemicals Indicative of Manufacturing Industrial Activities--

Table 3 is a listing of various chemicals that may be associated with a variety of different industrial activities. If the industrial activities in an outfall watershed are known, it may be possible to examine the non-stormwater outfall flow for specific chemicals (e.g., listed in Table 3) to identify which industrial activities may be responsible for the dry-weather flow.

TABLE 3. SIGNIFICANT CHEMICALS IN INDUSTRIAL WASTEWATERS

Chemical:	Industry:
Acetic acid	Acetate rayon, pickle and beetroot manufacture.
Alkalies	Cotton and straw kiering, cotton manufacture, mercerizing, wool scouring, and laundries.
Ammonia	Gas, coke, and chemical manufacture.
Arsenic	Sheep-dipping, and felt mongering.
Chlorine	Laundries, paper mills, and textile bleaching.
Chromium	Plating, chrome tanning, and aluminum anodizing.
Cadmium	Plating.
Citric acid	Soft drinks and citrus fruit processing.
Copper	Plating, pickling, and rayon manufacture.
Cyanides	Plating, metal cleaning, case-hardening, and gas manufacture.
Fats, oils	Wool scouring, laundries, textiles,and oil refineries.
Fluorides	Gas, coke, and chemical manufacture, fertilizer plants, transistor manufacture, metal refining, ceramic plants, and glass etching.
Formalin	Manufacture of synthetic resins and penicillin.
Hydrocarbons	Petrochemical and rubber factories.
Hydrogen peroxide	Textile bleaching, and rocket motor testing.
Lead	Battery manufacture, lead mining, paint manufacture, and gasoline manufacture.
Mercaptans	Oil refining, and pulp mills.
Mineral acids	Chemical manufacture, mines, Fe and Cu pickling, brewing, textiles, photo-engraving, and battery manufacture.
Nickel	Plating.
Nitro compounds	Explosives and chemical works.
Organic acids	Distilleries and fermentation plants.
Phenols	Gas and coke manufacture, synthetic resin manufacture, textiles, tanneries, tar, chemical, and dye manufacture and sheep-dipping.
Silver	Plating, and photography.
Starch	Food, textile, and wallpaper manufacture.
Sugars	Dairies, foods, sugar refining, and preserves.
Sulfides	Textiles, tanneries, gas manufacture, and rayon manufacture.
Sulfites	Wood process, viscose manufacture, and bleaching.
Tannic acid	Tanning, and sawmills.
Tartaric acid	Dyeing, wine, leather, and chemical manufacture.
Zinc	Galvanizing, plating, viscose manufacture, and rubber process.

Source: Van der Leeden, et al. 1990.

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Toxicity Screening Tests

In addition to the parameters described above, relative toxicity can be an important outfall screening parameter. Short-term toxicity tests, such as the Microtox™ test (from Microbics) are valuable for quickly and cheaply assessing the relative toxicity (to a selected test organism) of different storm drain baseflows. These tests can be used to identify outfalls that contain flows in the most serious (toxic) category and that require immediate investigation. These tests are also very useful in identifying likely sources of toxicants to the drainage system by utilizing a toxicity reduction evaluation (TRE) procedure in the drainage system. If an outfall contains a highly toxic flow, then specific metallic and organic toxicants can be analyzed to support source identification.

TRACER CHARACTERISTICS OF SOURCE FLOWS

Table 4 summarizes the relative concentrations of tracer parameters in source flows. The unique "fingerprints" of each flow category shown can be used to identify the flow components, as shown in Section 6. This table also contains redundancies, (e.g., potassium and ammonia) to help identify sanitary wastewater and septic tank effluent. Fluoride and hardness are similarly used to identify treated potable water and surfactant (MBAS) and fluorescent measurements are used to identify washwaters.

Table 5 is a summary of the tracer parameter concentrations found in Birmingham, Alabama, from April 1991 to September 1992. This table is a summary of the "library" that describes the tracer conditions for each potential source category. The important information shown on this table includes the median and coefficient of variation (COV) values for each tracer parameter for each source category. The COV is the ratio of the standard deviation to the mean. A low COV value indicates a smaller spread of data compared to a data set having a large COV value. It is apparent that some of the abstracted and generalized relationships shown on Table 4 did not exist during the demonstration project. This stresses the need for obtaining local data describing likely source flows.

The fluorescence values shown on Table 5 are direct measurements from the Turner™ (Model 111) fluorometer having general purpose filters and lamps and at the least sensitive setting (number 1 aperture). The toxicity screening test results are expressed as the toxicity response noted after 25 minutes of exposure. The Microtox™ unit measures the light output from phosphorescent algae. The I_{25} value is the percentage light output decrease observed after 25 minutes of exposure to the sample. If an outfall sample has a very high light reduction value, it is typically subjected to additional organic and metallic toxicant tests. Fresh potable water has a relatively high response because of the chlorine levels present. Aged, or dechlorinated, potable water has much smaller toxicity responses.

Appropriate tracers are characterized by having significantly different concentrations in flow source categories requiring identification. In addition, effective tracers also need low COV values within each flow category. Table 4 indicates the expected changes in concentrations per category and Table 5 indicates how these expectations compared with the results of an extensive local sampling effort. The study indicated that the COV values were quite low for each category, with the exception of chlorine, which had much greater COV values. The high chlorine COV values reinforce what was previously indicated (under Total Available Chlorine), that chlorine is not recommended as a quantitative tracer to estimate the flow components. Similar data must be collected in each community where these procedures are to be used. The following subsection discusses how the number of samples needed per category can be estimated.

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TABLE 4. FIELD SURVEY PARAMETERS AND ASSOCIATED NON-STORMWATER FLOW SOURCE CATEGORIES

Parameter	Natural Water	Potable Water	Sanitary Wastewater	Septic Tank Effluent	Indus. Water	Wash-Water	Rinse Water	Irrig. Water
Fluorides	-	+	+	+	+/-	+	+	
Hardness Change	-	+/-	+	+	+/-	+	+	+
Surfactants	-	-	+	-	-	+	-	-
Fluorescence	-	-	+	+	-	+	-	-
Potassium	-	-	+	+	-	-	-	-
Ammonia	-	-	+	+	-	-	-	-
Odor	-	-	+	+	+	+/-	-	-
Color	-	-	-	-	+	-	-	-
Clarity	-	-	+	+	+	+	+/-	-
Floatables	-	-	+	-	+	+/-	+/-	-
Deposits/Stains	-	-	+	-	+	+/-	+/-	-
Vegetation Change	-	-	+	+	+	+/-	-	+
Structural Damage	-	-	-	-	+	-	-	-
Conductivity	-	-	+	+	+	+/-	+	+
Temperature Change	-	-	+/-	-	+	+/-	+/-	-
pH	-	-	-	-	+	-	-	-

NOTE:
- \- implies relatively low concentration
- \+ implies relatively high concentration
- +/- implies variable conditions

TABLE 5. TRACER CONCENTRATION FOUND IN BIRMINGHAM, ALABAMA WATERS (MEAN, STANDARD DEVIATION AND COEFFICIENT OF VARIATION, COV)

	Spring Water	Treated Potable Water	Laundry Waste-water	Sanitary Waste-water	Septic Tank Effl.	Car Wash-water	Radiator Flush Water
Fluorescence (% scale)	6.8 2.9 0.43	4.6 0.35 0.08	1020 125 0.12	250 50 0.20	430 100 0.23	1200 130 0.11	22,000 950 0.04
Potassium (mg/L)	0.73 0.070 0.10	1.6 0.059 0.04	3.5 0.38 0.11	6.0 1.4 0.23	20 9.5 0.47	43 16 0.37	2800 375 0.13
Ammonia (mg/L)	0.009 0.016 1.7	0.028 0.006 0.23	0.82 0.12 0.14	10 3.3 0.34	90 40 0.44	0.24 0.066 0.28	0.03 0.01 0.3
Fluoride (mg/L)	0.031 0.027 0.87	0.97 0.014 0.02	33 13 0.38	0.77 0.17 0.23	0.99 0.33 0.33	12 2.4 0.20	150 24 0.16
Toxicity (% light decrease after 25 min., I[26])	<5 n/a n/a	47 20 0.44	99.9 <1 n/a	43 26 0.59	99.9 <1 n/a	99.9 <1 n/a	99.9 <1 n/a
Surfactants (mg/L as MBAS)	<0.5 n/a n/a	<0.5 n/a n/a	27 6.7 0.25	1.5 1.2 0.82	3.1 4.8 1.5	49 5.1 0.11	15 1.6 0.11
Hardness (mg/L)	240 7.8 0.03	49 1.4 0.03	14 8.0 0.57	140 15 0.11	235 150 0.64	160 9.2 0.06	50 1.5 0.03
pH (pH units)	7.0 0.05 0.01	6.9 0.29 0.04	9.1 0.35 0.04	7.1 0.13 0.02	6.8 0.34 0.05	6.7 0.22 0.03	7.0 0.39 0.06
Color (color units)	<1 n/a n/a	<1 n/a n/a	47 12 0.27	38 21 0.55	59 25 0.41	220 78 0.35	3000 44 0.02
Chlorine (mg/L)	0.003 0.005 1.6	0.88 0.60 0.68	0.40 0.10 0.26	0.014 0.020 1.4	0.013 0.013 1.0	0.070 0.080 1.1	0.03 0.016 0.52
Spec. Conduct. (μS/cm)	300 12 0.04	110 1.1 0.01	560 120 0.21	420 55 0.13	430 311 0.72	485 29 0.06	3300 700 0.22
Number of Samples	10	10	10	36	9	10	10

Determining Number of Observations Needed

It is very important to determine the number of observations needed for each tracer parameter for each source category in order to build a useful data library for analyzing the outfall data. This determination is a function of the tolerable error level in the data means and the standard deviations. The following paragraphs briefly describe a method that can be used to estimate the sampling effort needed to develop a useful library of source characteristic data.

Estimating Errors--

One equation that can be used to calculate the number of analyses needed, based on the allowable error is (Cochran 1963):

Number of samples = 4(standard deviation)^2/(allowable error)^2

With a 95 percent level of confidence, this relationship determines the number of samples needed to obtain a value within the range of the sample mean, plus and minus the error. Similarly, this equation can be used to predict the 95 percent confidence interval, based on the measured (or estimated) standard deviation and number of samples obtained:

Error = 2(standard deviation)/(number of samples)$^{0.5}$

where the confidence interval is the mean plus and minus the calculated error value.

Example of Log_{10} Transformation--

These equations assume a normal distribution of the data. However, most water quality data needs to be log_{10} transformed before a normal distribution is obtained. As an example, consider a tracer having a COV of 0.23 and a median value of 0.14. The resulting log_{10} transformed standard deviation would be about 0.12. For ten samples, the resulting 95 percent confidence range of the median observation (0.14 mg/L) is:

Error = 2(0.12)/(10)$^{0.5}$ = 0.076 in log_{10} space

The confidence interval is therefore log_{10}(0.14) +/- 0.076, which is -0.778 to -0.930 in log10 space. This results in a conventional 95 percent confidence range of $10^{-0.930}$ (= 0.12) to $10^{-0.778}$ (= 0.17). The error in the estimate of the median value is therefore between 14 and 21% for ten samples. If the original untransformed data were used, the error associated with 10 samples is 15%, within the range of the estimate after log transformations. These results are close because of the low COV value (0.23). If the COV value is large, the need for log transformations increases. Figure 3 (Pitt 1979) shows the approximate sample size needed to obtain different allowable errors for different COV values (using nontransformed data).

The COV value in the above example (0.23) was close to the median COV value for all of the source categories and tracer parameters shown on Table 5. Therefore, about 10 samples per source flow category should generally result in less than a 25 percent error for the median values obtained.

As shown in a later section, narrow confidence intervals are needed in order to estimate the relative mixes of the non-stormwater sources as measured at the outfall. Therefore, much care needs to be taken in order to estimate the characteristics of the potential non-stormwater flow sources, especially the COV values and medians.

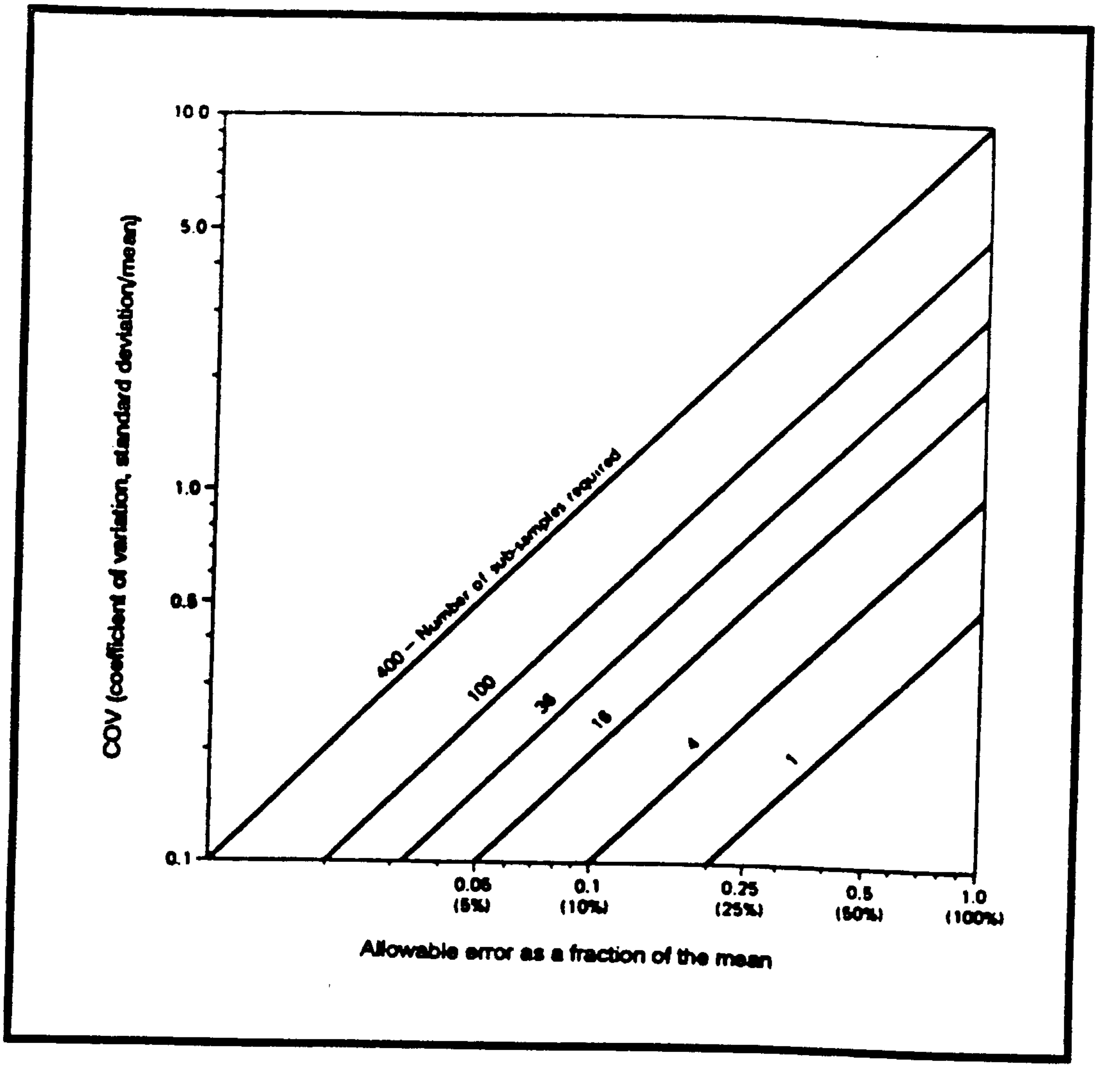

Figure 3. Required number of samples for allowable error and COV

Source: Pitt 1979

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Understanding the mechanisms affecting the non-stormwater sources (e.g., time of day, season, area of town, type and magnitude of land use activities, etc.) and obtaining a relatively large data base library for the source flow tracer concentrations is very important and should be a significant portion of a dry-weather flow source identification project.

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SELECTION OF ANALYTICAL METHODS

The selection of the analytical procedure to be used is dependent on a number of factors, including (in order of importance):

- appropriate detection limits
- freedom from interferences
- good analytical precision (repeatability)
- low cost and good durability
- minimal operator training required

The following sub-sections discuss these requirements and present the recommended analytical procedures. Tracer characteristics in potential local source flows affect most of these requirements. Therefore, the suggested analytical procedures may not be the most cost-effective for all areas.

Detection Limit Requirements

In order to identify potential non-stormwater sources, it is necessary to have a basic knowledge about each potential source flow. As shown earlier, a significant sampling and analysis effort is needed to develop a library of source flow tracer concentrations. The COVs and means of the tracer concentrations are needed to estimate the detection limits required by the analytical procedures.

There are a number of different types of detection limits defined for laboratory use. Most instrument manufactures present a minimum readable value as the instrument detection limit (IDL) in their specifications for simple test kits. The usual definition of IDL, however, is a concentration that produces a signal to noise ratio of five. The method detection limit (MDL) is a more conservative value and is established for the complete preparation and analysis procedure. The practical quantification limit (PQL) is higher yet and is defined as a routinely achievable detection limit with a relatively good certainty that any reported value is reliable. Standard Methods (APHA, et al. 1989) estimates that the relationship between these detection limits is approximately: IDL:MDL:PQL = 1:4:20. Therefore, the detection limit shown in much of the manufacturer's literature is much less than what would be used by most analytical laboratories.

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Because of the screening nature of the outfall field surveys, the instrument detection capabilities are appropriate for the methodology described in this Users' Guide. The larger uncontrollable errors associated with obtaining representative outfall samples and in the variations of the tracer concentrations in the potential source flows would tend to diminish the significance of errors associated with reading concentration values from the instrument that are lower than the PQL.

A quick (and conservative) estimate of the needed detection limit can be made by only knowing the median concentration and the concentration variation of the tracer in the least contaminated component flow. Any amount of another component having a greater tracer concentration will increase the tracer concentration of the mixture. By ignoring this increase, minimum detection limits can be estimated based on the numerous probability calculations presented in the background demonstration project report (Pitt and Lalor publication pending):

COV value:	Multiplier for detection limit:
<0.5 (low)	0.8
0.5 to 1.25 (medium)	0.23
>1.25 (high)	0.12

As an example, if the baseflow tracer has a low COV (<0.5), then the estimated required detection limit is about 0.8 times the median tracer concentration.

More than 80 percent of the library categories (source flows and tracers) examined in Birmingham, Alabama during the demonstration of these procedures (shown on Table 5) had low COV values. About 15 percent had medium COV values, and about 5 percent had high COV values. Free available chlorine had medium or high COV values for almost all source categories. This is a major reason why chlorine is not used quantitatively to identify source flow components in outfall samples. Chlorine is used in a similar manner as an aesthetic parameter (e.g., turbidity or odor). If high chlorine concentrations are found at the outfall (greater than about 0.5 mg/L), then a major treated potable water leak is likely associated with the dry-weather flow.

Table 6 lists the detection limit requirements for the tracer parameter concentrations found during the Birmingham, Alabama, demonstration project. The recommended analytical methods satisfy most of the required detection limits, except for ammonia and surfactants in spring water and surfactants in potable water. The spring water ammonia concentrations were about equal to the detection limit, but because the variation in the ammonia concentrations were so large, a much lower detection limit would be preferable.

Figures 4 through 7 are probability plots showing the required analytical detection limits for mixtures of two source area flows both having low COV values (similar to the majority of expected conditions). Pitt and Lalor (publication pending) present similar plots for all possible combinations of COV values. These figures show four curves corresponding to four mixtures. PER100 is for a 100 percent solution of the flow having the higher tracer concentration, PER50 is for a solution having 50 percent each of two components, PER15 is for a solution of 15 percent of the component having the higher tracer concentration and 85 percent of the component having the lower tracer concentration, while PER0 is a solution only made of the component having the lower tracer concentration. Figure 4 is for two components that have mean concentrations differing by 1.33 times, Figure 5 is for a mixture where the component mean concentrations differ by five times, Figure 6 is for two components with mean concentrations differing by 20 times, and Figure 7 is for two components with mean concentrations differing by 75 times. Each figure shows the detection limits, relative to the lower base concentrations, for different probability of detection values. The detection limits required are reduced significantly as the means of the tracer components differ by greater amounts, especially for low probabilities of detection.

For example, if the two tracer mean concentrations vary by about five times (e.g., treated potable water and sanitary wastewater potassium concentrations from Table 5) and a mixture of 15 percent sanitary wastewater and 85 percent potable water needs to be identified with a 90 percent probability of detection, the required detection limit would be about:

1.4 [factor from Fig.5] x 1.6mg/l [potassium in treated potable water Table 5] = 2.2 mg/L

The more conservative approach stated above would result in a minimum detection limit of:

0.8 [factor for COV < 0.5] x 1.6mg/l = 1.2 mg/L.

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TABLE 6. DETECTION LIMIT REQUIREMENTS FOR TRACER CONCENTRATIONS FOUND IN BIRMINGHAM, ALABAMA WATERS

Tracer Parameter and Units	Median Conc. (mg/L) of Least Contaminated Sources: median (COV)	Required Detection Limit	Available Detection limit[1]
Fluorescence % of full scale	Potable water: 4.6 (0.08) Spring water: 6.8 (0.43)	3.7 5.4	0.1
Potassium mg/L	Spring water: 0.73 (0.10) Potable water: 1.6 (0.04)	0.58 1.3	0.01
Ammonia mg/L	Spring water: 0.01 (1.7) Potable and Radiator water: 0.03 (0.23)	0.001 0.024	0.01
Fluoride mg/L	Spring water: 0.031 (0.87) Sanitary wastewater: 0.77 (0.23)	0.01 0.62	0.01
Surfactants mg/L as MBAS	Spring and potable water: <1 Sanitary wastewater: 1.5 (0.82)	- 0.35	0.01
Hardness mg/L as $CaCO_3$	Laundry water: 14 (0.57) Potable and radiator water: 49 (0.03)	3.2 39	1
Color HACH™ color units	Spring and potable water: <1 Sanitary wastewater: 38 (0.55)	- 8.7	1
Specific Conductivity μS/cm	Potable water: 110 (0.01) Spring water: 300 (0.04)	88 240	10

(1) From anlaytical methods discussed under: "Recommended Analytical Methodology".

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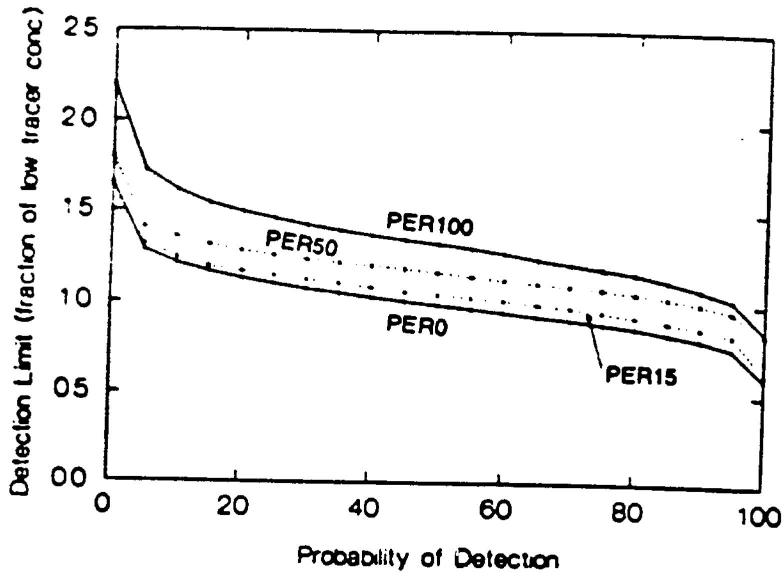

Figure 4. Required detection limits for low COV mixture components having means differing by 1.3 times.

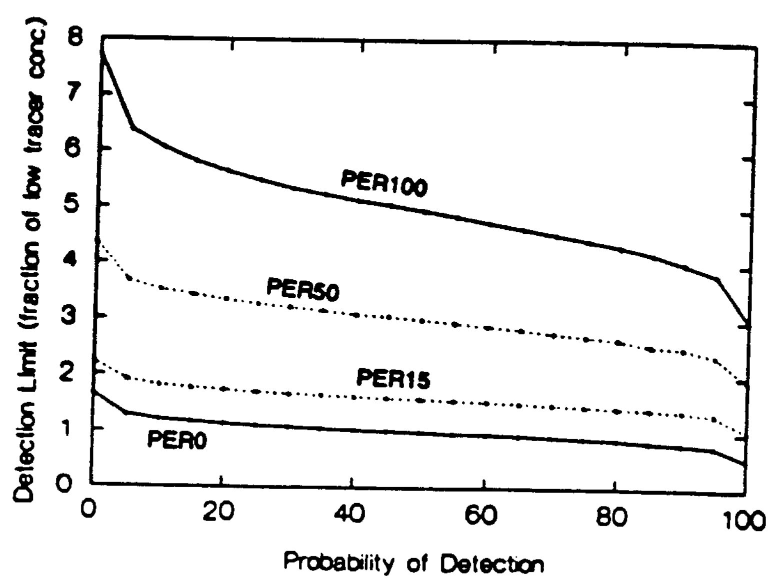

Figure 5. Required detection limits for low COV mixture components having means differing by 5 times.

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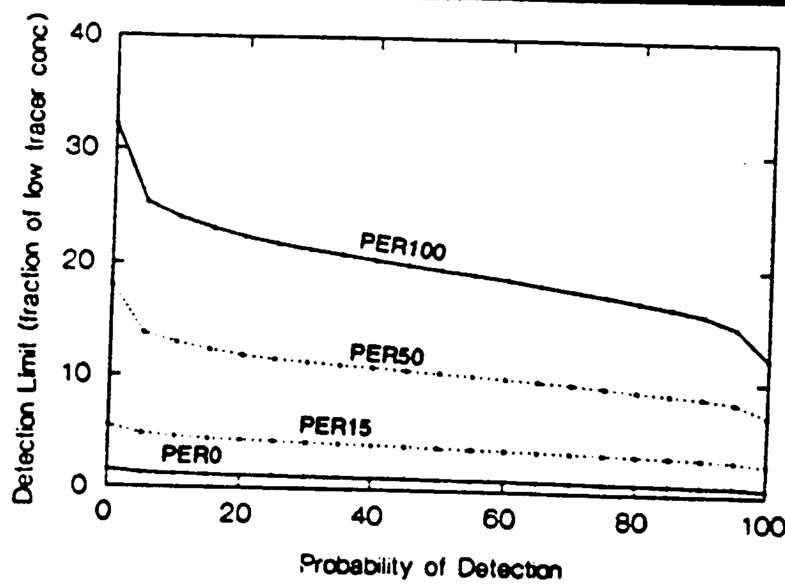

Figure 6. Required detection limits for low COV mixture components having means differing by 20 times.

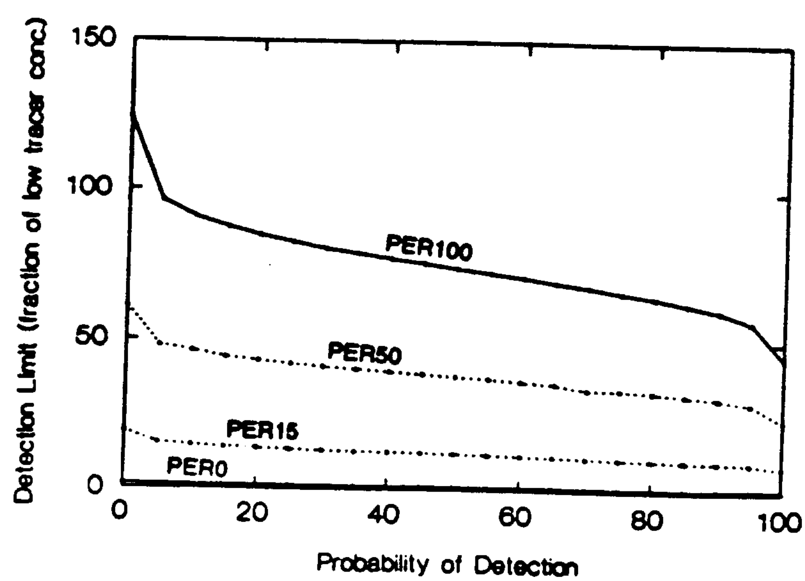

Figure 7. Required detection limits for low COV mixture components having means differing by 75 times.

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Even with the above analytical requirements satisfied, it may still be difficult to precisely estimate the degree of contamination, especially for low contamination levels and for high COVs. The ratio of the tracer concentration in the contaminating source flow to the tracer concentration in the cleaner baseflow must increase as the desire to detect smaller contaminating source flows is required. Listed below, for 90 percent confidence levels and low COV values, are percentages of source flow in the baseflow and the corresponding minimum concentration ratios (source to clean baseflow tracer concentrations) required for the detection of the source flow contamination of the baseflow.

Percent of Source Flow Contamination in Baseflow:	Required concentration ratios (low COV values):
1%	50
5%	10
10%	7
25%	3
35%	1.5
50%	1.2

As an example, the median tracer concentration in the contaminating source flow must be about 10 times greater than the median tracer concentration in the cleaner baseflow to detect a five percent source flow contamination of the baseflow. If the tracer COV values are "medium" or "high", then the required concentration differences are much greater (up to 250 times difference in concentrations may be required).

Therefore, the differences in tracer concentrations must be quite large, and the COVs quite small, in order to have confident estimates of low levels (percentages) of contaminating source flows. Few tracers exhibit such a wide range in characteristics between source flow and baseflow categories. This is the main reason why the use of multiple tracers for source flow identification is important. Some tracers may not uniformly produce good estimates of contaminating source flow levels, but the use of redundant tracers for the same decision (e.g., ammonia and potassium to identify sanitary wastewater; fluorides and hardness to identify treated potable water; and surfactants and fluorescence to identify wash waters) and good estimates of local contaminant characteristics, will minimize these errors.

The actual minimum level of contaminating source flow that will be detectable will be dependent on the analytical precision, as discussed next.

<u>Required Sample Analytical Precision</u>

The repeatability of the analytical method is an important consideration in its selection. Precision, as defined in <u>Standard Methods</u> (APHA, <u>et al.</u> 1989), is a measure of the closeness with which multiple analyses of a given sample agree with each other. It is determined by repeated analyses of a stable standard, conducting replicate analyses on the samples, or by analyzing known standard additions to samples. Precision is expressed as the standard deviation of the multiple analysis results.

Figure 8 is a summary of the probability plots from Pitt and Lalor (publication pending) and indicates the needed analytical precision (repeatability) as a fraction of the median tracer concentration (i.e., the flow with the lower tracer concentration) to resolve one percent contamination of the baseflow by the source flow, at a 90 percent confidence level. This figure was developed for COV values of the tracer parameters in the contaminating flows ranging from 0.16 to 1.67.

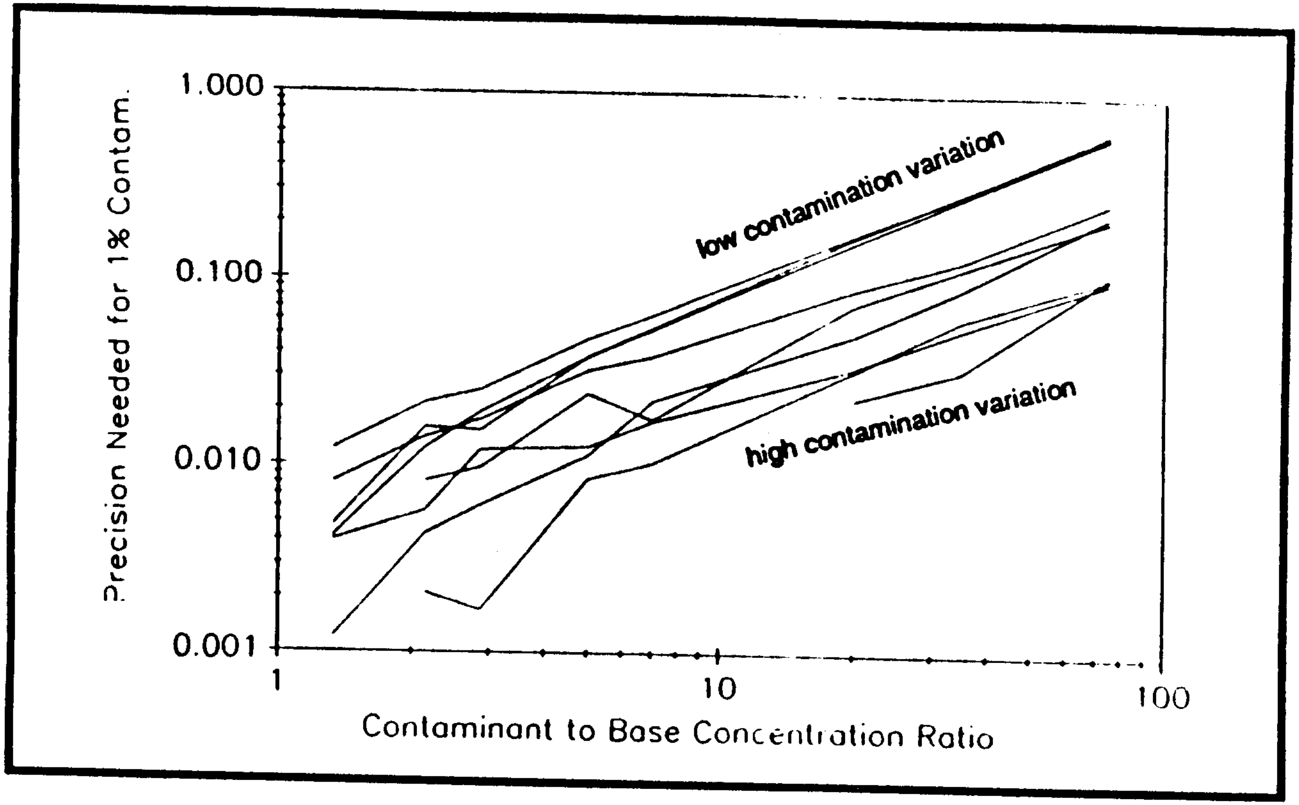

Figure 8. Analysis precision needed for detection of one percent contamination at ninety percent confidence.

If the available analytical precision is worse than these required values, then small contaminating flow levels may not be detected. Therefore, even with adequate analytical detection limits, poor analytical precision may not allow adequate identification of low levels of contaminating flow. In many cases, it is expected that a contaminating flow level of just a few percent can cause significant toxic and pathogenic problems. Examples include gasoline spills, direct connections of raw sanitary wastewater, and metal plating bath wastewaters.

If the tracer concentrations of the flow components are close in value and the variation of the concentrations are high, then it will be very difficult to adequately discern flow components. In contrast, if the tracer concentrations of the flow components are widely different and have low variabilities, then much smaller levels of contaminating flows could be detected. As an example, if the median contaminant tracer concentrations differ by a factor of 10 in two flow components, but have high concentration variations (high COV values), a precision of between 0.015 to 0.03 of the lower baseflow median tracer concentration is needed, for each percent of contaminating flow that needs to be detected. If the median tracer concentration in the cleaner baseflow is 0.15 mg/L (with a corresponding tracer median concentration of 10 times this amount, or 1.5 mg/L, in the contaminating source flow), then the required analytical precision is about 0.015 x 0.15 = 0.002 mg/L to 0.03 x 0.15 = 0.005 mg/L per one percent of contaminating flow to be detected. If at least five percent of contaminating flow is needed to be detected, then the minimum precision would have to be 5 x 0.002 = 0.01 mg/L.

The conservative method noted previously can be used to estimate the detection limit requirements for the above example:

low COV in the cleaner baseflow: 0.8 x 0.15 mg/L = 0.12 mg/L
medium COV in the cleaner baseflow: 0.23 x 0.15 mg/L = 0.035 mg/L
high COV in the cleaner baseflow: 0.12 x 0.15 mg/L = 0.018 mg/L.

The required analytical precision would therefore be about one-half of the lowest detection limit needed, and about 1/12 of the largest estimated required detection limit.

Recommended Analytical Methodology

An important part of the development of these investigation procedures and the demonstration project (Pitt and Lalor publication pending) was the laboratory and field testing of alternative analytical methods. Dry-weather outfall samples were subjected to different tests which compared several analytical methods for each of the major tracer parameters of interest. Tests were conducted to enable comparison of the results of alternative tests with standard procedures and to identify which methods had suitable detection limits, based on real samples. In addition, representative samples were further examined using standard addition methods (known amounts of standards added to the sample and results compared to unaltered samples) in order to identify matrix interferences. Matrix interferences are generally caused by contaminants in the samples interfering with the analysis of interest. Many of the analysis methods were also tested against a series of standard solutions to identify analytical precision (repeatability), linearity, and detection limits. The following paragraphs (and Table 7) summarize the recommended analytical procedures.

Most of the recommended analyses are conducted using small "field-type" instruments. However, despite their portability, the use of these instruments in the field can introduce many errors. Temperature and specific conductivity are the only analyses that are recommended for field analyses. For the other analyses, samples are collected at the site, iced, and taken back to the laboratory for analyses. The recommended analytical procedures can be easily conducted in a temporary laboratory; all that is needed is a work space and adequate ventilation. Access to power and water would be

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TABLE 7. SAMPLE ANALYSES LAB SHEET

Sample number: ____________________

Date: ____________________

Location: ____________________

Outfall #: ____________________

Specific conductivity YSI™ SCT meter (field) ____________________

Temperature YSI™ SCT meter (field) ____________________

pH pH meter (lab) ____________________

Ammonia Direct Nesslerization (lab) ____________________

Color HACH™ color kit (lab) ____________________

Fluoride HACH DR/2000™ spect. with AccuVacs™ (lab) ____________________

Hardness HACH™ field titration kit (lab) ____________________

Surfactants HACH™ detergent field kit (lab) ____________________

Fluorescence Turner™ fluorometer (lab) ____________________

Potassium HACH DR/2000™ spect. (lab) ____________________

Turbidity HACH™ Nephelometer (lab) ____________________

Chlorine HACH DR/2000™ spect. with AccuVacs™ (lab) ____________________

Toxicity Microtox™ 100% sample screen (lab) ____________________

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helpful, but all of the equipment can be operated with batteries. At each outfall, a (2 L) sample of dry-weather discharge needs to be collected and stored in a polyethylene container. Another (500 mL) sample can also be collected in a glass container having a Teflon-lined lid for toxicity screening and selected toxicant analyses. All samples must be analyzed (or extracted) within accepted time limits.

Descriptions of the procedures and parameters recommended for the analysis and identification of dry-weather outfall samples are:

Water color--

Determine in the laboratory using a simple comparative colormetric (color wheel) field test kit from the HACH Company. Apparent color (unfiltered samples), expressed in HACH color units.

pH--

pH is measured in the laboratory using a standard laboratory pH meter after accurate calibration using at least two buffer solutions bracketing the expected sample pH value. (pH measurements using pH test paper have been found to be generally within one unit of the laboratory meter. However, this difference is too large and is not recommended. Small "pen" pH meters most suitable for field use can easily be off by a 0.5 pH unit and are relatively hard to calibrate. They accordingly must be used with care.)

Specific conductivity and temperature--

These parameters are quickly and easily measured in the field using a multi-parameter SCT meter from YSI model 33. Both specific conductivity and temperature must be calibrated against standard specific conductivity solutions and a standard thermometer. Specific conductivity should also be corrected to standard values obtained at 25°C (APHA, et al. 1989):

$$K = (K_m C)/[1 + 0.0191(t-25)]$$

where K = specific conductivity at 25°C

K_m = measured specific conductivity at temperature t°C

and C = cell constant

The cell constant is a correction factor determined by measuring a 0.01M KCl solution at 25°C, after three rinses, compared to 1413 µS/cm, the expected value. This equation results in about a 2% change in specific conductivity for every degree in temperature difference from 25°C. The International System of Units (Système International d' Unités, SI) specific conductivity unit of measurement is the µS/cm which is numerically equivalent to the U.S. Customary unit, µmhos/cm.

Fluoride--

Easily analyzed in the laboratory using a field spectrophotometer and evacuated reagent and sample vessels (HACH DR/2000™ and AccuVac™ ampules using SPADNS reagent, without distillation). The AccuVac™ procedure works well for sample concentrations less than 2.5 mg/L; however, in rare instances of higher concentrations, sample dilution is required because of non-linear instrument responses. The samples should be filtered through a 0.45 µ membrane filter (e.g., Millipore™ filter) before analysis to minimize color interference. (Specific-ion probes were also evaluated, but the technique proved to be too inconsistent, especially for personnel having little training.)

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Ammonia--

Easily measured in the laboratory using a direct Nesslerization procedure and spectrophotometer (HACH DR/2000™ Nessler method, but without sample distillation). The samples should be filtered through a 0.45 μ membrane filter before analysis to minimize color interference. (The use of various indicator test papers and simple field test kits for ammonia determination gave poor results. Specific-ion probes were also tested. Typical problems encountered for these procedures, (except for the direct Nesslerization procedure), were color interferences, long analysis times, inconsistent results, and poor performance when standard solutions were analyzed.)

Potassium--

Measured in the laboratory either using a spectrophotometer (HACH DR/2000™ Tetraphenylborate method), or a flame atomic absorption spectrophotometer (if available). The samples should be filtered through a 0.45 μ membrane filter before spectrophotometric analysis to minimize color interference. (Specific-ion probes were also evaluated and indicated the same poor results found for fluorides and ammonia.)

Surfactants--

Measured in the laboratory using a simple comparative colormetric (color wheel) method (from the HACH Company). The samples should be filtered through a 0.45 μ membrane filter before analysis to minimize color interference. This procedure should be carried out under a laboratory fume hood. (Specific-ion probe titrations for surfactants were not successful because of poor detection limits.)

Fluorescence--

Analyzed using a laboratory fluorometer (Turner model 111). The fluorometer had general purpose filters and lamps and was operated at the most sensitive setting (number one aperture).

Hardness--

Determined in the laboratory using a field-titrimetric kit (HACH Digital Titrator Model 16900). The samples should be filtered through a 0.45 μ membrane filter before analysis to minimize color interference. (A number of simple field test kits were tested but the direct reading titration method proved most convenient and accurate. However, hardness test paper can be used to estimate the titration end point.)

Turbidity--

Determined using a HACH Naphelometer in the laboratory.

Chlorine--

Total available chlorine was determined with the DPD (N, N-diethyl-p-phenylenediamine) method using a HACH DR/2000™ spectrometer with AccuVac™ ampules.

Toxicity-screening--

Toxicity screening tests have been found to be very useful as indicators of contamination of storm drains. The Microtox™ (from Microbics) toxicity screening test can be used for relative toxicity values. The 100 percent screening test was most commonly used. If the light output decrease after 25 minutes (the I_{25} value) was greater than 50 percent, then the standard Microtox test was used to determine the sample dilution required for a 50 percent light decrease (the EC50 value). If a sample results in a large toxic response, then specific toxicant analyses (organics and metals) could be performed to better identify the toxicant source. In general, the Microtox™ screening test was found to be an efficient method for toxicity analysis, particularly for identifying samples requiring further analyses. (A number of simple test kits were used for specific heavy metal analyses, but with very poor results. High-detection limits and interferences make these methods impractical, unless an outfall is grossly contaminated with a concentrated source. such as raw plating bath wastewater.)

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SECTION 5

INITIAL FIELD SCREENING SAMPLING ACTIVITIES

SAMPLING STRATEGY

The importance of sampling all outfalls, regardless of size, should be stressed. Figure 9 shows the distribution of outfalls for the Birmingham, Alabama area surveyed for the city's stormwater discharge permit application. The median equivalent diameter of the 566 outfalls that had drainage area estimates available was 36 in. About 20 percent of the outfalls were greater than 60 in. in diameter and about 20 percent were less than 20 in. in diameter. Most of the largest outfalls were actually drainage ditches. There was an average of about 70 acres draining to each outfall, but the drainage areas ranged from much less than one acre to over 1500 acres. About 40 percent of the outfalls were affected by either commercial or industrial land uses and would therefore be considered as critical drainage areas for both dry-weather flows and stormwater runoff.

The Birmingham, Alabama demonstration project that tested this protocol covered a residential and commercial drainage area having approx. 70 outfalls. The median outfall size of the outfalls in this study area was 16 in., and more than 75 percent of the outfalls were less than 36 in. in diameter. Examination of the outfalls during seven separate sampling occasions found that while some of the dry-weather flows occurred intermittently, most were continuous. About 25 percent of the outfalls were found to be consistently flowing during dry weather, with about two-thirds of the flows discharging from pipes that were less than 36 in. in diameter. About five percent of the outfalls exhibited dry-weather flows which were extremely toxic or were raw, undiluted, sanitary wastewater. Each of these contaminated outfalls were 20 in., or less, in diameter. Some of the worst dry-weather flow discharge problems were associated with very small (4 in. diameter) pipes draining automobile service areas adjacent to the receiving water. It was found that small outfalls can contribute significant pollutant loads to receiving waters and should not be neglected if receiving water improvement is a serious goal.

FIELD DATA COLLECTION

Before the field data can be collected, preliminary mapping and land use evaluation work is needed. Section 3 described the preliminary work and the likely data sources for the information that is needed before the field investigations can begin. The most important preliminary information required is:

- outfall locations,
- outfall drainage areas,
- commercial and industrial activities in each drainage area, and
- locations of septic tanks in the individual drainage areas.

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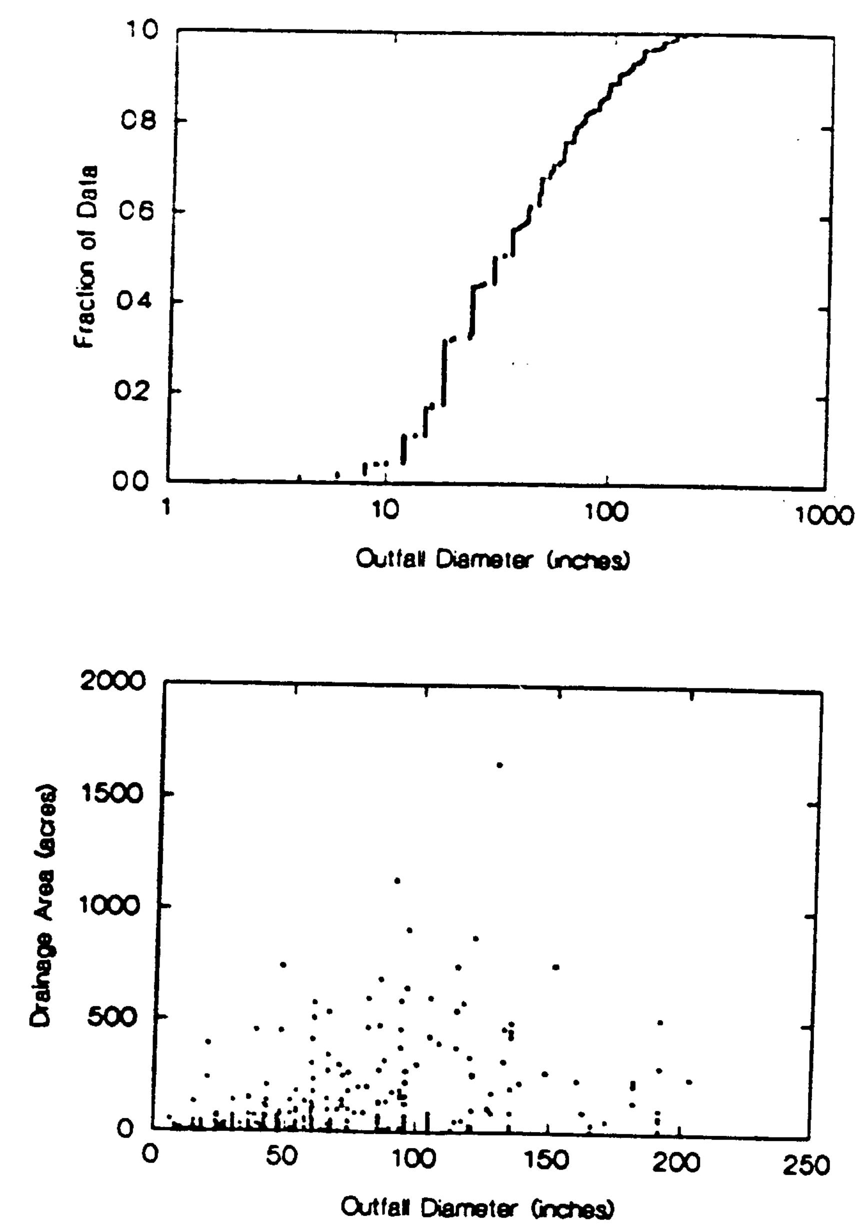

Figure 9. Outfall characteristics for Birmingham, Alabama demonstration project.

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Outfall Locations

Frequently, city maps of known outfall locations are inadequate. Many outfalls are not located on city drainage maps because of infrequent or improper updating, or unauthorized installations. Because it is very difficult for communities to maintain up-to-date maps of drainage facilities, actual stream surveys are needed to verify and update existing information. Illicit outfalls will not usually be shown on maps, and field surveys will be required to detect these as well. Most newer developments do have accurate drainage and outfall maps, but the outfall locations may not have been transferred to an overall city map. A few cities have Geographic Information Systems (GIS) in place and are including the storm drainage systems on appropriate data overlays. It is important to identify all outfalls because present data indicates no relationship between the most significant sources of non-stormwater discharges and the largest drainage areas, or the largest diameter outfalls.

Because of the likelihood of poor data concerning the outfall locations, it will probably be necessary to "walk" the creeks and actively look for outfalls. In most cases, it requires several trips (about three) to locate all outfalls. The initial outfall surveys should be conducted during times when riparian vegetation is minimal. Whenever an outfall is located, it needs to be marked (coded using spray paint or by other means).

If the receiving water is a small creek, it can be waded in a downstream direction. If the receiving water body cannot be waded, a small boat or canoe can be used to look for outfalls above the water. Submerged outfalls are more difficult to find and require more careful inspections for storm drain manholes along the shore. In flood or estuary tidal areas, surveys should be conducted during low tides when more outfalls are likely to be exposed. In many cities, streets parallel the banks of creeks or drainage canals that contain outfalls. It may be possible to carefully search the opposite bank from a moving automobile. It may also be cost-effective to use light aircraft (including helicopters) to search for outfalls. Submerged outfalls could be easier to identify from the air than from the water in cases where discharge plumes are visible.

Obviously, outfall characterizations should be conducted during these surveys, if possible. In all cases, at least two people are needed to look for outfalls, especially if wading a creek. Another person can drive a shuttle car to a convenient downstream location for crew rotation.

Field Survey

The main elements of the field sampling plan are the collection of necessary information and equipment, and preliminary screening of outfalls.

Collect necessary information and equipment--

Maps--Maps are the most important part of the field equipment. Adequate field maps can be prepared by enlarging standard USGS 7-1/2 minute quadrangle maps to appropriate scales. In addition, detailed street maps are also needed to locate specific street crossings and to identify locations of outfalls in the field.

Field sampling and analysis equipment--Table 8 lists the equipment that is needed for a field survey. In no case should personnel conduct the field surveys alone, wade streams without wearing waders, or be in boats without wearing life preservers. Heavy duty waders (heavy Cordura™ nylon) are preferred. Urban streams contain appreciable debris (broken bottles, etc.). In addition, urban

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TABLE 8. FIELD EQUIPMENT LIST

Temperature and specific conductivity meter.
Field notebook containing maps and non-stormwater flow evaluation field sheets.
Waterproof marker/pen.
Camera and film.
Spray paint.
Tape measures (both 3m and 30m).
Flashlight.
Watch (with second hand).
Glass sample containers with waterproof labels (500 mL).
Plastic sample containers with waterproof labels (1 to 2 L.).
Ice boxes with ice (left in vehicle).
Backpack.
Grab water sampler (dipper on long pole).
Hand operated vacuum pump sampler for shallow flows.
Waders and walking stick.
First aid kit and pocket knife.
Self protection pepper spray.
Two-way radios for communication between field crew and van driver.
Hand held GPS (global positioning satellite) system receiver (only capable of locating positions within about 100 to 350 feet).

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streams are isolated wildlife areas which tend to concentrate certain wildlife species that live in close proximity to man (including cottonmouths, water moccasins, copperheads, and rattlesnakes), plus contain lush growths of poison ivy or oak. The self protection pepper spray may be especially handy in case of harassing dogs.

This equipment would supplement needed boating equipment, if boats are used. Some of this equipment (ice coolers and ice, along with extra bottles) would be kept in the vehicle. In most cases, the vehicle should be moved in about 1/2 mile increments. This length would typically contain up to ten outfalls, with relatively few flowing outfalls to sample. The collected samples would therefore be iced within about 1/2 hour of collection. It is possible that the vehicle driver could conduct critical analyses (chlorine, pH and ammonia) while waiting. It is suggested that a three person crew rotate, with a new driver at each new shuttle location.

Arrange for lab testing and other support equipment--Before the field crew goes into the field to collect samples, the laboratory needs to be notified and ready to analyze the samples soon after they are available. As shown in the next section, the laboratory testing procedures for the basic tracer parameters are all simple and can be conducted in an unsophisticated laboratory. It may be feasible for the field crew to conduct the sample analyses in the afternoon of the day when they are collected.

Preliminary screening of outfalls--

Location of outfalls--Outfall locations need to be transferred to field maps and the daily activities planned. The number of outfalls that can be visited and sampled in a single day is highly dependent on outfall accessibility and mobility along the receiving water. The initial survey requires the longest time, after which repeated surveys require much less effort. In a small creek having shallow and slow water with numerous road crossings, about three miles of creek can be walked (with about 40 outfalls visited and ten outfall samples obtained) in a half-day of field activity with a crew of three people. Most other conditions would require additional labor for the same sampling effort. In all cases, careful planning, especially having an idea of where the outfalls are located, would greatly reduce the labor involved.

Scheduling field surveys--It is important to schedule the field surveys during low water levels (during low tides or low flows) because outfalls could be submerged and concealed during high water conditions. It is also best not to conduct the field surveys during periods of high flow in the receiving waters because of safety concerns.

Field surveys which are timed (diurnally, or seasonally) to coincide with periods with a greater potential for non-stormwater entries, are likely to reveal more dry-weather discharges. As examples, morning periods (or in areas of tourism, during the tourist season) usually experience the greatest sanitary wastewater flows. Scheduling sampling during these morning hours would be most successful in identifying sanitary wastewater contamination of the storm drainage system. Many inappropriate industrial entries to the storm drainage system also occur on a scheduled basis, e.g., cleaning up work areas between work shifts, or increased wastewater flows during periods of the year when the specific industry is especially busy. Again, investigating potentially affected storm drain outfalls during these critical periods would result in better data.

The field survey schedule will need to be flexible to avoid sampling during and immediately after a storm event, to ensure only dry-weather flows are recorded. In most urban areas storm runoff drainage flows will cease within 12 hours following the storm event, but this will need to be reviewed for each watershed area. The time to flow through the upstream drainage system and any detention and subsequent release of the storm water could extend this 12 hour period. This subject is discussed

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further under Section 5, Irregular Flows.

Sampling techniques--After an outfall is located, it is labeled with paint or marked by other means and the form shown on Table 9 is completed in the field. Table 10 describes the physical observation choices, previously discussed in Section 4. The use of field sheets and laboratory record keeping is very important because of the large number of outfalls that will likely be surveyed in each municipality.

Table 9 is a field sheet that can be used to record the observations and analytical results for the outfall survey. The top of the sheet includes basic outfall descriptive and weather information, a flow rate estimate, and an indication if industrial or commercial activities are known to occur in the area. The physical observation data section requires simple circling of the most appropriate value, or writing in another response. Samples should be obtained of floatable and staining materials for further laboratory microscopic analyses. If unusual vegetative conditions or damage to structures are found, then the extent and appearance of the damage should be described. In all cases, several photographs need to be taken of outfall conditions for each site visit. The analyses results are written on the form, along with a short descriptions of the equipment used.

Flows are estimated and visually characterized for each outfall visit. Field temperature and specific conductivity measurements are made in the field, and dry-weather discharge water samples are collected for later (same day) laboratory analyses. A single water sample (1 to 2 L) is sufficient for almost all analyses that may be conducted on the sample. This sample can be collected in a polyethylene collapsible container. In addition, another (500 mL) sample can be collected in a glass bottle (having a Teflon lined lid) if a toxicity screening procedure (like Microtox™) and selected organic tracers are to be analyzed. Specific sample volume requirements need to be determined in conjunction with the laboratory personnel. Excess samples should be placed in smaller polyethylene bottles and frozen for potenual future analyses (e.g., heavy metals and major ions).

Sample preservation--Usually icing of samples after collection and same-day laboratory analyses is adequate. Ammonia, chlorine, and pH are susceptible to change with time and special tests may be needed to determine the tolerable delay before laboratory analyses. As noted previously, it is not efficient to analyze the samples in the field, especially after each sample is collected.

Field tests--The only tests recommended for field analyses are temperature and specific conductivity. If a multi-purpose temperature/specific conductivity meter is being used for the temperature analyses, then both can be easily determined in the field.

Record keeping, sample preservation, and analyses--As noted above, the collected water samples need to be analyzed soon after collection. A central laboratory is much more effective than trying to analyze each sample in the field as it is collected. Section 4 presents the recommended laboratory procedures.

Data analyses--

Identification of contaminated outfalls--Section 6 describes several methods to identify the likely components in each flowing outfall. This information is then used to identify the contaminated dry-weather flows.

Isolation and correction of contaminating flow sources--After the problem outfalls are identified, drainage system surveys are used to find the sources of the contaminating flows. These procedures are briefly discussed later in this User's Guide.

TABLE 9. SAMPLE EVALUATION SHEET

Outfall # ______ Photograph # ______ Date: ____________

Location: ____

Weather: air temp.: ___ °C rain: Y N sunny cloudy

Outfall flow rate estimate: ____ L/sec

Known industrial or commercial uses in drainage area? Y N
describe: ____

PHYSICAL OBSERVATIONS:

Odor: none sewage sulfide oil gas rancid-sour other:_____

Color: none yellow brown green red gray other:_______

Turbidity: none cloudy opaque

Floatables: none petroleum sheen sewage other:______ (collect sample)

Deposits/stains: none sediment oily describe:________ (collect sample)

Vegetation conditions: normal excessive growth inhibited growth
extent: ____

Damage to outfall structures:
identify structure: ______________________________
damage: none / concrete cracking / concrete spalling / peeling paint / metal corrosion
other damage: ______________________________
extent: ______________________________

ANALYSES: EQUIPMENT USED:

Specific conductivity:	___ µS/cm	____________
Temperature:	___ °C	____________
Fluoride:	___ mg/L	____________
Hardness:	___ mg/L	____________
Surfactants:	___ mg/L	____________
Florescence:	___ % of scale	____________
Potassium:	___ mg/L	____________
Ammonia:	___ mg/L as N	____________
pH:	___	____________

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TABLE 10. INTERPRETATIONS OF PHYSICAL OBSERVATION PARAMETERS AND LIKELY ASSOCIATED FLOW SOURCES

Odor - Most strong odors, especially gasoline, oils, and solvents, are likely associated with high responses to the toxicity screening test. Typical obvious odors include: gasoline, oil, sanitary wastewater, industrial chemicals, decomposing organic wastes, etc.

- sewage: smell associated with stale sanitary wastewater, especially in pools near outfall.
- sulfide ("rotten eggs"): industries, e.g., meat packers, canneries, dairies, etc; and stale sanitary wastewater.
- oil and gas: petroleum refineries or facilities associated with vehicle maintenance and operation or petroleum product storage.
- rancid-sour: food preparation facilities (restaurants, hotels, etc.).

Color - Important indicator of inappropriate industrial sources. Industrial dry-weather discharges may be of various colors, but dark colors, such as brown, gray, or black, are most common.

- yellow: chemical, textile, and tanning plants.
- brown: meat packers, printing plants, metal works, stone and concrete works, fertilizer application, and petroleum refining facilities.
- green: chemical plants, and textile facilities.
- red: meat packers.
- gray: dairies.

Turbidity - Often affected by the degree of gross contamination. Dry-weather industrial flows with moderate turbidity can be cloudy, while highly turbid flows can be opaque. High turbidity is often a characteristic of undiluted dry-weather industrial discharges.

- cloudy: sanitary wastewater, concrete or stone operations, fertilizer facilities, and automotive dealers.
- opaque: food processors, lumber mills, metal operations, and pigment plants.

Floatable Matter - A contaminated flow may contain floating solids or liquids directly related to industrial or sanitary wastewater pollution. Floatables of industrial origin may include animal fats, spoiled food, oils, solvents, sawdust, foams, packing materials, or fuel.

- oil sheen: petroleum refineries or storage facilities and vehicle service facilities.
- sewage: sanitary wastewater.

(continued)

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TABLE 10. (continued)

Deposits and Stains - Refer to any type of coating near the outfall and are usually of a dark color. Deposits and stains often will contain fragments of floatable substances. These situations are illustrated by the grayish-black deposits that contain fragments of animal flesh and hair which often are produced by leather tanneries, or the white crystalline powder which commonly coats outfalls due to nitrogenous fertilizer wastes.

sediment: construction site erosion.
oily: petroleum refineries or storage facilities and vehicle service facilities.

Vegetation - Vegetation surrounding an outfall may show the effects of industrial pollutants. Decaying organic materials coming from various food product wastes would cause an increase in plant life, while the discharge of chemical dyes and inorganic pigments from textile mills could noticeably decrease vegetation. It is important not to confuse the adverse scouring effects of high stormwater flows on vegetation with highly toxic dry-weather intermittent flows.

excessive growth: food product facilities.
inhibited growth: high stormwater flows, beverage facilities, printing plants, metal product facilities, drug manufacturing, petroleum facilities, vehicle service facilities and automobile dealers.

Damage to Outfall Structures - Another readily visible indication of industrial contamination. Cracking, deterioration, and spalling of concrete or peeling of surface paint, occurring at an outfall are usually caused by severely contaminated discharges, usually of industrial origin. These contaminants are usually very acidic or basic in nature. Primary metal industries have a strong potential for causing outfall structural damage because their batch dumps are highly acidic. Poor construction, hydraulic scour, and old age may also adversely affect the condition of the outfall structure which are not indications of upstream contaminating entries.

concrete cracking: industrial flows
concrete spalling: industrial flows
peeling paint: industrial flows
metal corrosion: industrial flows

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Irregular Flows

Irregular flows pose a special problem during the field surveys. Outfall apparent "dry-weather" flows can be intermittent in nature, only flowing soon after rains and then remaining dry, or may flow when inappropriate water sources enter the storm drainage system. If irregular flows are associated with rains, outfall surveys should be postponed until sufficient time has lapsed since the last major rain. For most urban areas, storm runoff drainage ends several hours (but usually less than 12) after the rain stops. Extended, but decreasing flows, after rains could be associated with high groundwater or percolating rain water infiltrating into the drainage system. In this case, most outfall surveys should be further delayed. However, some pollutant sources may be associated with these after storm flows, especially contaminated groundwaters (septic tank problems, leaky underground storage tanks, etc.). Therefore, it may be important to sample these flows, especially if these contaminant sources potentially exist.

Basic field indicators, such as the presence of residual stains or deposits, oil sheens, coarse solids, floatables, color, odors, etc., in the absence of a flow, indicate the likelihood of intermittent dry-weather flows. These observations will be enhanced by installing simple "tell-tale" devices, e.g., a terry-cloth (strain the discharge) or small caulk dam in the drain. Outfalls exhibiting these signs of non-continuous discharges should be visited several times to increase the probability of observing and sampling a dry-weather discharge. Analyzing pooled water immediately below the outfall or collected between visits in small, constructed dams within the storm drain can greatly assist in identifying non-continuous discharges. Coarse solids and/or floatables can be captured through the erection of coarse screens and/or booms at a manhole site, the mouth of the outfall, or in the receiving stream. It may be necessary to visit suspect outfalls frequently. However, it is virtually impossible to capture an isolated short-term intermittent flow (e.g., from the illegal dumping of wastes into the storm drainage system) from outfall visits.

Simple outfall area characteristics, noted above, are the most reliable indicator of a potential intermittent source at an outfall. In addition to using a dam, or other indicator device (e.g., a small screen to capture particulate debris), it may be desirable to use an automatic water sampler at especially important outfalls. Automatic samplers would be unreasonable and expensive to use at many outfalls in an area and test locations would need to be carefully selected. A sampler located in a close-by manhole and set to sample every fifteen minutes (with four samples placed in each bottle) can monitor for intermittent flows for a period of 24 hours. Automatic samplers can also be used to characterize variable quality flows. This information can be valuable in identifying possible discharge sources.

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SECTION 6

DATA ANALYSIS TO IDENTIFY PROBLEM OUTFALLS AND FLOW COMPONENTS

The field screening surveys are to be used as an initial effort to identify the outfalls needing more detailed drainage area investigations which would identify specific pollutant sources and control options. These field screening surveys, discussed in Sections 4 and 5, include physical, chemical, and relative toxicity evaluations of outfall and/or discharge conditions.

The purpose of the procedures presented in this User's Guide is to separate storm drain outfalls into general categories (with a known level of confidence) and to identify which outfalls (and drainage areas) need further analyses and investigations. The categories used in this Guide are outfalls affected by non-stormwater entries from: (1) pathogenic or toxic pollutant sources, (2) nuisance and aquatic life threatening pollutant sources, and (3) unpolluted water sources.

The pathogenic and toxic pollutant source category should be considered the most severe because it could cause disease upon water contact or consumption and cause significant impacts on receiving water organisms. They may also cause significant water treatment problems for downstream consumers, especially if they contain soluble metal and organic toxicants. These pollutants may originate from sanitary, commercial, and industrial wastewater non-stormwater entries. Other important residential area activities that may also be considered in this most critical category (in addition to sanitary wastewater) include inappropriate household toxicant disposal, automobile engine de-greasing, vehicle accident clean-up, and irrigation runoff from landscaped areas excessively treated with chemicals (fertilizers and pesticides).

Nuisance and aquatic life threatening pollutant sources can originate from residential areas and can include laundry wastewater, landscaped area irrigation runoff, automobile washing, construction site dewatering, and washing of concrete mixing trucks. These pollutants can cause excessive algal growths, depressed dissolved oxygen concentrations, tastes and odors in downstream water supplies, offensive coarse solids and floatables, and highly colored, turbid or odorous waters.

Relatively clean or unpolluted water discharged through stormwater outfalls can originate from natural springs feeding urban creeks that have been converted to storm drains, infiltrating groundwater, and infiltrating potable water from water line leaks.

A method must be used to compare data from individual outfall dry-weather samples to the library of dry-weather source flow data to identify which outfalls belong in which general category of contamination listed above. This comparison should result, at the very least, in the identification of the outfalls that are considered as major pollutant sources for immediate remediation. The degree of detail which can be identified for an outfall will depend on the extent of the local data collected to describe the likely source flows.

The procedures that can be used to identify outfall flow components may begin with simple yes/no checks. For example, if no surfactants are measured in an outfall sample, then sanitary wastewater is unlikely to be a contributor to the outfall flow. If no fluoride is measured, then fluoride

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treated potable water sources could be ruled out as contributors. The probability that remaining contenders are present alone or in a mixture may be determined using a combination of matrix algebra and the selecting of random values from within specified ranges using a Monte Carlo process and many iterations.

Most contaminated outfalls will require correction before the receiving water quality recovers to acceptable levels. However, ranking the outfalls allows the most serious outfalls to be recognized and enables corrective action to be initially concentrated in the most cost-effective manner. In some of the case studies investigated, correcting only problems at the most critical outfalls resulted in insufficient receiving water quality improvements. It may be important to eventually correct all non-stormwater discharge problems throughout a city, not just the most severe problems. The field screening program should therefore be considered as an initial effort that needs to be followed-up with more detailed watershed drainage surveys in most of the areas having observed dry-weather flows. The follow-up watershed surveys are to identify and correct inappropriate pollutant entries into storm drainage systems, as discussed in Sections 7 and 8.

The identification of flow components of the dry-weather storm drain flow can be used to determine which outfalls have the greatest pollution potential. As an example, if an outfall contains sanitary wastewater, it could be a significant source of pathogenic microorganisms. Similarly, if an outfall contains plating bath water from a metal finisher, it could be a significant source of toxicants. These outfalls would be grouped into the most critical category of toxicants/pathogens. If an outfall contains washwaters from a commercial laundry or car wash, the wastewater could be a major source of nutrients and foaming material. These outfalls would be grouped into an intermediate category of nuisance and aquatic life threatening. Finally, if an outfall only contains unpolluted groundwater or water from leaky potable water mains, the water would be non-polluting and the outfall would be grouped into the last category of unpolluted water sources.

The five methods of data analyses presented in the following discussions present a hierarchy of methods, ranging from relatively simple reviews of the outfall characteristics to more sophisticated methods requiring computer modeling for evaluation. It is suggested that as many of the procedures be used as possible in evaluating the data, as each method provides some unique insights into the problems. Pitt and Lalor (publication pending) contains a more through discussion of these analysis procedures, including evaluation of the Birmingham, Alabama, demonstration project data.

INDICATORS OF CONTAMINATION

Indicators of contamination (negative indicators) are clearly apparent visual or physical parameters indicating obvious problems and are readily observable at the outfall during the field screening activities. These observations are very important during the field survey because they are the simplest method of identifying grossly contaminated dry-weather outfall flows. The direct examination of outfall characteristics for unusual conditions of flow, odor, color, turbidity, floatables, deposits/stains, vegetation conditions, and damage to drainage structures is therefore an important part of these investigations. Table 10 in Section 5 presented a summary of these indicators, along with narratives of the descriptors to be selected in the field.

This method does not allow quantifiable estimates of the flow components and if used alone will likely result in many incorrect determinations (missing outfalls that have important levels of contamination). These simple characteristics, discussed further below, are most useful for identifying gross contamination. Only the most significant outfalls and drainage areas would therefore be recognized from this method. The other methods, requiring chemical determinations, can be used to quantify the flow contributions and to identify the less obviously contaminated outfalls.

Indications of intermittent flows (especially stains or damage to the structure of the outfall) could indicate serious illegal toxic pollutant entries into the storm drainage system that will be very difficult to detect and correct. Highly irregular dry-weather outfall flow rates or chemical characteristics could indicate industrial or commercial inappropriate entries into the storm drain system.

During the demonstration phase of this research project (Pitt and Lalor publication pending), odors and high turbidity were found to be the most useful physical indicators of severely contaminated outfall flows. High turbidity correlated well with high levels of surfactants and toxicity. Noticeable odors also correlated well with elevated toxicity. Color was not a very useful indicator of gross contamination and elevated toxicity, unless the color exceed 65 HACH color units.

Gross industrial wastewater contamination may be indicated by the presence and nature of floatable material and deposits near the outfall. Table 11 summarizes possible chemical and physical characteristics of non-stormwater discharges which could come from various industries. The properties considered are pH, total dissolved solids, odor, color, turbidity, floatable materials, vegetation, and damage to outfall structure. The descriptions in each of these categories contain the most likely conditions for a non-stormwater discharge coming from a particular industry. It should be noted that outfalls are likely to be affected by several industrial sources simultaneously, especially if draining industrial parks. The initial watershed analysis, discussed previously, which needs to describe the industrial and commercial facilities that are operating in each outfall's watershed, will be of great assistance in identifying which industries may be contributing dry-weather entries into the storm drainage system.

SIMPLE CHECKLIST FOR MAJOR FLOW COMPONENT IDENTIFICATION

Figure 10 is a flow chart describing the analysis strategy to identify the major non-stormwater discharge sources in residential areas. The first indicator is the presence or absence of flow. If no dry-weather flow exists at an outfall, then indications of intermittent flows must be investigated. Specifically, stains, deposits, odors, unusual stream-side vegetation conditions, and damage to outfall structures can all indicate intermittent non-stormwater flows. However, frequent visits to outfalls over long time periods are needed to confirm that only stormwater flows occur. The other points on the flow chart (Figure 10) serve to indicate if major contaminating sources are present, or if the water is uncontaminated water. The other methods discussed later are needed to quantify the component contributions.

Treated Potable Water

A number of tracer parameters may be useful for distinguishing treated potable water from natural waters:

- Major ions or other chemical/physical characteristics of the flow components can vary substantially depending upon whether the water supply sources are groundwater or surface water, and whether the sources are treated or not. Specific conductance may also serve as a rough indicator of the major water source.

- Fluoride can often be used to separate treated potable water from untreated water sources. Untreated water sources can include local springs, groundwater, regional surface flows or non-potable industrial waters. If the treated water has no fluoride added, or if the natural water has fluoride concentrations close to potable water fluoride concentrations, then fluoride may

TABLE 11. CHEMICAL AND PHYSICAL PROPERTIES OF INDUSTRIAL NON-STORMWATER ENTRIES INTO STORM DRAINAGE SYSTEMS

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris & Stains	Damage to Outfall Structures	Vegetation	pH	Total Dissolved Solids
Primary Industries									
20 *Food and Kindred Products*									
201 Meat Products	Spoiled Meats Rotten Eggs and Flesh	Brown to Reddish Brown	High	Animal Fats, Byproducts Pieces of Processed Meats	Brown to Black	High	Flourish	Normal	High
202 Dairy Products	Spoiled Milk Rancid Butter	Gray to White	High	Animal Fats Spoiled Milk Products	Gray to Light Brown	High	Flourish	Acidic	High
203 Canned & Preserved Fruits & Vegetables	Decaying Products Compost Pile	Various	High	Vegetable Wastes, Seeds, Skins, Cores, Leaves	Brown	Low	Normal	Wide Range	High
204 Grain Mill Products	Slightly Sweet & Musty Grainy	Brown to Reddish Brown	High	Grain Hulls and Skins Straw & Plant Fragments	Light Brown	Low	Normal	Normal	High
205 Bakery Products	Sweet and or Spoiled	Brown to Black	High	Cooking Oils, Lard, Flour, Sugar	Gray to Light Brown	Low	Normal	Normal	High
206 Sugar and Confectionary Products	NA	NA	Low	Low Potential	White Crystals	Low	Normal	Normal	High
207 Fats and Oils	Spoiled Meats, Lard or Grease	Brown to Black	High	Animal Fats, Lard	Gray to Light Brown	Low	Normal	Normal	High
208 Beverages	Flat Soda, Beer or Wine, Alcohol, Yeast	Various	Moderate	Grains & Hops, Broken Glass, Discarded Canning Items	Light Brown	High	Inhibited	Wide Range	High
21 Tobacco Manufactures	Dried Tobacco, Cigars, Cigarettes	Brown to Black	Low	Tobacco Stems & Leaves	Brown	Low	Normal	Normal	Low
22 Textile Mill Products	Wet Burlap, Bleach, Soap, Detergents	Various	High	Papers and Fillers Fibers, Oils, Grease	Gray to Black	Low	Inhibited	Basic	High
23 Apparel and Other Finished Products	NA	Various	Low	Some Fabric Particles	NA	Low	Normal	Normal	Low
Material Manufacture									
24 Lumber & Wood Products	NA	NA	Low	Some Sawdust	Light Brown	Low	Normal	Normal	Low
25 Furniture & Fixtures	Various	Various	Low	Some Sawdust, Solvents	Light Brown	Low	Normal	Normal	Low
26 Paper & Allied Products	Bleach, Various Chemicals	Various	Moderate	Sawdust, Pulp Paper Wastes, Oils	Light Brown	Low	Normal	Wide Range	Low
27 Printing, Publishing, and Allied Industries	Ink, Solvents	Brown to Black	Moderate	Paper Dust, Solvents	Gray to Light Brown	Low	Inhibited	Normal	High
31 Leather & Leather Products	Leather, Bleach Rotten Eggs or Flesh	Various	High	Animal Flesh & Hair Oils & Grease	Gray to Black Salt Crystals	High	Highly Inhibited	Wide Range	High
33 Primary Metal Industries	Various	Brown to Black	Moderate	Ore, Coke, Limestone Millscale, Oils	Gray to Black	High	Inhibited	Acidic	High
34 Fabricated Metal Products	Detergents, Rotten Eggs	Brown to Black	High	Dirt, Grease, Oils Sand, Clay Dust	Gray to Black	Low	Inhibited	Wide Range	High
32 Stone, Clay, Glass, and Concrete Products	Wet Clay, Mud Detergents	Brown to Reddish-Brown	Moderate	Glass Particles Dust from Clay or Stone	Gray to Light Brown	Low	Normal	Basic	Low

(continued)

TABLE 11. (continued)

Industrial Categories Major Classifications SIC Group Numbers		Odor	Color	Turbidity	Floatables	Debris & Stains	Damage to Outfall Structures	Vegetation	pH	Total Dissolved Solids
Chemical Manufacture										
28	*Chemicals & Allied Products*									
281 2	Alkalis and Chlorine	Strong Halogen or Chlorine Pungent, Burning	Alkalis - NA Chlorine - Yellow to Green	Moderate	Glass Particles Dust from Clay or Stone	Gray to Light Brown	Highly Inhibited	Normal	Basic	Low
281 6	Inorganic Pigments	NA	Various	High	Low Potential	Various	Low	Highly Inhibited	Wide Range	High
282	Plastic Materials and Synthetics	Pungent, Fishy	Various	High	Plastic Fragments, Pieces of Synthetic Products	Various	Low	Inhibited	Wide Range	High
283	Drugs	NA	Various	High	Gelatin Byproducts for Capsulating Drugs	Various	Low	Highly Inhibited	Normal	High
284	Soap, Detergents, & Cleaning Preparations	Sweet or Flowery	Various	High	Oils, Grease	Gray to Black	Low	Inhibited	Basic	High
285	Paints, Varnishes, Lacquers, Enamels and Allied Products (SB Solvent Base)	Latex- Ammonia SB-Dependent upon Solvent (Paint Thinner, Mineral Spirits)	Various	High	Latex - NA SB-All Solvents	Gray to Black	Low	Inhibited	Latex Basic SB-Normal	High
286	*Industrial Organic Chemicals*									
286 1	Gum and Wood Chemicals	Pine Spirits	Brown to Black	High	Resins and Pine Tars	Gray to Black	Low	Inhibited	Acidic	High
286 5	Cyclic Crudes, & Cyclic Intermediates, Dyes, & Organic Pigments	Sweet Organic Smell	NA	Low	Translucent Sheen	NA	Low	Highly Inhibited	Normal	Low
287	*Agricultural Chemicals*									
287 3	Nitrogenous Fertilizers	NA	NA	Low	NA	White Crystalline Powder	High	Inhibited	Acidic	High
287 4	Phosphatic Fertilizers	Pungent Sweet	Milky White	High	NA	White Amorphous Powder	High	Inhibited	Acidic	High
287 5	Fertilizers, Mixing Only	Various	Brown to Black	High	Pelletized Fertilizers	Brown Amorphous Powder	Low	Normal	Normal	High
29	*Petroleum Refining and Related Industries*									
291	Petroleum Refining	Rotten Eggs Kerosene, Gasoline	Brown to Black	High	Any Crude or Processed Fuel	Black Salt Crystals	Low	Inhibited	Wide Range	High
30	Rubber & Miscellaneous Plastic Products	Rotten Eggs Chlorine, Peroxide	Brown to Black	Moderate	Shredded Rubber Pieces of Fabric or Metal	Gray to Black	Low	Inhibited	Wide Range	High

(continued)

TABLE 11. (continued)

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris & Stains	Damage to Outfall Structures	Vegetation	pH	Total Dissolved Solids
Transportation & Construction									
15 Building Construction	Various	Brown to Black	High	Oils, Grease, Fuels	Gray to Black	Low	Normal	Normal	High
16 Heavy Construction	Various	Brown to Black	High	Oils, Grease, Fuels Diluted Asphalt or Cement	Gray to Black	Low	Normal	Normal	High
Retail									
52 Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	NA	Brown to Black	Low	Some Seeds, Plant Parts, Dirt, Sawdust, or Oil	Light Brown	Low	Normal	Normal	Low
53 Gen. Merchandise Stores	NA	NA	NA	NA	NA	Low	Normal	Normal	Low
54 Food Stores	Spoiled Produce Rancid, Sour	Various	Low	Fragments of Food Decaying Produce	Light Brown	Low	Flourish	Normal	Low
55 Automotive Dealers & Gasoline Service Stations	Oil or Gasoline	Brown to Black	Moderate	Oil or Gasoline	Brown	Low	Inhibited	Normal	Low
56 Apparel & Accessory Stores	NA	NA	Low	NA	NA	Low	Normal	Normal	Low
57 Home Furniture, Furnishings, & Equipment Stores	NA	NA	Low	NA	NA	Low	Normal	Normal	Low
58 Eating & Drinking Places	Spoiled Foods Oil & Grease	Brown to Black	Low	Spoiled or Leftover Foods	Brown	Low	Normal	Normal	Low
Coal Steam Electric Power	NA	Brown to Black	High	Coal Dust	Black Amorphous Powder	Low	Normal	Slight y Acidic	Low
Nuclear Steam Electric Power	NA	Light Brown	Low	Oils, Lubricants	Light Brown	Low	Normal	Normal	Low

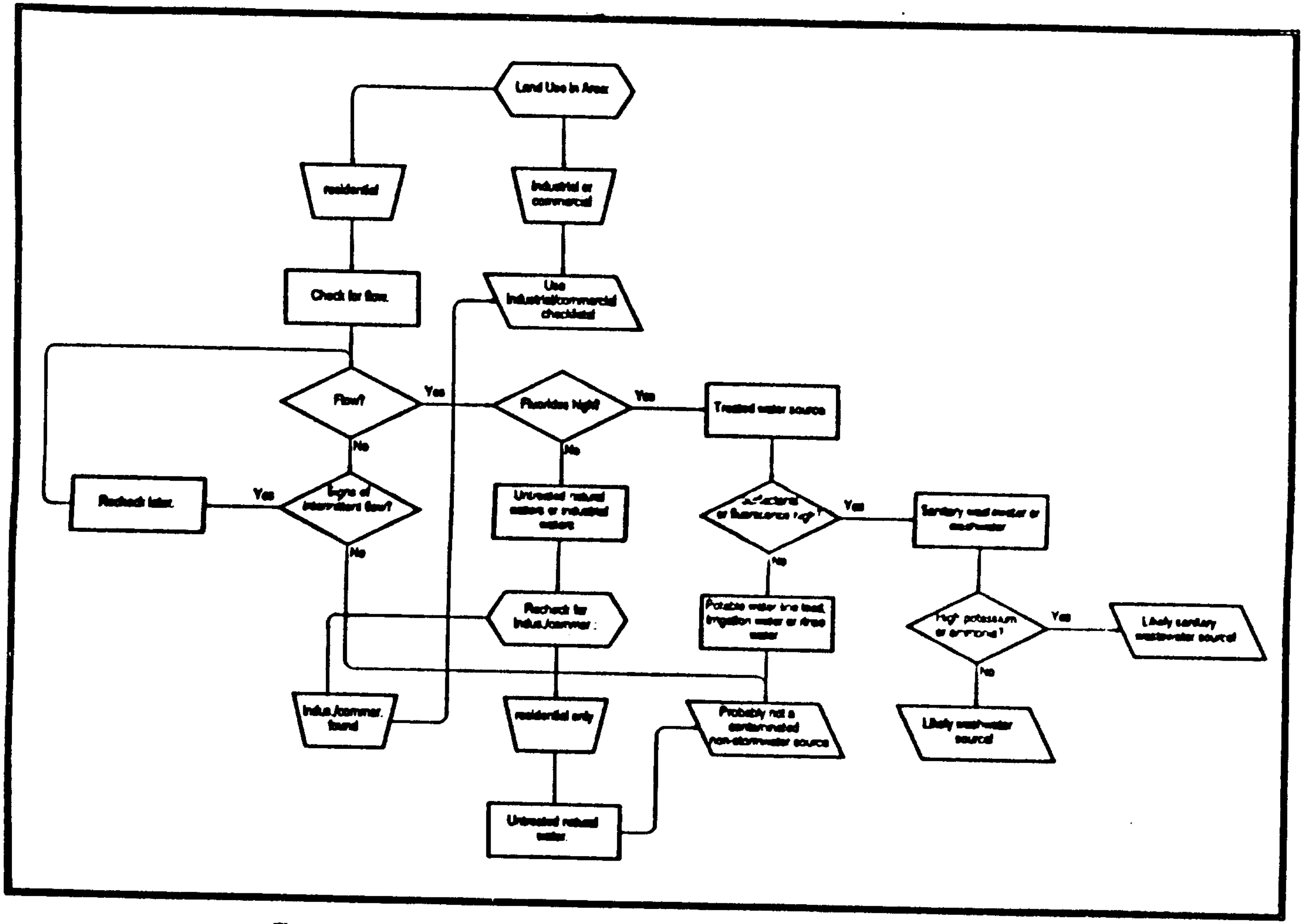

Figure 10. Flow chart to identify residential area non-stormwater flow sources.

not be an appropriate indicator.

- Hardness can also be used as an indicator if the potable water source and the baseflow are from different water sources. An example would be if the baseflow is from hard groundwater, and the potable water is from softer surface supplies.

- If the concentration of chlorine is high, then a major leak of disinfected potable water is likely to be close to the outfall. Because of the rapid dissipation of chlorine in water (especially if some organic contamination is present) it is not a good parameter for quantifying the amount of treated potable water observed at the outfall.

Water from potable water supplies (that test positive for fluorides, or other suitable tracers) can be relatively uncontaminated, e.g., potable waterline leakage or irrigation runoff, or heavily contaminated, e.g., sanitary wastewater.

<u>Sanitary Wastewaters</u>

In areas containing no industrial or commercial sources, sanitary wastewater is probably the most severe dry-weather contaminating source of storm drain flows. The following parameters can be used for quantifying the sanitary wastewater components of the treated potable water portion:

- Surfactant analyses may be useful in determining the presence of sanitary wastewaters. However, surfactants present in water originating from potable water sources could indicate sanitary wastewaters, laundry wastewaters, car washing wastewater, or any other waters containing surfactants. If surfactants (or fluorescence) are not present, then the potable water could be relatively uncontaminated (potable waterline leaks or irrigation runoff).

- The presence of fabric whiteners (as measured by fluorescence using a fluorometer in the laboratory or in the field) can also be used in distinguishing laundry and sanitary wastewaters.

- Sanitary wastewaters often exhibit predictable trends during the day in flow and quality. In order to maximize the ability to detect direct sanitary wastewater connections into the storm drainage system, it would be best to survey the outfalls during periods of highest sanitary wastewater flows (mid to late morning hours).

- The ratio of surfactants to ammonia or potassium concentrations may be an effective indicator of the presence of sanitary wastewaters or septic tank effluents. If the surfactant concentrations are high, but the ammonia and potassium concentrations are low, then the contaminated source may be laundry wastewaters. Conversely, if ammonia, potassium, and surfactant concentrations are all high, then sanitary wastewater is the likely source. Some researchers have reported low surfactants in septic tank effluents. Therefore, if surfactants are low, but potassium and ammonia are both high, septic tank effluent may be present. However, Pitt and Lalor (publication pending) found high surfactant concentrations in septic tank effluent during the Birmingham, Alabama demonstration project. This further stresses the need to obtain local site specific characterization data for potential contaminating sources.

- Obviously, odor and other physical characteristics, e.g., turbidity, coarse and floating "tell-tale" solids, foaming, color, and temperature would also be very useful in distinguishing sanitary wastewater from washwater or laundry wastewater sources. However, these indicators may not be very obvious for small levels of sanitary wastewater contamination.

FLOW-WEIGHTED MIXING CALCULATIONS

Before any flow-weighted mixing calculations can be made, the characteristics of potential contaminating sources must be identified. Table 12 summarizes hypothetical concentration medians and COVs for tracers that have been recommended to be used in the investigation of non-stormwater entries into storm drainage systems in residential areas. This method is an extension of the checklistmethod described above and attempts to quantify the likely source flow components at the outfall during dry weather.

Two general groupings of flow sources can usually be recognized for each of these tracers, a high concentration group and a low concentration group. Table 13 describes these groups, along with their composite tracer concentration ranges, variations, and medians. The outfall flow can be split between the two general groupings by simple algebra. This method can result in substantial errors if the tracer concentrations cannot be separated into distinct source groupings. The next two methods, using matrix algebra to solve simultaneous equations, do not require this simplifying assumption.

Example Calculations

The drainage area for a sampled outfall had no septic tanks or commercial and industrial land uses. The likely flow sources had source flow characteristics as described in Table 12. The required detection limits and precision for outfall characterizations must be determined, as previously described, for these source flow characteristics and desired study results. This outfall had the following tracer concentrations in a dry-weather sample:

Fluoride: 0.6 mg/L

Hardness: 200 mg/L as $CaCO_3$

Surfactants: 0.6 mg/L as MBAS

Potassium: 3 mg/L

Ammonia: 3 mg/L

The water had a slight septic odor, with some floatables of apparent sanitary wastewater origin. In addition, dry-weather flow was observed at the outfall during all visits.

It is apparent that this outfall has a direct connection(s) of raw sanitary wastewater. This method can determine the approximate mix of sanitary wastewater in the outfall flow and identify the other flow components. Table 14 summarizes the example calculations used in this analysis. The list below indicates the approximate expected source components at this outfall from this analysis:

Raw sanitary wastewater: 5%

Laundry wastewater: 5%

Groundwater: 70%

Remainder (most likely potable water, but may also contain irrigation water): 20%

This analysis did not consider the potential ranges in observed tracer concentrations and the

TABLE 12. ASSUMED SOURCE FLOW QUALITY
(All Conc. in mg/L)

Source		Fluoride	Hardness (as Ca Co_3)	Surfactants (as MBAS)	Potassium	Ammonia (N as NH_3)
Surface Waters	median	0.14	39	0.35	0.72	0.76
	COV	0.23	0.20	0.13	0.23	1.1
Ground-waters	median	0.29	250	0.05	1.7	0.22
	COV	0.23	0.14	0.13	0.40	0.63
Septic Tank Effluent	median	1.3	39	0.05	21	47
	COV	0.14	0.20	0.13	0.91	1.5
Raw Sanitary Wastewater	median	1.3	39	4.6	21	22
	COV	0.14	0.20	2.2	0.91	0.63
Laundry Wastewater	median	1.3	39	4.6	5.3	0.31
	COV	0.14	0.20	2.2	0.57	0.91
Irrigation Water	median	1.3	39	0.35	0.72	0.38
	COV	0.14	0.20	0.13	0.23	1.1

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TABLE 13. CHARACTERISTICS OF SOURCE GROUPINGS

Fluorides

	surface & groundwaters	all other categories
overall range:	0.1→0.4 mg/L	1→1.5 mg/L
COV:	0.54	0.14
median:	0.20 mg/L	1.3 mg/L
Concentration ratio of medians:	6.5	

Hardness

	groundwaters	all other categories
overall range:	200→300 mg/L	30→50 mg/L
COV:	0.14	0.20
median:	250 mg/L	39 mg/L
Concentration ratio of medians:	6.4	

Surfactants

	raw sanitary wastewater & laundry wastewater	all other categories
overall range:	0.2→100 mg/L	0.04→0.4 mg/L
COV:	2.2	0.83
median:	4.6 mg/L	0.14 mg/L
Concentration ratio of medians:	33	

Potassium

	septic tank effluent & raw sanitary wastewater	all other categories
overall range:	10→100 mg/L	0.5→11 mg/L
COV:	0.91	1.2
median:	21 mg/L	2.3 mg/L
Concentration ratio of medians:	9.1	

Ammonia

	septic tank effluent & raw sanitary wastewater	all other categories
overall range:	6→380 mg/L	0.1→3 mg/L
COV:	1.5	1.3
median:	47 mg/L	0.44 mg/L
Concentration ratio of medians:	107	

TABLE 14. MIXTURE CALCULATIONS TO IDENTIFY SOURCE FLOW COMPONENTS

Fluorides: 0.6 mg/L observed at outfall

x = fraction of surface & groundwater with concentration of 0.2 mg/L
y = fraction of treated water (all other sources) with concentration of 1.3 mg/L
(x & y fraction concentrations taken from Table 13)

x(0.2) + y(1.3) = 0.6 (for a unit volume of outfall water)
x + y = 1 (for no other sources of fluorides)

x = 0.63 (surface & groundwater)
y = 0.37 (all other sources)

Hardness 200 mg/L as $CaCO_3$ observed at outfall

x = fraction of groundwater with concentration of 250 mg/L as $CaCO_3$
y = fraction of all other sources with concentration of 39 mg/L as $CaCO_3$

x(250) + y(39) = 200

x = 0.76 (groundwater)
y = 0.24 (all other sources)

From Fluorides and Hardness Data:

Groundwater & Surface water = 0.63
Groundwater alone = 0.76
Surface water alone = -0.13→0

Therefore:
Groundwater fraction = (0.63 + 0.76)/2 = 0.7

Surfactants: 0.6 mg/L as MBAS observed at outfall

x = fraction of sanitary & laundry wastewater with a concentration of 4.6 mg/L as MBAS
y = fraction of all other sources with a concentration of 0.14 mg/L as MBAS

x(4.6) + y(0.14) = 0.6

x = 0.10 (sanitary & laundry wastewater)
y = 0.90 (all other sources)

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TABLE 14. (continued)

Potassium: 3 mg/L observed at outfall

x = fraction of sanitary wastewater
with a concentration of 21 mg/L
y = fraction of all other sources
with a concentration of 2.3 mg/L

$$x(21) + y(2.3) = 3$$

x = 0.04 (sanitary wastewater)
y = 0.96 (all other sources)

Ammonia: 3 mg/L observed at outfall

x = fraction of sanitary wastewater
with a concentration of 47 mg/L
y = fraction of all other sources
with a concentration of 0.44 mg/L

$$x(47) + y(0.44) = 3$$

x = 0.06 (sanitary wastewater)
y = 0.94 (all other sources)

From Surfactants, Potassium, and Ammonia Data:

Sanitary wastewater = (0.04 + 0.06)/2 = 0.05

Laundry wastewater = 0.1 - 0.05 = 0.05

resulting errors that may be associated with the above mixture portions. The following procedures are better suited for error analyses.

MATRIX ALGEBRA SOLUTION OF SIMULTANEOUS EQUATIONS

It is possible to estimate the outfall source flow components using a set of simultaneous equations. The number of unknowns should equal the number of equations available, resulting in a square matrix. If there are eleven likely source categories, then there should be eleven tracer parameters used. If there are only four possible sources, then only four tracer parameters should be used.

Further statistical analyses may therefore be needed to rank the usefulness of the tracers for distinguishing different flow sources. Pitt and Lalor (publication pending) show examples of how cluster and principal component analyses can be used to identify redundancy and other problems in the data library. As an example, chlorine is not useful for these analyses because the concentration variability within many source categories is high (it is also not a conservative parameter). Chlorine may still be a useful parameter, but only to identify possible large potable waterline leaks. It cannot be used to quantify the flow components. Another parameter having problems for most situations is pH. The variation of pH between sources is very low (they are all very similar). However, pH may still be useful to identify industrial wastewater problems, but it cannot be used to quantify flow components. pH is also not linearly affected by mass balance mixtures (a solution of 50 percent/50 percent of two components would not result in a pH value that is the average of the two individual pH values).

These equations are structured on a mass balance basis, like the previous procedure, but they can be used to distinguish all source categories simultaneously. A simplified example is shown in the following discussion considering just four possible flow components and four tracer parameters (P1, P2, P3, P4). This would result in the following set of equations for each outfall sample:

tracer parameter:	possible sources: 1		2		3		4		outfall quality
P1:	(A1)(C11)	+	(A2)(C21)	+	(A3)(C31)	+	(A4)(C41)	=	m1
P2:	(A1)(C12)	+	(A2)(C22)	+	(A3)(C32)	+	(A4)(C42)	=	m2
P3:	(A1)(C13)	+	(A2)(C23)	+	(A3)(C33)	+	(A4)(C43)	=	m3
P4:	(A1)(C14)	+	(A2)(C24)	+	(A3)(C34)	+	(A4)(C44)	=	m4

A1 through A4 represent the fraction of flow contributed from each possible flow source. The "C" terms represent concentrations from the source flow library for each particular parameter (P) within each flow source(1-4). The "m" terms represent the concentration of P actually measured in the outfall sample.

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The following is an example for an outfall dry-weather sample:

possible sources:

tracer parameter:	potable water	ground water	sanitary wastewater	laundry wastewater	outfall quality
fluoride:	(A1)(0.97 mg/L)	+ (A2)(0.031 mg/L)	+ (A3)(0.77 mg/L)	+ (A4)(33 mg/L)	= 3.8 mg/L
hardness:	(A1)(49 mg/L)	+ (A2)(240 mg/L)	+ (A3)(140 mg/L)	+ (A4)(14 mg/L)	= 126 mg/L
surfactants:	(A1)(0 mg/L)	+ (A2)(0 mg/L)	+ (A3)(1.5 mg/L)	+ (A4)(27 mg/L)	= 3.0 mg/L
potassium:	(A1)(1.6 mg/L)	+ (A2)(0.73 mg/L)	+ (A3)(6.0 mg/L)	+ (A4)(3.5 mg/L)	= 2.2 mg/L

This simple 4x4 matrix can be solved using available scientific calculators or math programs for personal computers, or by hand. For this example, the following are the approximate flow components (rounded to the nearest 5 percent):

- treated potable water (A1): 30%
- groundwater (A2): 35%
- sanitary wastewater (A3): 20%
- laundry wastewater (A4): 10%

These component contributions do not all add up to 100 percent. A number of errors, especially variations in source area characteristics and other sources present that were not considered, tend to result in component sums that are not 100 percent. The following method is similar, but considers uncertainty in source area characteristics and results in a range of likely component contributions.

MATRIX ALGEBRA CONSIDERING PROBABILITY DISTRIBUTIONS OF LIBRARY DATA

A stochastic version of the above procedure enables the variation in the library values to be considered. The matrix is set up in the same way, but instead of using a single value representing the parameter concentration for each likely source flow, a Monte Carlo simulation is used to randomly select values. A large number of analyses (from a few hundred to many thousands) are conducted and the percentage contributions for each component source are presented as a probability distribution instead of a single value.

It is therefore necessary to describe the distribution of source flow characteristics. In most cases, the tracer parameters can be represented using log-normal distributions. Some parameters, however, are adequately described with normal distributions. Again, local source flow monitoring is necessary to obtain this information. Pitt and Lalor (publication pending) contains examples using this method, including the code for the necessary computer program.

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SECTION 7

WATERSHED SURVEYS TO CONFIRM AND LOCATE INAPPROPRIATE POLLUTANT ENTRIES TO THE STORM DRAINAGE SYSTEM

After initial outfall surveys have indicated the presence of contamination, further detailed analyses are needed to identify and locate the specific contaminant source(s) (e.g., residential, commercial, and/or industrial) in the drainage area. For source identification and location, upstream survey techniques should be used in conjunction with an in-depth watershed evaluation. Information on watershed activities can be obtained from aerial photography and/or zoning maps, while upstream survey techniques will include the analysis of the dry-weather flow at several manhole points along the storm drainage system to narrow the location of the contaminating source; tests for specific pollutants or ions associated with known activities within the outfall catchment area; and the measurement of water flow rate and temperature, visual and T.V. inspections, and smoke and dye tests.

USING TRACER PARAMETERS IN THE DRAINAGE SYSTEM

In order to identify the specific contaminant sources in the drainage system, further detailed watershed analyses are needed. These may include:

- drainage system surveys (tests for specific pollutants, visual inspections, T.V. drainage pipe inspections, and smoke and dye tests),
- in-depth watershed evaluation (including aerial photographs), and
- industrial and commercial site studies.

Review Industrial User Surveys or Reports

This will require the submission of a questionnaire to industries to determine which industries or commercial locations are discharging to a storm drainage system. However site inspections will still be required because questionnaires may not be returned or may give incorrect details (either deliberately or unknowingly).

Follow-up Drainage Area and On-Site Investigations.

Further drainage area investigations upstream of identified problem outfalls would be conducted after the outfall studies have indicated dry-weather discharge problems. In order to be cost-effective, only a sub-sample of manholes located in a drainage area identified as having significant non-stormwater sources should be tested for the tracers. As an example, the main storm drain trunk sewer could be divided into tenths and the manholes closest to these subdivisions would be sampled. This would identify the upper limit of the drainage area above which the major sources are not located. A location may also be identified where the downstream manhole tracer mass yields (concentration times flow rate) are the same. This would mark the downstream limit of the contributing area for the tracers of concern. After the main trunk drainage reach is identified that contains the major non-stormwater sources, the branch storm drain lines can be similarly subdivided (but into fewer sections each, perhaps about three) and evaluated. Depending on the drainage area and complexity of the storm drainage system, this scheme could be suitably modified to enable the identification of relatively small areas responsible for the non-stormwater pollutant entries into the storm drainage system. These small areas would then be subject to the more intensive on-site investigations by smoke tests, dye studies, and T.V. inspections.

The above drainage system analysis procedure may find that the drainage system is contaminated by widespread sanitary wastewater entries, possibly due to sanitary and storm drainage systems in extremely poor condition. This situation may require that the drainage system undergo extensive and costly repairs. It may be more appropriate to consider the storm drainage system as a combined sewer and examine control alternatives that have been developed for combined sewer systems. This would also save further detailed drainage system analyses costs.

These drainage system surveys would be followed by industrial and commercial on-site investigations (e.g., dye and smoke studies and T.V. inspections) to locate specific sources of non-stormwater pollutant entries into the drainage system. Additionally, aerial photography can be very useful during later phases of non-stormwater discharge control projects. As an example, aerial photography can help identify areas having failing septic systems located in residential areas served by storm drainage systems. Aerial photography can also be used to identify continuous discharges to surface drainage systems, such as sump discharges, and to identify storage areas that may be contributing significant amounts of pollutants during rains. For example, the Tennessee Valley Authority (TVA), among other agencies, has extensively used aerial photography (stereo color infrared) to identify pollution sources, especially from failing septic tanks (Perchalski and Higgins 1988). The TVA's flights are made in early spring when investigating septic tank failures, to be able to identify unusual grass conditions, with minimal interference from trees. The flights are made at 6,000 feet, with resulting image scales of 1 inch to 1,000 feet. Their photography costs have been about $40 to $150 per square mile.

FLOW MASS BALANCES, DYE STUDIES, AND SMOKE TESTS

Industrial areas are known to contribute significantly polluted wet-weather stormwater discharges, along with contaminated dry-weather entries into the storm drainage system. Additional industrial site investigations are therefore needed to identify activities that apparently contribute these contaminants to the storm drainage system. Figure 11 is an industrial site survey form prepared by the Non-Point Source and Land Management Section of the Wisconsin Department of Natural Resources (R. Bannerman, personal communication). This form has been used to help identify industrial activities that contribute significantly polluted, indirectly connected dry- and wet-weather non-stormwater entries into the storm drainage system.

This form only considers outside sources that would affect the storm drainage system by entering through inlets or through sheetflow runoff into drainage channels. It does not include any information concerning indoor activities, or direct plumbing connections to the storm drainage system. However, the information included on this form can be very helpful in devising runoff control programs for industrial areas. This information most likely affects wet-weather discharges much more than dry-weather discharges. Obvious dry-weather leaching or spillage problems are also noted on the form.

Locating An Industrial Source

Hypothetical examples have been created to demonstrate how dry-weather discharges can be characterized so that their likely industrial sources can be identified. These examples show how observations of outfall conditions and simple chemical analyses, combined with a basic knowledge of wastewater characteristics of industrial and commercial operations located in the drainage area, can

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City: ______ Industry Name: ______
Site Number: ______ Photo # ______
Street Address: ______ Roll # ______
Type of industry: ______
Instructions: Fill in blanks or circle best answer in following:

Material/waste Storage Areas
1. Type of material/waste: ______
2. Method of storage: pile tank dumpster other ______
3. Area occupied by material/waste (acres): ______
4. Type of surface under material/waste: paved unpaved
5. Material/waste is disturbed: often sometimes never unsure
6. Description of spills (material, quantity & frequency): ______
7. Nearest drainage (feet) and drainage type: ______
8. Control practice: berm tarp buffer none other ______
9. Tributary drainage area, including roofs (acres) ______
10. Does storage area drain to parking lot: yes no unsure

Heavy equipment storage
1. Type of equipment: ______
2. Area covered by equipment (acres): ______
3. Type of surface under equipment: paved unpaved
4. Nearest drainage (feet) and drainage type: ______
5. Control practice: berm tarp buffer none other ______
6. Tributary drainage area, including roofs (acres) ______
7. Does storage area drain to parking lot: yes no unsure

Air pollution
1. Description of setteable air pollutants (types & quantities): ______
2. Description of particulate air pollutant controls: ______

Railroad yard
1. Size of yard (number of tracks): ______
2. General condition of yard: ______
3. Description of spills in yard (material, quantity & frequency): ______
4. Type of surface in yard: paved unpaved
5. Nearest drainage (feet) and drainage type: ______
6. Type of control practice: berm buffer other ______
7. Does yard drain to parking lot: yes no unsure
8. Tributary drainage area, including roofs (acres): ______

Loading Docks
1. Number of truck bays: ______
2. Type of surface: paved unpaved
3. Description of spills in yard (material, quantity & frequency): ______
4. Nearest drainage (feet) and drainage type: ______
5. Type of control practice: berm buffer other ______
6. Does loading area drain to parking lot: yes no unsure
7. Tributary drainage area, including roofs (acres): ______

Source: From Wisconsin Dept. of Natural Resources (R. Bannerman, Personal communication)

Figure 11. Industrial Inventory Field Sheet. (Use other sheets for multiple areas on same site)

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be used to identify the possible pollutant sources. The initial activities include pollutant analyses of outfalls being investigated. This requires the characterization of the non-stormwater flows, the identification of the likely industries responsible for the observed discharges, and finally, locating the possible specific sources in the watershed.

Hypothetical Conditions--

The hypothetical industries which were identified as being located in a stormwater drainage area (from the watershed analysis) included a vegetable cannery, general food store, fast food restaurant, cheese factory, used car dealer, cardboard box producer, and a wood treatment company. The methods used to determine the most likely industrial source of the dry-weather discharges are considered for three hypothetical situations of outfall contamination.

Case Example One--The hypothetical results of the pollutant analysis for the first situation found constant dry-weather flow at the outfall. The measurements indicated a normal pH (6) and low total dissolved solids concentrations (300 mg/L). Other outfall characteristics included a strong odor of bleach, no distinguishing color, moderate turbidity, sawdust floatables, a small amount of structural corrosion, and normal vegetation.

The significant characteristic in this situation is the sawdust floatables (see Figure 12). The industries which could produce sawdust and have dry-weather flow drainage to this pipe are the cardboard box company and the wood treatment company. According to SIC code, the cardboard box company would fall under the category of "Paper Products" (SIC# 26) while the wood treatment company would be under that of "Lumber and Wood" products (SIC# 24). Looking up these two industries by their corresponding SIC group numbers in Table 11 and comparing the listed properties, indicates that the paper industry has a strong potential for the odor of bleach. Wood products does not indicate any particular smell.

Based upon this data, the most likely industrial source of the industrial non-stormwater discharge would be the cardboard box company. Table 2 under SIC# 26 indicates that there is a high potential for direct connections in paper industries under the categories of water usage and illicit or inadvertent connections. At this point, further testing should be conducted at the cardboard box company to find if the constant source of contamination is coming from cooling waters, process waters, or direct piping connections (process waters are the most likely source given the bleach and sawdust characteristics).

Case Example 2--The results of the pollutant analysis for the second situation found intermittent dry-weather discharges at the outfall. The test measurements indicated a low pH (3) and high total dissolved solids concentrations (approximately 6,000 mg/L). Other characteristics included a rancid-sour odor, grayish color, high turbidity, gray deposits containing white gelatin-like floatable material, structural damage in the form of spalling concrete, and an unusually large amount of plant life.

The rancid-sour smell and the presence of floatable substances at this outfall indicates that some type of food product is probably spoiling. This narrows the possible suspect industries to the fast food restaurant, cheese factory, vegetable cannery, and food store (see Figure 13). The corresponding SIC categories for each of these industries are "Eating and Drinking Places" (SIC# 58), "Dairy Products" (SIC# 202), "Canned and Preserved Fruits and Vegetables" (SIC# 203), and "Food Stores" (SIC# 54). Comparison of the properties listed in Table 11 for these SIC numbers indicates that elevated plant life is common to industrial wastes for the "Dairy Products" and "Food Stores" categories. However, the deciding factor is the low pH, which is only listed for "Dairy Products". Thus, the white gelatin-like floatables are most likely spoiled cheese byproducts which are also the probable cause of the sour-rancid smell.

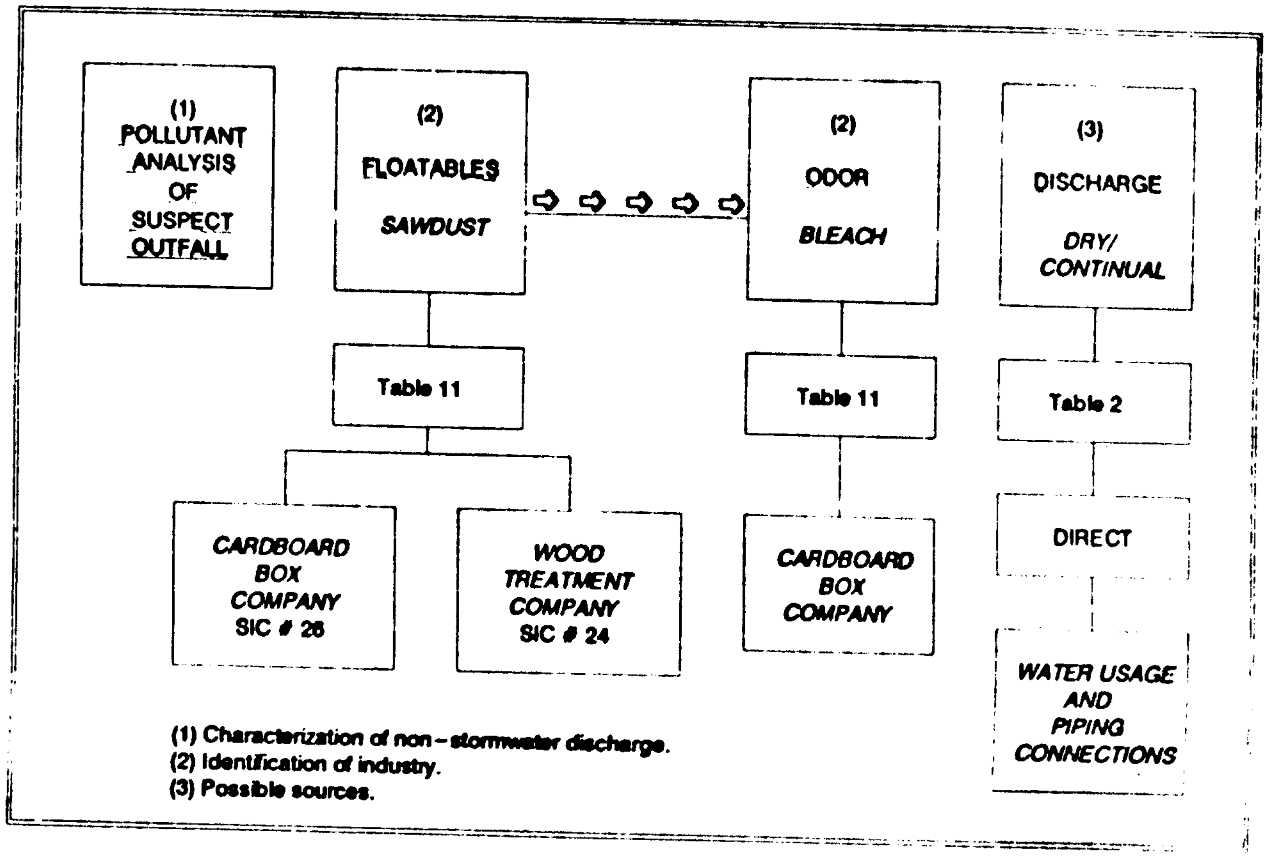

Figure 12. Flowsheet for Industrial Case 1.

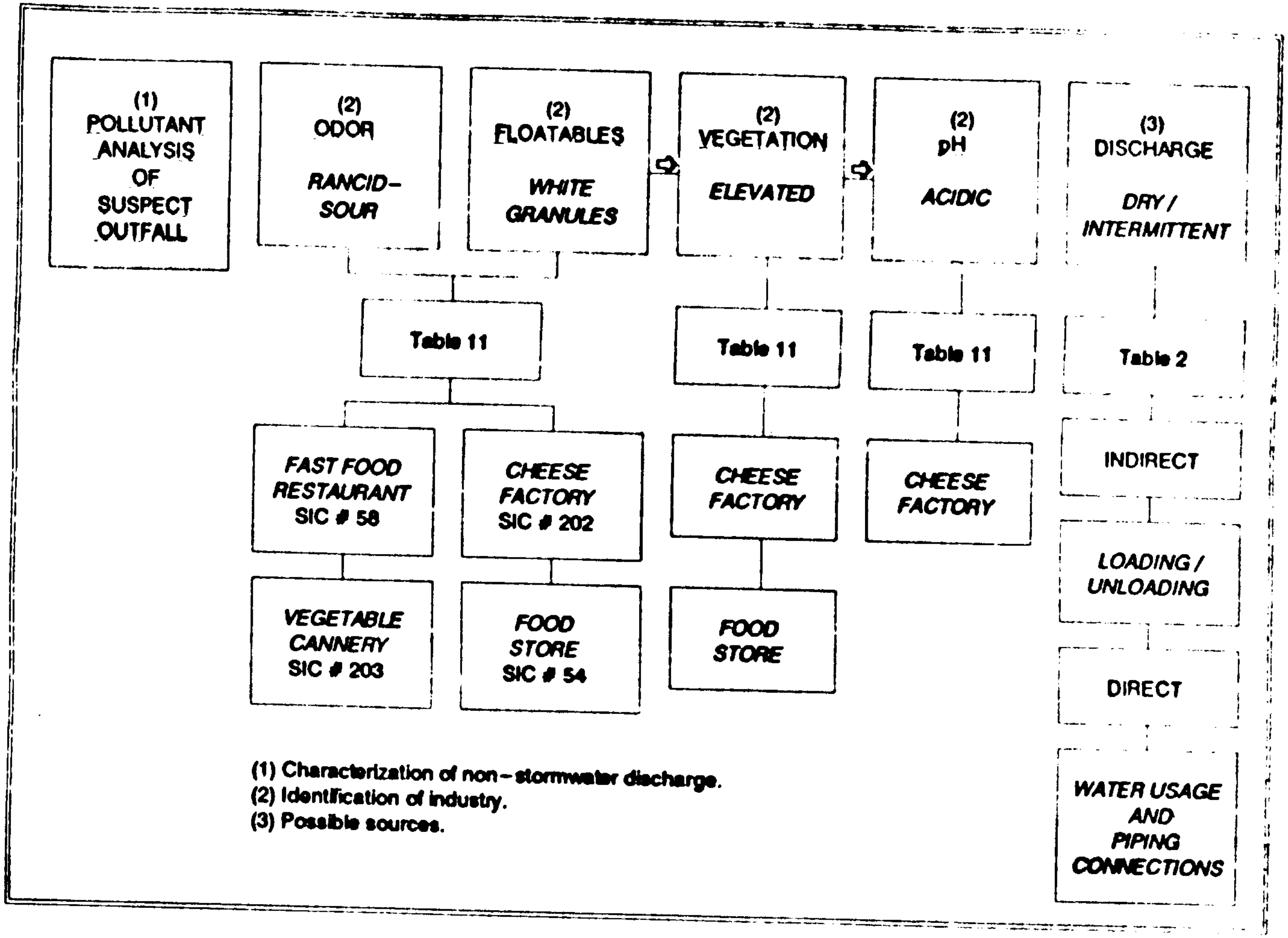

Figure 13. Flowsheet for Industrial Case Example 2.

Since the dry-weather entry to the storm drainage system occurs intermittently, the flow could be caused by either a direct or indirect connection. To locate the ultimate source of this discharge coming from the cheese factory, both direct and indirect industrial situations are considered under the category of "Dairy Products" in Table 2. Thus, further examination of the loading dock procedures, water usage, and direct piping connections should be conducted since these categories all exhibit high potential for pollution in dairy production.

Case Example 3-- The results of the test measurements for the final situation found a normal pH (6) and low total dissolved solids (about 500 mg/L). Signs of contaminated discharges were found at the outfall only during and immediately following rainfalls. Other outfall properties observed included an odor of oil, deep brown to black color, a floating oil film, no structural damage, and inhibited plant growth (see Figure 14).

According to Table 11, the fast food restaurant and the used car dealer are the only two industrial sources in this area with high potential for causing oily discharges. Their respective SIC categories are "Eating and Drinking Places" (SIC# 58) and "Automotive Dealers" (SIC# 55). Comparison of the properties shown on Table 11 indicates inhibited vegetation only for the second category. Thus, the most likely source of the discharge is the used car dealer.

Furthermore, the source of contamination must likely be indirect, since the discharge occurs only during wet weather. Reference to Table 2, under the category of "Automotive Dealers", indicates a high potential for contamination due to outdoor storage. This fact, plus the knowledge that most used cars are displayed outdoors, makes it fairly clear that surface runoff is probably carrying spilled car oil into the storm drain during rains.

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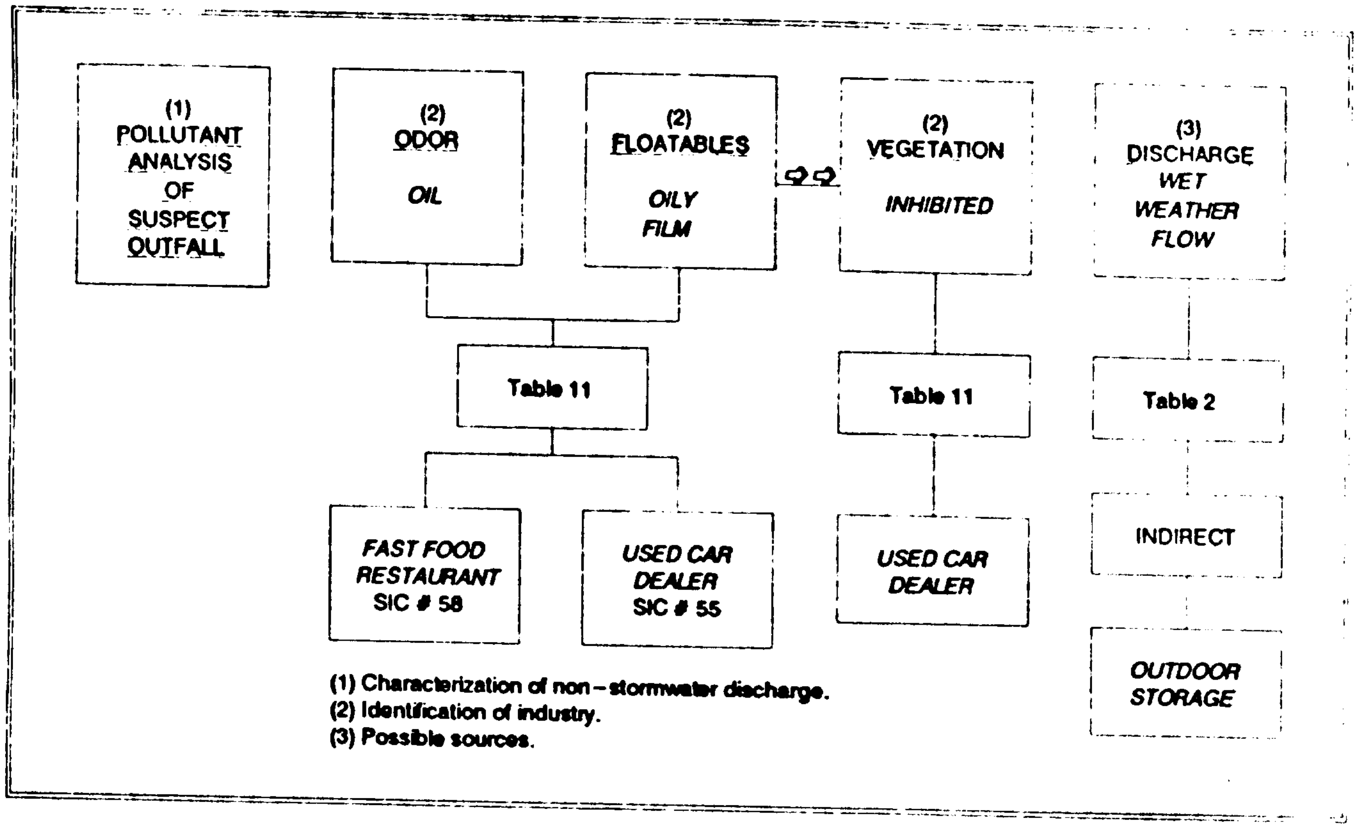

Figure 14. Flowsheet for Industrial Case Example 3.

SECTION 8

CORRECTIVE TECHNIQUES

In addition to identifying problems of unauthorized or inappropriate entries to stormwater systems, it is even more important to prevent problems from developing at all, and to provide an environment in which future problems will be avoided. Thus, a combined approach of identifying and correcting existing problems and avoiding future problems has considerable merit. In this section, the focus is on discussing ways in which future problems can be avoided. However it should be noted that this is not an in depth review, but has been included to provide the reader with suggestions that could be incorporated into a pollution prevention program.

There are also situations in which the sanitary system is so connected to the stormwater system that good intentions, vigilance, and reasonable remedial actions will not be sufficient to solve the problems. In an extreme case, it may be that while it was thought that a community had a separate sanitary sewer system and a separate storm drainage system, in reality the storm drainage system is acting as a combined sewer system. When recognized for what it really is, the alternatives for the future become clearer: undertake the considerable investment and commitment to rebuild the system as a truly separate system, or recognize the system as a combined sewer system, and operate it as such, without the disillusionment that it is a problem-plagued storm drainage system which can be rehabilitated.

Less extreme than designating a polluted stormwater drainage system a combined sewer system, is the action of focusing on pollution prevention by:

- public education,
- an organized systematic program of disconnecting commercial and industrial non-stormwater entries into the storm drainage system,
- tackling the problem of widespread septic system failure,
- disconnecting direct sanitary sewerage connections,
- rehabilitating storm or sanitary sewers to abate contaminated water infiltration, and
- developing zoning and ordinances.

In this section, the above items will be discussed, together with a section on treatment of wide spread sanitary sewerage failure.

PUBLIC EDUCATION

One can argue that an ill informed and apathetic public has condoned the past actions of private citizens, commercial entities, industrial concerns, and public officials which led to some of the past and present problems with unauthorized entries to storm drainage systems. One also knows the power of an aroused, concerned public in altering behavior at all levels. Thus, public education has a role to play. It can be effective in altering the behavior of an individual who had assumed that the inlet on the curb was the place to discharge used crankcase oil. It can be effective when organized groups lobby for the return of a stream or a reservoir to a clean and attractive condition.

Public education carries with it the implicit assumption that an educated public will make the "right" decisions, the educated public will be concerned about the "right" problems, and it will encourage private and public organizations to develop solutions to the "right" problems. Fortunately, most of the problems, issues, and corrective measures are clear cut with respect to unauthorized entries to the stormwater system. Public education is a communication art associated with significant changes when successful, and imperceptible change when unsuccessful. As with all education, it does not end, but is a continuing process. The following paragraphs describe some of the ways in which public officials can help to educate the public. The "public" has been subdivided into categories which are representative of the problem areas with respect to unauthorized entries to storm drainage systems. The subcategories of the public are:

- industrial
- commercial
- residential
- governmental

Industrial decision makers can be educated by public officials through direct contact when they seek information, by education of the consultants from whom industry seeks advice, and by education of trade associations. Indirect educational opportunities are provided by speaking to meetings of professional organizations and by writing in professional newsletters and journals. Industrial decision makers are a small group which is likely to respond as they recognize that they have to address the problem of unauthorized entries to the stormwater system.

Commercial storm drainage system users are a larger group to educate. The educational process will have to focus on both proprietors and their employees. It will have to recognize the state of both groups, new businesses opening; existing businesses moving, expanding, and closing; and employees entering the work force and changing jobs. Education will have to be focused in the local community. The role of trade and professional associations will be less than was the case with industrial groups. News announcements in the local press will play a role as well as mailed news items. Individual contact between a public official and the proprietor of a commercial establishment will play a larger role. Follow up and repeated contact may be necessary to answer questions and cope with employee turnover. Public education can also benefit from failures. For example, certain violations of discharge practices may be so serious, or flagrant, that a citation or fine results. The local press, if informed, may find such an incident newsworthy. The general public, or other potential offenders, may benefit from this educational procedure.

An informed public willing to act on their convictions is the product sought from public education. The public educator focuses on large groups, as one-on-one contact is unlikely to be either time or cost effective. Long range educational goals may be tackled through school programs, while shorter range educational goals may focus on community groups. Public education will have to focus on broader environmental issues than inappropriate entries to storm drains. Subgroups in the community may play important roles in public education. For example, scouts may undertake community improvement projects including placing signs on curbside storm drains informing the public that the drain is for stormwater only, and not for discharge of wastes. Thus, public education must take advantage of opportunities presented by groups looking for community improvement projects, the opportunities that are available in working with the school system, and opportunities arising from the news media being supplied with newsworthy items.

The final group that public officials should address in public education is other public officials and governmental institutions. Some small governmental units may not know about precautions to be taken with discharges to storm drainage systems unless they are properly informed. Such subgroups may include road departments, sanitation workers, and workers at public institutions such as hospitals and prisons. A multilevel, multitarget public education program can help to avoid problems.

COMMERCIAL AND INDUSTRIAL SITE DISCONNECTIONS OF NON-STORMWATER SOURCES

Out of convenience and out of ignorance, commercial and industrial sites may impose an increasing load on the storm drainage system. This may be through direct discharges to the storm drainage system, or it may be through diffuse and indirect sources in which the site grounds are contaminated by spills and discharges which are then washed off by storm runoff to the storm drain during rainfall events or by washwater during wash-down operations. The problem is compounded by the vast array of sizes of commercial and industrial enterprises. A single person enterprise has little opportunity to build expertise on the subject of stormwater pollution, while a large industrial enterprise may have an environmental division. To the uninformed person, any curb opening may be thought to be part of a comprehensive sanitary wastewater treatment system and the proper entrance point for polluted water discharges or other debris.

Corrective measures for improper uses of storm drains have to be developed recognizing the differences in knowledge and sophistication of the client. Industrial users are relatively few in number but are expected to have the most complex problems. If industrial users are aware, or made aware, of existing and or new federal, state, or local regulations to prevent pollution of stormwater drainage systems, they will usually comply with the regulation. If not, these regulations provide the authority and communication means to instigate corrective action.

Commercial groups are heterogeneous. An appropriate way of working with them to institute changes in their use of storm drainage systems, may be to work with one category of commercial groups at a time. For example, consider gasoline filling stations as a single category. It is possible to focus on correcting similar problems at many facilities that exist in this category. The flushing of radiators may be seasonally common. A typical practice is to let radiator flushing waters (including coolants) to drain to an inlet to the storm drainage system. Education followed by assurance that there will be strict enforcement of discharge regulations or ordinances may be effective. However, a group such as gasoline filling stations cannot be expected to have a long institutional memory as new operators take over and others drop out. Thus, vigilance and follow-up are important to insure that there is not a gradual diminution of appropriate practices.

For both small commercial and large industrial enterprises, willful and knowledgeable violation of the regulations limiting entries to storm drainage systems have to be dealt with firmly and promptly or the enforcement program runs the chance of becoming ineffective. Thus the governmental unit undertaking responsibility for improving the practices regarding entries to storm drainage systems must have an enforcement plan ready.

FAILING SEPTIC TANK SYSTEMS

Failing septic tank systems can have an impact on an otherwise well functioning storm drainage system. Before discussing corrective measures, it is important to identify the relationship that may develop between a septic tank system and a storm drainage system.

A septic tank system consists of two major components: a septic tank and a leaching field (a waste spreading or soil absorption system). In addition, of course, there is piping associated with the system. Sanitary wastewaters are piped directly to the septic tank. The septic tank typically is made of concrete, is rectangular in shape, is usually divided into two compartments, and has a capacity of one to several thousand gallons. The septic tank serves as an anaerobic digestion, floatation and settling unit in which biological action converts the biodegradable liquid and solid waste particles into stable end products. Gravity separates a significant portion of both biodegradable and non-biodegradable particulate matter to the tank bottom or top (depending on whether the particles sink or rise, respectively). Some of the products of this partial treatment process are carbon dioxide, methane, hydrogen sulfide and other odor producing gases, digested and refractory or relatively non-biodegradable sludge, and floating scum. Because the septic tank remains full, it must discharge a volume of wastewater each time a volume of wastewater is discharged into it. This discharged water enters a leaching field where some additional treatment occurs and the final effluent is discharged to the ground.

A septic tank may be a low maintenance treatment unit, but it is not entirely maintenance free. As the septic tank continues to be loaded, the scum and sludge layers build up so that the remaining volume available for treatment is reduced. Thus, some of the partially digested or undigested solids, scum, and sludge may be carried from the septic tank to the leaching field where the soil void space may become clogged. As the soil voids become clogged, the ability of the leaching field to handle the liquid portion of the waste is reduced, and surface ponding of the wastewater may result. Of course, ponding could have been prevented by having the septic tank serviced; that is, by having the septic tank pumped. Pumping removes the sludge, scum, and other contents of the septic tank so that its storage and treatment capacity is restored. Pumping frequency varies depending on the size of the septic tank and its loading rate. Residential septic tanks may need to be pumped every two to five years. Commercial and institutional septic tanks may need more frequent pumping.

Failed septic tank systems have the potential to pollute stormwater because the leaching field will saturate the ground, and possibly form ponded water on the ground surface. The ponded water may run off and enter a storm drain inlet or drainage ditch, or infiltrate the ground in another area which is intercepted by a storm drain through infiltration. When it rains, any remaining ponded water may be washed off with the runoff to the storm drainage system. Depending on the severity of the septic tank failure, the ponded water can have the characteristics of partially treated sanitary wastewater or nearly untreated sanitary wastewater. Thus, septic tank failures can contaminate the stormwater drainage system during both wet and dry weather.

Septic tank systems may fail even with good maintenance practices. Such failure can result when the soil is simply not permeable enough for the leaching field, or when the soil absorbance capacity is exceeded through long use. A tight clay soil may have such low permeability that the leaching capacity is very limited. If a number of homes are built in close proximity, their septic tank leaching fields may collectively exceed the soil's capacity, leading to a stormwater pollution problem. Even properly operating septic tank systems are a potential pollutant source. Because the basic function of the leaching field is to discharge partially treated effluent to the ground, this septic tank effluent can infiltrate into nearby stormwater drainage systems.

Various corrective methods exist for failing septic tank systems that pollute stormwater. These methods include: improve maintenance, institute preventative measures to avoid problems, and abandon the septic tank system with connections made to a sanitary sewerage system. In some cases, improved maintenance may be the answer. Some persons will not do any maintenance to their septic tank system until it fails (they note ponded water in the leaching field area). Then they call for the septic tank to be pumped. In many cases, this is not sufficient to correct the problem: it may be too little action too late. The preventative action of having the septic tank pumped should have taken place prior to failure of the system. Education may provide part of the remedy. The septic tank user may respond to exhortations to have the septic tank pumped on a regular basis, before failure. Coercion through ordinances may be another answer. Ordinances may require that the septic tank be pumped at a specified frequency, with a public body monitoring the program to ensure that maintenance has been carried out.

It sometimes happens that soil conditions and population density rule out both voluntary or involuntary maintenance. In this case, it may be necessary to consider abandoning the septic tank system and installing a system consisting of sanitary sewers leading to a treatment plant. Another option consists of abandoning the septic tank treatment method in favor of small package treatment units that provide aerobic treatment of the sanitary wastewater which is then discharged to a regional leaching field. This option may succeed where the septic tank system has failed, because wastes treated in an aerobic unit may not have the leaching field clogging potential of wastes treated in an anaerobic septic tank. However, experience has shown that these advantages are only obtained with proper control and maintenance. Aerobic systems are more sensitive than conventional septic tank systems to improper maintenance and may therefore not offer any real benefits.

DIRECT SANITARY SEWERAGE CONNECTIONS

Due to indifference, ignorance, poor enforcement of ordinances, or other reasons, a stormwater drainage system may have sanitary wastewater sewerage direct connections. Obviously, the sanitary wastewater entering the storm drain will not receive any treatment and will pollute a large flow of stormwater, in addition to the receiving water. If the storm drain has a low dry-weather flow rate, the presence of sanitary wastewater may be obvious due to toilet paper, feces, and odors. In cases of high dry-weather flows, it may be more difficult to obviously detect raw sanitary wastewaters due to the low percentage of sanitary wastewater in the mixture. Even though the sanitary wastewater fraction may be low, the previously discussed field testing procedures (e.g., testing for surfactants, ammonia, potassium, and fluorides) will assist in the detection and quantification of sanitary wastewater contamination in the storm drainage system. Flow monitoring may show the variations in the flow rate that are typical of sanitary wastewater.

Dye testing can be effective in finding specific sanitary wastewater connections between a house and a storm drainage system. Dye, such as diluted rhodamine or fluorescein, is flushed down the toilet of a house and the storm drain is monitored to determine whether the dye appears. Care has to be exercised when using this method, as these dyes may stain fixtures that are being tested, and any spillage in the house causes stains that are very difficult to remove.

Monitoring of the storm drainage system with television cameras can show the locations of breaks in the storm drain where a sanitary wastewater sewer or house lateral was attached. Television cameras may also show discharges taking place at these locations, demonstrating that the lines are in active use.

Corrective measures involve undertaking a program of disconnecting the sanitary sewer connections to the storm drainage system and reconnecting them to a proper sanitary wastewater sewerage system. The storm drainage system then has to be repaired so that the holes left by the disconnected sanitary sewer entrances do not become a location for dirt and groundwater to enter.

REHABILITATING STORM OR SANITARY SEWERS TO ABATE CONTAMINATED WATER INFILTRATION

Infiltration of contaminated water into a stormwater drainage system can cause substantial pollution of the system. This could occur where a sanitary sewer overlies and crosses (or parallels) a storm drain, with sanitary wastewater exfiltrating from the sanitary sewer and percolating the storm drain. Other instances would be in areas of polluted groundwater, where the storm drainage is below the water table or intercepts infiltrating groundwater, or in areas having septic tank systems, as discussed previously.

It would be best to correct the sanitary sewer if only one drainage system can be corrected. This would have the dual advantage of preventing infiltration of high or percolating groundwaters and preventing pollution of stormwater with exfiltrating sanitary wastewater. Rehabilitation of the drainage systems by use of inserted liners, or otherwise patching leaking areas, are possible corrective measures. It is important that all drains with infiltration problems be corrected for this corrective action to be effective. This would also include repairing house lateral sanitary wastewater lines, as well as the main drainage runs. However, these corrective measures are more likely to be cost effective when only a relatively small part of the complete drainage systems require rehabilitation.

ZONING AND ORDINANCES

Land use controls achieved by zoning have the potential to exacerbate problems or diminish them. For example, in an area with soils that are ill suited for septic tanks and leaching fields, the potential for future problems is increased if zoning allows small lots for single family residential development and allows septic tank systems. As the area develops, septic tank failures will become common, resulting in increased pollution of stormwater and groundwater. On the other hand, in areas having poor soils, zoning can require correspondingly larger lot sizes and larger leaching fields, resulting in fewer future problems. Ordinances may specify the results that have to be achieved by infiltration tests used to size leaching fields. Also, ordinances can require that a responsible public official be present when the infiltration test is run to decrease the likelihood of false or spurious results being reported. Certified septic tank installers, also checked by public official inspectors, should also be required to increase the likelihood of the system being installed correctly.

Zoning can also have a role to play in avoiding development of land that is subject to frequent flooding. In such land, flooding and high groundwater conditions can result in the sanitary sewerage system being gradually overloaded by infiltration so that cross flow to the storm drainage system can occur.

Ordinances can help to control problems by putting the force of law and public policy behind desirable practices. For example, ordinances can make mandatory practices such as septic tank maintenance that otherwise would be voluntary. By making the practice mandatory, desirable practices are performed on a regular schedule so that large problems have less opportunity to develop. Ordinances can also regulate the persons doing the pumping of septic tanks so that they discharge the septage to wastewater treatment plants where it can be properly treated rather than it being discharged improperly where the pollution problem is just transferred from one location to another.

Ordinances can also help prevent and or control pollution from many other sources by restrictions on: disposal of household toxic substances to storm drains, storage of chemicals by industry, disposal of industrial wash down water, etc.

Zoning and ordinances represent important means for governing bodies to anticipate problems, to avoid problems, and to manage problems, so that desirable ends are achieved and undesirable consequences are avoided. Enactment of zoning and ordinances occurs in the public arena where interested persons can participate and express their views and concerns. The public can become educated in this process, but zoning and ordinances have the desirable characteristic of being remembered and remaining enforceable long after an individual forgets, becomes disinterested, or becomes recalcitrant.

Another important step that municipalities can take is the development of policies and procedures for the management of spills from transportation (including both roadway and rail) and pipeline accidents. Spills should not be merely washed into the storm drainage system, but should be collected for proper treatment and disposal.

WIDESPREAD SANITARY SEWERAGE FAILURE

Connections (whether directly by piping or indirectly by exfiltration or infiltration) of sanitary sewers to the storm drainage system may be so widespread that the storm drainage system has to be recognized as a combined sewer system. This could also be the case when the prevalence of septic tank failures leads to widespread sanitary wastewater runoff to the storm drainage system. One usually thinks of a combined sewer system as having all of the sanitary sewer connections to the same sewers that carry stormwater, but the previous discussion suggests that there are degrees of a storm drainage system becoming a combined sewer system. Previously, the recommendations have been made that widespread failure of septic tank systems might necessitate the construction of a sanitary sewer to replace the septic tanks. Also recommended was a program of identifying and disconnecting sanitary sewers from the storm drainage system.

Prior to these actions taking place, the storm drainage system operates to some degree as a combined sewer system. It may be that the sanitary sewerage system is not capable of handling the load that would be imposed on it if a complete sewer separation program were undertaken. Or, in an extreme case, no sanitary sewer system may exist. By recognizing that a combined sewer system does in fact exist may help to focus attention on appropriate remedial measures. The resources may also not be available to undertake construction of a separate sanitary wastewater drainage system.

One should then focus on how to manage the combined sewer system that is in place. Management may require that end-of-pipe storage/treatment be investigated. Also, the combined sewer system may be tied into other combined sewers so that more centralized treatment and storage can be applied. Operation of a combined sewer system may be preferable to having the stormwater and the large number of sanitary entries receive no treatment.

An early identification and decision to designate a storm drainage system a combined sewer system, will prevent abortive time and costs being spent on further investigations. These resources can then be more effectively used to treat the newly designated combined sewer system.

In essence, recognition of a system as being a combined sewer system provides a focus in the regulatory community so that it may be possible to operate the system so as to minimize the damage to the environment.

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GLOSSARY

Accuracy - The combination of bias and precision of an analytical procedure which reflects the closeness of a measured value to a true value.

Baseflow - The dry-weather flow occurring in a drainage system, with no apparent source. Likely to be mostly infiltrating groundwaters in a sanitary or storm drainage system, but can also be contaminated with illicit wastewaters. See constant (or continual) dry-weather flow.

Batch dump - The disposal of a large volume of waste material during a short period of time. Usually an industrial waste.

Bias - A consistent deviation of measured values from the true value, caused by systematic errors in a procedure.

Coefficient of Variation (COV) - A measure of the spread of data (ratio of the standard deviation to the mean).

Combined Sewer - A sewer designed for receiving surface (dry- and wet-weather) runoff, municipal (sanitary and industrial) wastewater, and subsurface waters from infiltration. During dry weather, it acts as a sanitary sewer, but it also carries stormwater from wet-weather runoff.

Combined sewer overflow (CSO) - Flow from an outfall (discharge conduit) of a combined sewer collection system, in excess of the interceptor capacity or due to a malfunctioning or improperly set flow regulator, that is discharged into a receiving water and/or an auxiliary CSO control storage-treatment system.

Constant (or continual) dry-weather flow - Uninterrupted flow in a storm sewer or drainage ditch occurring in the absence of rain. See baseflow.

Deposits and stains - Any type of coating or discoloration that remains at an outfall as result of dry-weather discharges.

Detection limit - A number of different detection limits have been defined: IDL (instrument detection limit), is the constituent concentration that produces a signal greater than five times the signal to noise ratio of the instrument; MDL (method detection limit) is the constituent concentration that, when processed through a complete method, produces a signal with a 99 percent probability that it is different from a blank; PQL (practical quantification limit) is the lowest constituent concentration achievable among laboratories within specified limits during routine laboratory operations. The ratios of these limits are approximately: IDL:MDL:PQL = 1:4:20 (APHA, et al. 1989).

Direct (dry-weather) entries into the storm drainage system - Sources which enter a storm drainage system directly, usually by direct piping connections between the wastewater conduit and the storm drain.

Domestic sanitary wastewater - Sewage derived principally from human sources.

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Drainage area - The area of land from which a storm drainage system collects precipitation and storm runoff and then delivers the resulting stormwater to a specific point.

Dry-weather flow - Flow in a storm sewer or drainage ditch occurring in the absence of storm flow. But it is also a constituent of wet-weather flow. See baseflow.

Entries to storm drainage - Water (relatively clear or polluted) discharged into a stormwater drain from sources such as, but not limited to, direct industrial or sanitary wastewater connections, roof leaders, yard and area drains, cooling water connections, manhole covers, groundwater or subterraneous stormwater infiltration, etc.

Floatables - Floating materials, (plastic containers, condoms, sanitary napkins, tissues, corks, paper containers, wood, leaves, oil films, slimes, scum, etc.), that are either part of the inappropriate waste streams discharged to a stormwater system, or collected by flows which enter a stormwater drainage system.

Geographic Information System (GIS) - Computer software that maps land areas and produces images and information relating to the land area, e.g., topography, drainage, public utilities, roads, buildings, industry, land use, and demography.

Groundwater infiltration - Seepage of below water table groundwater and subterraneous stormwater into stormwater, sanitary wastewater, or combined sewer drainage systems, through such means as defective pipes, pipe joints, connections, or manhole walls.

Hardness - Caused by the presence of the divalent cations (principally calcium and magnesium) in water. Causes an increased amount of soap usage before producing a lather and scale to form in hot water pipes, boiler vessels, condensate return lines, cooling systems, kettles, etc.

House Lateral - A pipe connecting a house to a lateral or other sewerline. Also called a service connection.

Indirect dry-weather entries into the storm drainage system - Non-stormwater sources which enter a storm drainage system indirectly, usually by floor, areaway, and yard drains or inlets; and spills and dumping.

Industrial dry-weather entries into the storm drainage system - Any solid or liquid waste coming from industrial sources which enter storm drainage systems during periods of dry weather.

Infiltration - The process whereby water enters a drainage system underground through such means as defective pipes, pipe joints, connections, manhole walls, etc.

Inflow - The process whereby water enters a sanitary wastewater drainage system from surface locations, (e.g., through depressed manhole covers, yard and areaway inlets, roof leader setc.).

Intercepted stormwater/groundwater - The portion of surface runoff or groundwater moving through the soil that enters a storm drainage, combined sewer, or sanitary sewer system.

Interceptor - A sewer that receives flows from a number of wastewater trunk lines.

Intermittent dry-weather flow - Irregular flow in a storm drainage system occurring in the absence of storm flow.

Lateral - A drain or sewer that has no other drains or sewers discharging into it, except for service connections, or house laterals.

Leaching field - A system which facilitates the infiltration of a septic tank effluent into the soil. This is typically done by a pipe and infiltrating trench system which takes the effluent from a septic tank and distributes it through the leaching field, where additional treatment of the effluent occurs as it percolates through the ground or soil column.

Monte Carlo probabilistic simulation - A statistical modeling approach used to determine the expected frequency and magnitude of an output by running repetitive simulations using statistically selected inputs for the model parameters.

Municipal sewage/wastewater - Sewage/wastewater from a community which may be composed of domestic sewage/wastewater, industrial wastewater and/or commercial wastewater, together with subsurface infiltration.

National Pollution Discharge Elimination System (NPDES) - A national system of permits issued to industrial, commercial, and municipal dischargers to limit the amount of pollutants that can be discharged to waters of the USA.

Non-contact cooling water - Water that decreases the temperature of an object, without ever physically contacting the object.

Nonpoint pollution source- Any unconfined and nondiscrete conveyance from which pollutants are discharged, or sn urban drainage system not under the NPDES. These sources are usually from agricultural, silvicultural, and rural land areas..

Outfall - In this User's Guide, an outfall refers to a point at which a stormwater drainage system discharges to a receiving water. There is sometimes a concrete structure or retaining wall at this location to protect the end of the discharge pipe and prevent erosion of the receiving water bank.

Pathogen - A disease-causing microorganism.

Point source - Any discernible, confined, and discrete conveyance from which pollutants are, or may be, discharged. Under the NPDES it is an outfall discharge, or overflow of treated or untreated sanitary, industrial, combined sewage, or stormwater (from a municipality greater than 100,000 in population).

Pollutant - Any material in water or wastewater interfering with designated beneficial uses.

Potable water - Water that has been treated, or is naturally fit for drinking, i.e., the water has no harmful contents to make it unsuitable for human consumption.

Precision - The measure of the degree of agreement among replicate analyses of a sample, usually expressed as the standard deviation.

Pretreatment - The removal of material such as, gross solids, grit, grease, metals, toxicants. etc. or treatment such as aeration, pH adjustment, etc. to improve the quality of a wastewater prior to discharge to a municipal wastewater system. This is usually done by the industrial user of the water, but can also refer to the initial treatment processes of a sewage treatment plant.

Process line discharge - The disposal of anything used in, or resulting from, a manufacturing process.

Process water - Water used in industry to perform a variety of functions, or as an actual product ingredient.

Receiving waters - Natural or man-made water systems into which stormwaters, or wastewaters, are discharged.

Rinse water - Water that cleans or reduces the temperature of an object through actual physical contact with the object.

Sanitary sewer - A sanitary wastewater drainage system intended to carry wastewaters from residences, commercial buildings, industrial plants, and institutions together with minor quantities of groundwater, stormwater and surface water that are not admitted intentionally [40 CFR 35.2005 (b) (37)].

Sanitary wastewater - Wastewater of human origin.

Service Connection - See house lateral

Septic tank - A tank which receives sanitary wastewater direct from its source, (usually residential), and permits settling of the heavy solids and floatation of greases and fats along with anaerobic digestion. Septic tanks, typically need to meet minimum regulatory standards, e.g., minimum volume and detention time.

Sewage - In this text the term "sewage" refers to sanitary wastewater or wastewaters generated from commercial or industrial operations, it does not include stormwater.

Sewer - A pipe, conduit or drain generally closed, but normally not flowing full, for carrying sanitary, industrial and commercial wastewater and storm-induced (combined wastewater and stormwater) flows.

Sewerage - System of piping and appurtenances, with and without control-treatment facilities for collecting and conveying wastewaters with or without pollution abatement from source to discharge.

Specific Conductivity - Expressed in microSiemens/cm (or micromhos/cm). It is an indication of the dissolved solids (charged) concentration in a liquid.

Storm drainage discharge - Flow from a storm drain that is discharged to a receiving water.

Storm drain - A pipe, or natural or man-made channel, or ditch, that is designed to carry only stormwater, surface runoff, street washwaters, and drainage from source to point of discharge [40 CFR 35.2005 (b) (47)].

Stormwater - Water resulting from precipitation which either infiltrates into the ground, impounds/puddles, and/or runs freely from the surface, or is captured by storm drainage, a combined sewer, and to a limited degree, by sanitary sewer facilities. See urban runoff and urban stormwater runoff.

Surfactants - Surface-active agents and common components in detergents which affect the surface tension of water and can cause foaming.

SIC - Standard Industrial Classification, a code used to describe an industry.

Total solids - The entire quantity of solids in the liquid flow or volume including the dissolved and particulate (suspended, floatable, and settleable) fractions.

Toxicity - The degree to which a pollutant causes physiological harm to the health of an organism.

Tracer - In this User's Guide, a tracer is a distinct component, or combination of components ("fingerprint"), of a polluting source which is identified in order to confirm the entry of the polluting source to a storm drainage system.

Trace Metals - Metals present in small concentrations. From a regulatory standpoint, this usually refers to metal concentrations that can cause toxicity at trace concentrations.

Turbidity - The lack of clarity in the water usually caused by suspended particulate matter and measured by interference to light penetration.

Urban runoff - Any runoff stormwater from an urban drainage area that reaches a receiving water body or subsurface. During dry weather, it may be comprised of many baseflow components, both relatively uncontaminated and contaminated. See stormwater and urban stormwater runoff.

Urban stormwater runoff - Stormwater from an urban drainage area that reaches a receiving water body or subsurface caused by weather precipitation (rain, snow, etc.). See stormwater and urban runoff.

Watershed - A geographic region (area of land) within which precipitation drains into a particular river, drainage system or body of water that has one specific delivery point.

Wet-weather flow - Any flow resulting from precipitation (rain, snow, etc.) which may introduce contaminants into storm drainage combined sewerage, or sanitary sewerage systems.

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March 1995

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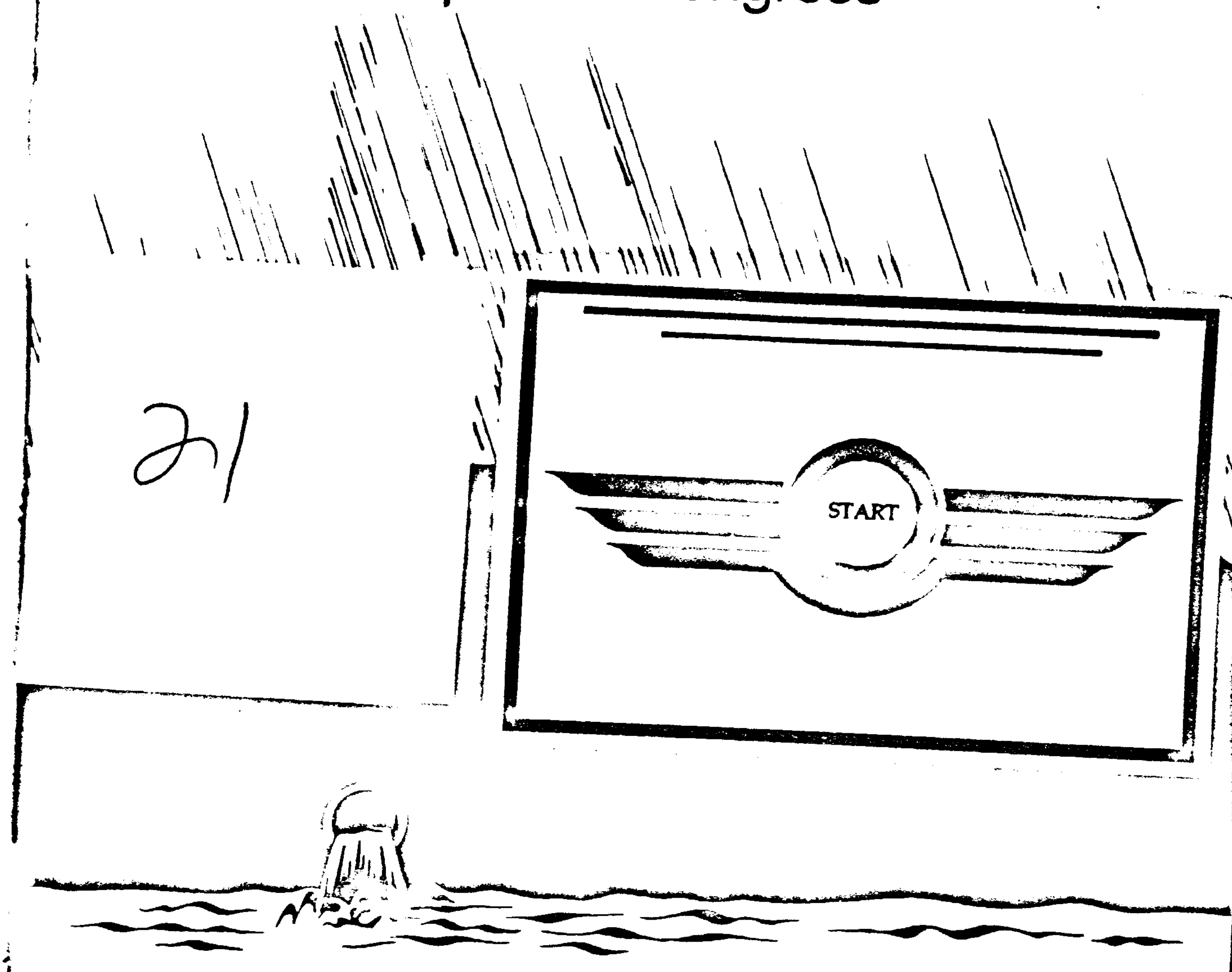
EPA

Storm Water Discharges Potentially Addressed By Phase II Of The National Pollutant Discharge Elimination System Storm Water Program

Report To Congress



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

MAR 29 1995

THE ADMINISTRATOR

Honorable Albert Gore, Jr.
President of the Senate
Washington, D.C. 20510

Dear Mr. President:

I am pleased to present the Environmental Protection Agency's (EPA) "Report to Congress on Storm Water Discharges Potentially to be Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program." With this Report as a starting point, I believe, together with Congress and our other partners, we can make substantial progress in utilizing more cost-effective and resourceful ways to control storm water pollution and to protect public health and the environment.

This Report responds to Section 402(p)(5) of the Clean Water Act and provides data, analysis, and recommendations concerning the number and type of discharges potentially to be covered by a phase II storm water program. The Report also identifies the nature and extent of these discharges and discusses one possible approach to implementing a phase II storm water program.

Although this Report discusses only one possible approach for a phase II storm water program, EPA looks forward to working with Congress, States, Tribes, local governments, and other stakeholders to identify other options for a phase II program. Already, EPA is taking steps to explore additional possibilities by developing partnerships and seeking ideas from all groups that will be involved. We will draw on our experience with the phase I storm water program and collaborative efforts with our stakeholders to ensure a cost-effective storm water program.

As a first step, EPA is establishing an urban wet-weather advisory group composed of stakeholders from industry, States, municipalities, commercial and retail establishments, environmental groups and others, to address policy and technical issues related to urban wet weather. A storm water phase II subgroup will be formed to consider cost-effective ways of addressing pollution from phase II storm water discharges. We will share the results of these efforts with Congress as they develop.

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In addition to the phase II efforts, we plan to review and streamline the phase I storm water program. We will consider changes to existing monitoring and permitting requirements for regulated phase I municipal dischargers and will resolve questions regarding what cities must do under the Act's storm water control "maximum extent practicable" requirements.

I believe this Report responds fully to the mandates of Section 402(p)(5) of the Clean Water Act, and I hope Congress finds it useful in determining how to proceed with the storm water program.

Sincerely,

Carol M. Browner

Enclosure

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

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MAR 29 1995

THE ADMINISTRATOR

Honorable Newt Gingrich
Speaker of the House
of Representatives
Washington, D.C. 20515

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Sincerely,

Carol M. Browner

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EXECUTIVE SUMMARY

Introduction

Storm water discharges have been linked to one-third of all assessed surface water quality impairments nationwide by transporting large quantities of pollutants to our Nation's waterways.[1] Significant sources of contaminated storm water include urban runoff, industrial activities, construction, mining, other types of resource extraction, and different commercial activities. To address this problem, Congress amended the Clean Water Act (CWA) in 1987 to establish a phased approach for issuing National Pollutant Discharge Elimination System (NPDES) permits for storm water discharges.

Phase I of the storm water program, now underway, controls storm water discharges only from industrial activity and municipal separate storm sewer systems serving populations greater than 100,000. Many other sources of polluted storm water remain unaddressed. To deal with them, Congress required the United States Environmental Protection Agency (EPA) to prepare a study identifying additional sources of storm water contamination and establishing procedures and methods to control these discharges under a Phase II storm water program.

This report presents the results of the study to identify potential sources for consideration in a Phase II program and a discussion of the nature and extent of pollutants in their discharges. This report also contains recommendations for how to control Phase II storm water sources.

[1] This estimate is based on information contained in EPA's *National Water Quality Inventory, 1992 Report to Congress*, prepared pursuant to the Clean Water Act, Section 305(b), which is based on State reports of assessments of surface water impacts.

The storm water sources identified in this report and the recommendations for controlling these sources, represent one possible approach, developed by EPA, to a Phase II storm water program. Other approaches are also feasible and EPA plans to explore these through a broad inclusionary process with stakeholders from industry, municipalities, commercial and retail establishments, environmental groups and other interested parties. This will be done by establishing a Federal Advisory Committee Act (FACA) subcommittee on Phase II. This subcommittee will be tasked with examining the key issues for a Phase II storm water program and with recommending cost-effective ways of addressing pollution from Phase II sources. The outcome of this effort may be the formulation of a Phase II storm water program that will differ in scope and procedure from the approach discussed in this report.

This report includes an introduction to the study (Chapter 1), a description of the approach used (Chapter 2), an analysis of municipal sources to be included in Phase II (Chapter 3), and a review of individual sources to be addressed in Phase II (Chapter 4), as well as numerous appendices, which provide supporting data and information.

Summary of Key Findings

EPA has identified two major classes of potential Phase II storm water discharges that are described in this report: (1) discharges from municipal separate storm sewer systems not subject to Phase I and (2) discharges from individual (industrial, commercial, and institutional) facilities not subject to Phase I.

Based on the identification and analysis of potential Phase II sources and available information on impacts of storm water discharges, this report recommends that Phase II of the storm water program focus on the 405 urbanized areas identified by the Bureau of the Census. As described in *President's Clinton's Clean Water Initiative*, municipalities in these urbanized areas would be authorized to regulate industrial dischargers and to address, as necessary, commercial, institutional, and retail services within their jurisdiction using a flexible approach rather than EPA or the States permitting these sources directly.

Significant environmental benefit, including reduced pollutant loadings from urbanized areas, will be obtained by extension of the storm water program to these areas. As summarized below and explained in detail in this report, urbanized areas contain a large percentage of population and population growth, as well as industrial, commercial, and retail facilities, while constituting only 2 percent of the total land area. Focusing Phase II of the storm water program on urbanized areas thus targets the highest concentration of pollutant sources and maximizes the potential benefits.

Background

Water Quality Impacts

While rainfall and snow are natural events, the nature of runoff and its impact on water resources are highly dependent on human activities and the use of the land. Storm water runoff can affect surface water quality in two basic ways: (1) natural flow patterns can be radically altered; and (2) pollution concentrations and loadings can be highly elevated.

The National Water Quality Inventory, a report prepared every 2 years summarizing biennial State reports required by Section 305(b) of the CWA, provides a national assessment of surface water impacts associated with runoff from various land uses. The most recent report in this series, *The National Water Quality Inventory, 1992 Report to Congress*, concludes that storm water runoff from a number of diffuse sources, including agricultural areas, municipal separate storm sewers, urban runoff, and atmospheric deposition, are the leading cause of surface water quality impairment cited by States. Five leading contributors to use impairment are shown in Table ES-1.

Storm water runoff from urbanized areas and industrial and commercial activities can contain high levels of contaminants, such as sediment, suspended solids, nutrients, heavy metals, pathogens, toxics, oxygen-demanding substances, and floatables.[2] In urban areas,

[2] National Water Quality Inventory: *1992 Report to Congress*, EPA, 1994.

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Table ES-1. Five Leading Sources of Water Quality Impairment for Selected Classes of Waters

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Municipal Point Sources
2	Municipal Point Sources	Urban Runoff / Storm Sewers	Urban Runoff / Storm Sewers
3	Urban Runoff / Storm Sewers	Hydrologic / Habitat Modification	Agriculture
4	Resource Extraction	Municipal Point Sources	Industrial Point Sources
5	Industrial Point Sources	Onsite Wastewater Disposal	Contaminated Sediments

Source: *National Water Quality Inventory, 1992 Report to Congress*, EPA, 1994.

the cumulative effect of widespread development will also change natural drainage patterns, causing much higher wet-weather peak flows and reduced dry-weather base flows in urban streams and wetlands. Increased peak flows can cause severe hydromodifications such as stream bank erosion, streambed scour, flooding, channelization, and alteration and/or elimination of habitat.[3] These flows will also accumulate and transport pollutants to receiving waters. These pollutants are generated from the numerous human activities within the urban area. Industrial and commercial operations, which are generally located in urban areas, can be significant sources of storm water contamination because of the nature of activities conducted, and materials stored, outdoors.

Appendix B provides an overview of the impacts associated with different pollutant classes and types of receiving waters and ground water. Pollutants associated with widespread urban development are discussed in Chapter 3. Pollutants associated with selected classes of industrial and commercial activities are discussed in Chapter 4.

Clean Water Act Framework

The 1972 amendments to the Federal Water Pollution Control Act (referred to as the Clean Water Act [CWA]) prohibit the discharge of any pollutant to navigable waters from a

[3] *Environmental Impacts of Storm Water Discharges—A National Profile*, EPA, June 1992, EPA 841-R-92-001.

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point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit issued under Section 402. In 1987, Section 402(p) was added to the CWA to modify the framework for addressing point source discharges composed entirely of storm water ("storm water discharges") under the NPDES program,[4] establishing a phased approach for issuing NPDES storm water permits. Phase I of the program addresses storm water from industrial facilities and discharges from municipal separate storm sewer systems serving populations of 100,000 or more. Section 402(p)(5) of the CWA directs EPA, in consultation with the States, to study additional storm water discharges not addressed by Phase I. Sections 402(p)(5)(A) and (B) direct EPA, in consultation with the States, to:

- Identify those storm water discharges or classes of storm water discharges for which National Pollutant Discharge Elimination System (NPDES) permits are not required under Phase I of the NPDES storm water program
- Determine, to the maximum extent practicable, the nature and extent of pollutants in such discharges.

Section 402(p)(5)(C) of the CWA requires EPA to establish procedures and methods to control Phase II storm water discharges necessary to mitigate impacts on water quality. Recommendations for procedures and methods to control Phase II storm water discharges are summarized in this report and described in detail in *President Clinton's Clean Water Initiative*, which is found in Appendix L. Together, this report, and *President Clinton's Clean Water Initiative*, fulfill the requirements of Section 402(P)(5) of the CWA.

Section 402(p)(6) of the CWA requires EPA, in consultation with State and local officials, to issue regulations for controlling designated Phase II storm water discharges necessary to protect water quality. The regulations must, at a minimum, establish priorities, requirements for State storm water management programs, and expeditious deadlines. The

[4] Storm water is defined in the NPDES regulations as "storm water runoff, snow melt runoff, and surface runoff and drainage." (40 *CFR* 122.26(b)(13))

program may include performance standards, guidelines, guidance, management practices, and treatment requirements, as appropriate.

Findings

Municipal Separate Storm Sewer Systems

The Bureau of the Census estimates that the population of the United States and associated territories was more than 252.2 million in 1990[5]. The concept of urbanized areas as defined by the Bureau of the Census served as an important tool for analyzing potential approaches to a Phase II program that addresses municipal separate storm sewer systems. More than 160 million people (63 percent of the total U.S. population) reside in the 405 urbanized areas, each with a population of 50,000 or more. The Bureau of the Census has defined an urbanized area as a central city (or cities) surrounded by a densely settled area. To meet the Bureau of the Census definition, the population of the entire urbanized area must be greater than 50,000 persons and the closely settled area outside of the city, the urban fringe, must have a population density generally greater than 1,000 persons per square mile (just over 1.5 persons per acre). These areas occupy less than 2 percent of the Nation's total land area and represent the largest, most widespread areas of dense urban development in the country.

The majority of new urban development also occurs in these urbanized areas. Construction activity related to new development is recognized as a significant source of pollution and impairment of waterbodies, providing some of the best opportunities for implementing storm water management controls in a highly cost-effective fashion. Between 1980 and 1990, the population of urbanized areas increased by 21.2 million.[6] Statistics on

[5] Population estimates based on the 50 States, the District of Columbia, Guam, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands.

[6] About 7 percent of this increase, (1.5 million people) are associated with the net addition of 30 new urbanized areas between 1980 and 1990.

the population, number of urbanized areas, and estimated pollutant loads in runoff in urbanized areas are summarized in Table ES-2 and discussed below.

Phase I of the NPDES program for storm water discharges addresses 81.7 million people in portions of 136 urbanized areas.[7] EPA estimates that about 40 percent of the pollutant loads in storm water discharged from urbanized areas come from Phase I municipalities. The portions of these 136 urbanized areas that are not addressed by Phase I had a combined population of 35.8 million people in 1990. EPA estimates that 28 percent of the pollutant loads in storm water discharged from urbanized areas come from these Phase II portions of the 136 urbanized areas with a Phase I municipality.

Of the Census-designated urbanized areas, 269 do not have any municipalities subject to Phase I of the storm water program. EPA estimates that 32 percent of the pollutant loads in storm water discharged from urbanized areas come from these 269 urbanized areas.

In addition to populations within urbanized areas discussed above, the Bureau of the Census has identified an additional urban population of 29 million people that live outside urbanized areas, as well as 62.8 million people classified as rural. Although discharges from municipal separate storm sewers serving these populations are potential Phase II sources, they are not addressed in detail in this report.

Individual Phase II Facilities

The findings of this report are summarized in terms of the identification, nature, and extent of unregulated individual facilities. Due to very limited national data on which to base

[7] There are 621 incorporated places (cities) and portions of 77 counties within these 136 urbanized areas. Of these municipalities, 140 cities and 45 counties are specifically identified in the NPDES regulations that were published in November 1990. EPA and authorized NPDES States have designated an additional 481 cities and 32 counties as Phase I municipalities. In addition, approximately 30 municipalities (located in 21 urbanized areas) have received combined sewer exclusions where the total population served by separate storm sewers is less than 100,000 after subtracting the population served by combined sewers. The methodology used to classify municipalities as Phase I vs. Phase II for the purposes of this report is discussed in Chapter 2.

Table ES-2. Estimated Pollutant Loadings From Urban Runoff

Classification	Population Category	Number of Urbanized Areas*	Population* (millions)	Percentage of Urbanized Area Loading
NATIONAL		405	252.2	NA
ALL URBANIZED AREAS	50,000 - 99,999	176	12.2	12
	100,000 -249,999	125	19.5	16
	Over 250,000	104	128.7	72
	TOTAL	405	160.4	100
URBANIZED AREAS AFFILIATED WITH PHASE I MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4)				
- Phase I MS4s within Phase I affiliated Urbanized Areas	50,000 - 99,999	8	0.4	0
	100,000 - 249,999	47	6.3	5
	Over 250,000	81	75.0	35
	SUBTOTAL	136	81.7	40
- Phase II Portions of Phase I affiliated Urbanized Areas	50,000 - 99,999	8	0.2	1
	100,000 - 249,999	47	1.9	2
	Over 250,000	81	33.7	25
	SUBTOTAL	136	35.8	28
	TOTAL	136	117.5	68
URBANIZED AREAS NOT AFFILIATED WITH A PHASE I MS4				
- Urbanized Areas Not Affiliated with Phase I MS4s	50,000 - 99,999	168	11.6	11
	100,000 -249,999	78	11.3	9
	Over 250,000	23	20.0	12
	TOTAL	269	42.9	32
- Urbanized Areas Containing a City with a CSO Exemption**	50,000 - 99,999	0	0	0
	100,000 -249,999	7	1.5	1
	Over 250,000	14	16.0	9
	TOTAL	21	17.5	10
PHASE I MS4s OUTSIDE URBANIZED AREAS		NA	4.3	NA

* Totals are based upon 1990 Census, and include Puerto Rico, Guam, Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands.
** Some municipalities identified in the November 1990 application regulations (55 *FR* 47990) as Phase I based on 1980 census data received combined sewer exclusions from Phase I where the total population served by separate storm sewers was less than 100,000 after subtracting the population served by combined sewers. (The 21 urbanized areas [with a population of 17.5 million] containing these municipalities are also contained in the above totals and are not in addition to those totals.)

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loadings estimates, the discussion of the extent of unregulated storm water discharges is limited to an analysis of the number and geographic distribution of the potential Phase II facilities. In general, the distribution of these facilities follows the distribution of population with a large percentage of facilities concentrated within urbanized areas.

EPA's efforts to identify sources and categories of storm water discharges for Phase II of the storm water program started with an examination of approximately 7.7 million commercial, retail, industrial, and institutional facilities for which permits are not required in Phase I. This examination resulted in the identification of two general classes of facilities with the potential for discharging pollutants to waters of the United States through storm water point sources. The first group (Group A) includes sources that are very similar, or identical, to Phase I activities but that were not included in Phase I due to the specific language of the statute or EPA's regulatory specificity in defining the universe of Phase I industrial activities. The second general class of facilities (Group B) were identified on the basis of potential activities and pollutants that may contribute to storm water contamination.

EPA estimates that there are approximately 100,000 facilities in Group A. Facilities in this group, which may be of high priority for Phase II due to their similarity to Phase I industrial facilities include: auxiliary facilities or secondary activities (i.e., maintenance of construction equipment and vehicles, local trucking for an unregulated facility such as a grocery store); facilities intentionally omitted from Phase I (i.e., treatment works with a design flow of less than 1 MGD, landfills that have not received industrial waste); and facilities exempted by the Intermodal Surface Transportation Efficiency Act of 1991 (most industrial activities owned or operated by municipalities of less than 100,000 people[a]).

Group B consists of nearly one million facilities. These have been organized into 18 Phase II sectors for the purposes of this report. Of these 18 sectors, the automobile service

[a] The Intermodal Surface Transportation Efficiency Act of 1991 exempted industrial activities owned or operated by municipalities of less than 100,000 population from Phase I permitting requirements with the exception of powerplants, airports, and uncontrolled sanitary landfills.

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sector (composed of gas/service stations, general automobile repair, car dealers, new and used, car and truck rental, etc.) makes up more than one-third of the total number of facilities identified in all 18 sectors. The 18 Phase II sectors are listed in Table ES-3.

EPA conducted a geographical analysis of these industrial and commercial facilities. The geographical analysis shows that the majority are located in urbanized areas, as presented in Table ES-3. In general, about 30 percent of potential Phase II facilities are found within the geographic jurisdiction of a Phase I municipality. Including the urbanized areas surrounding these Phase I municipalities adds another 12 to 13 percent of potential Phase II facilities. If all urbanized areas are included, an additional 16 percent of potential Phase II facilities are represented. Thus, nearly twice as many industrial facilities are found in all urbanized areas as are found in Phase I municipalities alone.[9]

President Clinton's Clean Water Initiative

President Clinton's Clean Water Initiative provides recommendations on how best to address the additional storm water sources identified by the study in a Phase II NPDES storm water program. The goal of *President Clinton's Clean Water Initiative* is to ensure that future storm water pollution prevention and management programs are focused where the maximum potential benefits can be obtained for the least cost, as well as to provide additional flexibility. A cost-benefit analysis was prepared for the *President's Initiative* and is summarized in Appendix L. No further cost-benefit analyses were conducted for this report.

The *President's Initiative* recommends that Phase II requirements focus on system-wide permits for municipal separate storm sewer systems in Census-designated urbanized areas. These areas consist of only 2 percent of the total land area, yet contain 63 percent of the

[9] Notable exceptions to this generalization include lawn/garden establishments, small currently unregulated feedlots, wholesale livestock, farm and garden machinery repair, bulk petroleum wholesale, farm supplies, lumber and building materials, agricultural chemical dealers, and petroleum pipelines, which can frequently be associated with smaller municipalities or rural areas.

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Table ES-3. Geographic Distribution of Potential Phase II Facilities in Relation to Urbanized Areas

Potential Phase II Facilities Identified		Cumulative % of Facilities Located Within:		
Description	Count	Phase I Areas	Phase I Areas + UAs	All UAs
Phase II - Group A	100,000*	32	45	61
Phase II - Group B	1,015,239	28	40	56
Group B Sectors				
Automotive Service	369,870	27	38	55
Machinery & Electrical Repair	135,744	29	40	56
Intensive Ag. Chemical Use	121,861	26	38	54
Wholesale, Machinery	77,562	32	47	65
Laundries	51,376	38	52	71
Wholesale, Wood Products	48,593	26	36	53
Livestock, Feedlots	43,421**	8	11	20
Petrol. Pipelines & Distributors	35,319	16	25	39
Photographic Activities	30,684	40	53	70
Various Utilities	22,242	24	36	53
Extensive Ag Chem Use	18,992	31	42	62
Transport, Rail and Other	14,808	47	64	81
Wholesale, Metal Products	14,303	36	54	75
Wholesale, Food	11,372	36	49	67
Laboratories	10,683	38	56	74
Muni. Services, Vehicle Maint.	4,611	25	35	51
National Security	2,414	34	43	60
Wholesale, Coal & Ores	1,384	23	31	48

* This figure is an approximation based on the total number of facilities in SIC codes 10 through 45 after subtracting an estimate of the number of facilities covered under Phase I. Geographical distribution information is based on all facilities in SIC codes 10 through 45, and may not be representative of all classes of facilities in this group. For the geographic distribution of specific SIC codes, refer to Appendix G.

** This number is based on SIC codes and does not reflect all feedlots potentially subject to Phase II. The United States Department of Agriculture has estimated that there are approximately 378,000 animal feeding operations between 20 and 1000 animal units. The facilities identified here should be representative of feedlots in general and allow estimation of the distribution of these facilities as a class.

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total population. Phase II areas account for nearly 60 percent of the loadings from urbanized areas, one and a half times the loadings from Phase I areas. In addition, 57 percent of the national population growth over the past decade has occurred in Phase II areas, compared to 30 percent in Phase I.

The *President's Initiative* contains flexibility in its recommendation that municipalities be authorized to regulate industrial discharges and to address commercial, institutional, and retail sources as necessary within their jurisdiction. This would allow municipalities to control Phase II sources using a flexible approach which would be less costly than having EPA or States permitting individual Phase II sources directly through individual or general permits. Facilities which could certify that there will be no exposure of contaminant sources to rain water and snow melt could be exempted from the storm water program altogether. This change would release low-risk facilities from NPDES requirements, allowing allocation of resources to more critical areas. This would also effectively create incentives for facilities to eliminate exposure of contaminants to rain and snow.

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CHAPTER 1. INTRODUCTION

The 1972 amendments to the Federal Water Pollution Control Act (referred to as the Clean Water Act [CWA]) prohibited the discharge of any pollutant to navigable waters from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. In 1987, Section 402(p) was added to the CWA to modify the framework for addressing point source discharges of storm water under the NPDES program. This provision established a phased approach for issuing NPDES permits for storm water discharges. Phase I of the program addresses storm water from industrial facilities and discharges from municipal separate storm sewer systems serving a population of 100,000 or more. Section 402(p)(5) of the CWA directs the United States Environmental Protection Agency (EPA), in consultation with the States, to study additional storm water discharges not addressed by Phase I of the program. Section 402(p)(5) requires a study for the purpose of:

(A) Identifying those storm water discharges or classes of discharges for which permits are not already required as part of the first phase of the NPDES storm water program, and

(B) Determining, to the maximum extent practicable, the nature and extent of pollutants in such discharges.

(C) Establishing procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality.

Section 402(p)(6) of the CWA provides for EPA to issue regulations that designate additional storm water discharges to be controlled to protect water quality under Phase II of the program and to establish a comprehensive program to regulate such designated sources. The program shall, at a minimum, establish priorities, requirements for State storm water management programs, and expeditious deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements, as

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appropriate. This report presents the results of the study required under Section 402(p)(5) of the CWA.

1.1 BACKGROUND ON THE STORM WATER PROBLEM

While rainfall and snow are natural events, the nature of runoff and its impact on water resources is highly dependent on human activities and use of land. Runoff from lands modified by human activities can affect surface water resources in two ways: (1) natural flow patterns can be modified; and (2) pollution concentrations and loadings can be elevated.

Prior to development of land, a natural hydraulic cycle exists. Rainfall infiltrates to recharge ground water supplies and surface runoff drains through the natural streams which flow to form a watershed. Natural flow patterns can be modified by activities that make the land surfaces more impervious. Activities that alter the natural vegetation can change the natural infiltration characteristics of a watershed. This is particularly evident where widespread urban development occurs. Urban land use results in the removal of vegetation cover and the building of impervious structures such as roads, parking lots, sidewalks, and buildings. In urban areas, the cumulative effect of widespread development may bring dramatic changes to natural drainage patterns, which can cause much higher wet-weather peak flows and reduced dry-weather base flows in urban streams and wetlands. Increased peak flows can cause hydromodifications such as stream bank erosion, streambed scour, flooding, channelization, and elimination and/or alteration of habitat.[1] Additional hydromodifications result from engineered activities to accommodate higher peak flows, such as channel excavation, lining (retaining walls, rip-rap), realignment, underground culverts, and draining of wetlands.

Increased imperviousness and loss of wetlands and natural flow channels associated with urban development also decreases the amount of rainwater available for ground water

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[1] *Environmental Impacts of Storm Water Discharges—A National Profile*, EPA, June 1992, EPA 841-R-92-001.

recharge. Reduced ground water levels lower base flows in streams during dry weather periods, which impairs the aquatic habitat, impairs riparian wetlands, and makes receiving streams more sensitive to other pollutant inputs and sedimentation.

Different activities and land uses can also contribute a wide variety of pollutants to runoff. Appendix B provides an overview of different types of impacts associated with different pollutant classes and types of receiving waters and ground water. Pollutants associated with widespread urban development are discussed in Chapter 3. Pollutants associated with selected classes of industrial and commercial activities are discussed in Chapter 4. Chapter 2 provides a description of the methodology and analysis used to develop Chapters 3 and 4.

1.1.1 National Summary of Impacts

The National Water Quality Inventory, a report prepared every 2 years summarizing biennial State reports, as required by Section 305(b) of the CWA, provides a national assessment of surface water impacts associated with runoff from various land uses. The most recent report in this series, *The National Water Quality Inventory, 1992 Report to Congress* provides a general assessment of water quality based on State reports indicating the portion of the States' waters that have been assessed that are not supporting designated uses. The report identifies the sources of use impairment for those waters (e.g., diffuse sources, point sources, and natural sources). Based on information from 51 States and Territories that reported on sources of pollution, the 1992 report indicates that roughly 40 to 60 percent of assessed rivers, lakes, and estuaries are not supporting the uses for which they are designated. In addition, 98 percent of the Great Lake shorelines assessed and 20 percent of the Ocean Coastal Waters were not fully supporting designated uses.

The National Water Quality Inventory, 1992 Report to Congress concludes that storm water runoff from a number of diffuse sources, including agricultural areas, separate storm sewers, urban runoff, and atmospheric deposition, is the leading cause of water quality

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impairment cited by States. Summaries of the major sources contributing to use impairment are provided in Tables 1-1 and 1-2.

The *National Water Quality Inventory* indicates that where impairment occurs, the type of land use (e.g., agriculture, urban, resource extraction) within a watershed is often related to the impairment. Urban land use, while only occupying a small fraction of the total land area of the country,[2] is responsible for a disproportionately high percentage of impairment. Urban land use is expected to be correlated to a number of major sources of impairment identified in the *National Water Quality Inventory*, including municipal point sources, separate storm sewers, urban runoff, combined sewer overflows, and many industrial point sources. At the same time, surface water resources in and near urban populations supply drinking water to 200 million U.S. citizens and provide recreational opportunities for millions more.[3]

The agricultural category listed in the *Inventory* comprises a number of activities, most of which are exempt from the definition of "point source" in Section 502(14) of the CWA which, in part, determines the jurisdiction of the NPDES program. One class of sources related to agriculture that is specifically identified in the statutory definition of point source is concentrated animal feeding operations (CAFOs). As discussed below, EPA has issued regulations to define the scope of the term "concentrated animal feeding operation." Although the contribution of various agricultural activities is difficult to evaluate independently, EPA has estimated that feedlots (which include both CAFOs identified as point sources under the NPDES regulations and other feedlots that are not addressed by the regulatory definition) contribute to 13 percent of impaired river miles, 7 percent of impaired

[2] For example, the 1990 Census indicates that 64 percent of the United States population lives in Census-designated urbanized areas of 50,000 or more. However, these urbanized areas are located on less than 2 percent of the total land area of the country. Other development, including smaller urban populations in areas of 10 acres or more and rural transportation, account for an additional 2 percent of land area. By comparison, agricultural activities, including cropland, pasture land and range land, account for 49 percent of the land in the United States. (See *Summary Report, 1987 National Resources Inventory*, Soil Conservation Service, December 1987).

[3] *President Clinton's Clean Water Initiative*, 1994.

Table 1-1. Major Sources of Water Quality Impairment

	Rivers	Lakes	Estuaries	Great Lake Shorelines	Ocean Coastal Waters
Percent of Waters Assessed	18	46	74	99	6
Percent of Assessed Waters Not Fully Supporting Use	44	57	44	98	20
Percent of Waters Not Fully Supporting Use That is Attributed to Source					
Industrial Point Sources	7		23		29
Municipal Point Sources	15	21	53		
Combined Sewer Overflows				8	59
Separate Storm Sewers/Urban Runoff	11	24	43	11	
Agriculture	72	56	43		
Resource Extraction	11		12		
Hydrologic/Habitat Modification	7	23			
On-Site Wastewater Disposal		16			
Contaminated Sediments				40	25
Land Disposal				31	42
Atmospheric Deposition				50	

<u>Explanation of Pollutant Sources</u>

Industrial Point Sources: Industrial process discharges and cooling water
Municipal Point Sources: Sewage treatment plants, including package plants
Combined Sewer Overflows: Discharges from sewage collection systems of sanitary sewage and runoff
Separate Storm Sewers/Urban Runoff: Discharges from separate storm sewers and other urban runoff
Agriculture: Crop production, pastures, rangeland, feedlots, animal holding/management areas, manure lagoons, aquaculture, and irrigation return flows
Silviculture: Forest management, harvesting, residue maintenance and road construction and maintenance
Resource Extraction: Mining and mine drainage
Hydrologic/Habitat Modification: Channelization, dredging, dam construction, flow regulation, bridge construction, streambank modification/destabilization, drainage/filling of wetlands
Land Disposal: Sludge, wastewater, landfills, industrial land treatment, septic systems, hazardous waste, sewage disposal

Source: *National Water Quality Inventory: 1992 Report to Congress*, EPA, 1994.

Table 1-2. Five Leading Sources of Water Quality Impairment for Selected Classes of Waters

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Municipal Point Sources
2	Municipal Point Sources	Urban Runoff / Storm Sewers	Urban Runoff / Storm Sewers
3	Urban Runoff / Storm Sewers	Hydrologic / Habitat Modification	Agriculture
4	Resource Extraction	Municipal Point Sources	Industrial Point Sources
5	Industrial Point Sources	Onsite Wastewater Disposal	Contaminated Sediments

Source: *National Water Quality Inventory, 1992 Report to Congress*, EPA, 1994.

lake acres, 3 percent of impaired estuary square miles, and negligible amounts of impairment in the Great Lakes and Coastal areas.[4]

1.2 THE NPDES STORM WATER PERMIT PROGRAM

The appropriate means of regulating storm water point sources within the NPDES program has been debated since the establishment of the NPDES program in 1972. Each attempt to devise a workable program has been the focus of substantial controversy concerning the water quality impacts, large number of storm water sources, nature of storm water runoff, and constraints of program priorities and resources.

1.2.1 Early Regulatory Approaches

In 1973, EPA promulgated regulations that exempted a number of categories of point sources from NPDES permit requirements, including: silvicultural point sources; CAFOs below a certain size; irrigation return flows from areas of less than 3,000 contiguous acres or 3,000 noncontiguous acres that use the same drainage system; nonfeedlot, nonirrigation agricultural point sources; and separate storm sewers containing only storm runoff uncontaminated by any industrial or commercial activity (38 *FR* 13530 (May 22, 1973)). The Agency maintained that exemptions were appropriate to conserve the Agency's enforcement resources for more significant point sources of pollution. In addition, the Agency noted that the characteristics of runoff pollution make it difficult to promulgate numeric effluent limitations for most of the point sources exempted by the 1973 regulations.

The Natural Resources Defense Council (NRDC) brought suit in the U.S. District Court for the District of Columbia challenging the Agency's authority to selectively exempt categories of point sources from permit requirements, *NRDC v. Train*, 396 F.Supp. 1393 (D.D.C. 1975), *aff'd*, *NRDC v. Costle*, 568 F.2d 1369 (D.C. Cir. 1977). The District Court held that EPA could not exempt discharges identified as point sources from regulation under

[4] *The Report of the EPA/State Feedlot Workgroup*, EPA, September 1993.

the NPDES permit program. However, in acknowledging the administrative burden placed on the Agency by requiring individual permits, the court recognized EPA's discretion to use certain administrative devices, such as area or general permits, to help manage its workload. In addition, the court recognized some discretion on EPA's part to define what constitutes a point source.

In response to the District Court's decision in *NRDC v. Train*, EPA issued a series of regulations addressing discharges from separate storm sewers (March 18, 1976, (41 *FR* 11307)), CAFOs (March 18, 1976, (41 *FR* 11458)), agricultural activities (July 12, 1976 (41 *FR* 28493)), silviculture activities (June 18, 1976 (41 *FR* 24709)), and aquaculture projects (May 17, 1977 (42 *FR* 25478)). Each of these regulations defined classes of point source discharges that would be subject to the NPDES permit program and exempted other classes of discharges from NPDES jurisdiction.

The regulations addressing NPDES requirements for agricultural activities defined the term agricultural point source to include any discernible, confined, and discrete conveyance from which any irrigation return flow is discharged into navigable waters. In response to these regulations, Congress amended the CWA in 1977 to specifically exclude return flows from irrigated agriculture from the definition of agricultural point source.[5] In 1987, Congress further amended the CWA to exclude agricultural storm water from the definition of agricultural point source.

The regulations addressing NPDES requirements for silvicultural activities defined the term silvicultural point source to include any discernible, confined, and discrete conveyance related to rock crushing, gravel washing, log sorting or log storage facilities which are

[5] *President Clinton's Clean Water Initiative* (1994) recommends that EPA, with the concurrence of the Departments of Agriculture and the Interior, and after consultation with States and other Federal agencies, should submit a report to Congress within two years after reauthorization of the CWA that evaluates the nature and extent of water quality problems presented by irrigation return flows, identifies the most promising and cost-effective technical and programmatic solutions to these problems, and recommends appropriate actions, including programmatic improvements and necessary legislative changes.

operated in connection with silvicultural activities and from which pollutants are discharged into navigable waters. The regulation clarified that the term did not include nonpoint source activities inherent to silviculture such as nursery operations, site preparation, reforestation and subsequent cultural treatment, thinning, prescribed burning, pest and fire control, harvesting operations surface drainage, and road construction and maintenance from which there is runoff.

The regulations addressing NPDES requirements for CAFOs clarified that CAFOs are point sources. CAFOs are defined as animal feeding operations that discharge to waters of the United States at times other than during events greater than a 25-year, 24-hour storm and that (1) have more than 1,000 animal units; (2) have more than 300 animal units and pollutants are discharged into navigable waters through a man-made flushing system or other man-made device, or pollutants are discharged directly into waters of the United States which originate outside of and pass over, across or through the facility or otherwise come into direct contact with the animals confined in the operation; or (3) are designated by EPA or an authorized NPDES State upon determining that it is a significant contributor of pollution to waters of the United States.

The regulations addressing NPDES requirements for concentrated aquatic animal production facilities (CAAPFs) clarified that CAAPFs are point sources. CAAPFs are defined as a hatchery, fish farm or other facility which harvest fish over specified limits or which is otherwise designated by EPA or an authorized NPDES State upon determining that it is a significant contributor of pollution to waters of the United States.

The regulations addressing separate storm sewers established a comprehensive permit program. This rule substantially increased the number of storm water discharges subject to the NPDES program. Permits continued to be required for conveyances carrying contaminated storm water runoff from areas used for industrial or commercial activities, as well as storm water discharges designated by the permit-issuing authority as significant contributors of pollution. These sources were required to submit individual permit applications required of industrial and commercial process wastewater dischargers. In addition, the 1976 rule brought into the permitting program separate storm sewers defined as "a conveyance or system of conveyances . . . located in an urbanized area and primarily operated for the purpose of collecting and conveying storm water runoff." Channelized storm water runoff from rural areas that did not contain runoff from commercial or industrial activity was not defined as a point source unless designated otherwise by the permitting authority. Permit applications were not required for separate storm sewers at that time. EPA planned to study these discharges and issue general or area permits to address these sources because these discharges were expected to be less significant than runoff from industrial facilities. During this time, permitting efforts for storm water discharges focused on industrial facilities with effluent guideline limitations for their storm water discharges.[6]

On June 7, 1979, and May 19, 1980, EPA published comprehensive revisions to the NPDES regulations (44 *FR* 32854 (June 7, 1979); 45 *FR* 33290 (May 19, 1980)). These rules essentially retained the March 18, 1976, broad definition of storm water discharges subject to NPDES permit requirements but required more stringent application data for storm water point sources. Under these regulations, the same application information required of all industrial and commercial process wastewater dischargers would be required of all storm water point sources. The new requirements included testing under certain circumstances for a substantially greater number of pollutants identified in the 1977 amendments to the CWA.

This regulation brought suits in several Courts of Appeals and District Courts by numerous major trade associations, several of their member companies, NRDC, and Citizens for a Better Environment. The suits challenged many aspects of the NPDES regulations, including the storm water provisions. Eventually all petitions for review were consolidated

[6] The following effluent limitations guidelines address storm water or a combination of storm water and process water: cement manufacturing (40 *CFR* Part 411); concentrated animal feeding operations (40 *CFR* Part 412); fertilizer manufacturing (40 *CFR* Part 418); petroleum refining (40 *CFR* Part 419); phosphate manufacturing (40 *CFR* Part 422); steam electric (40 *CFR* Part 423); coal mining (40 *CFR* Part 434); mineral mining and processing (40 *CFR* Part 436); ore mining and dressing (40 *CFR* Part 440); and asphalt emulsions (40 *CFR* Part 443).

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in the U.S. Court of Appeals for the D.C. Circuit (*NRDC v. EPA*, 673 F.2d 392 (DC Cir. 1980)).

After 2 years of intensive settlement negotiations with representatives of most of the petitioners, the Agency and industry petitioners signed a settlement agreement on July 7, 1982, which addressed a number of issues relating to the NPDES program, including storm water. Under the terms of the agreement, EPA agreed to changes to the storm water regulations which were finalized on September 26, 1984 (49 *FR* 37998).

The 1984 final rule recognized two fundamental issues regarding the NPDES regulation of storm water: (1) which storm water discharges should be classified as pcint sources, and, therefore, within the NPDES program and (2) what is the best way to regulate these sources. On the first issue, data available to EPA, such as the Nationwide Urban Runoff Program (NURP) study, indicated that there are water quality problems associated with storm water runoff. The final rule retained the broad coverage of the 1980 rule in mandating the permitting of all storm water point sources that discharge pollutants into waters of the United States. The September 26, 1984, rule defined a storm water point source as a channelized conveyance of storm water runoff that (1) is located in an urbanized area, as defined by the Bureau of the Census, (2) discharges from lands or facilities used for industrial or commercial activities, or (3) is designated by the Director of the NPDES Program.

To address the second issue of how to regulate these sources administratively, the final rule set forth two categories of storm water point sources, each with different application requirements. Group I storm water point sources were defined as sources either subject to effluent limitations guidelines, located at an industrial plant, or plant-associated area, or designated by the Director. All other storm water point sources were classified as Group II. Group I dischargers were required to submit the NPDES application form for industrial and commercial process wastewater discharges, including certain sampling and testing data. The application requirements for Group II were significantly reduced. Group II sources were

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required to submit only Form 1 and a narrative description of the drainage area, receiving water, and any treatment applied to the discharge.

These storm water regulations generated considerable controversy (through post-promulgation comment) and, once again, suits were filed. The 1984 rules deleted the term "contaminated" and relied instead on geographic criteria to define sources subject to permitting. Some commenters claimed that the new definitions would subject thousands of discharges to the program for the first time. However, in EPA's view, the scope of coverage of storm water point sources under the NPDES program was essentially unchanged by the September 26, 1984, rulemaking.

Upon consideration of post-promulgation comments, EPA concluded that it would be appropriate to obtain additional data on storm water discharges to assess their significance as an environmental problem and to identify the best means of control. Although the number of dischargers required to submit quantitative testing data had been reduced by the 1984 rule, tens of thousands of storm water point sources remained to be identified, tested, and analyzed. Despite the improvements made in the 1984 regulation, EPA realized it was appropriate to request comments on whether the collection of data from each individual Group I discharger was necessary and efficient. In addition, EPA realized that new deadlines would need to be established. EPA published proposed changes to the storm water regulations on March 7, 1985, at 50 *FR* 9362 and on August 12, 1985, at 50 *FR* 27354. These proposals were not finalized because of the passage of the Water Quality Act of 1987.

1.2.2 Water Quality Act of 1987

Section 402(p) was added to the CWA in 1987 to require implementation of a comprehensive two-phased approach for addressing storm water discharges under the NPDES program. Section 402(p)(1) prohibits EPA or NPDES States from requiring permits for discharges composed entirely of storm water ("storm water discharges") until October 1, 1992 (this deadline was later extended to October 1, 1994, by the Water Resources

Development Act of 1992), except for the following five classes of Phase I storm water discharges specifically listed under Section 402(p)(2):

- Storm water discharges issued a permit before February 4, 1987
- Storm water discharges associated with industrial activity
- Discharges from a municipal separate storm sewer system serving a population of 250,000 or more
- Discharges from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000
- Storm water discharges that EPA or an NPDES State determine to be contributing to a violation of a water quality standard or a significant contributor of pollutants to the waters of the United States.

Section 402(p)(3)(A) of the CWA requires storm water associated with industrial activity to meet all applicable provisions of Sections 402 and 301 of the CWA, including technology-based requirements and any necessary water quality-based requirements. Section 402(p)(3)(B) makes significant changes to the permit standards for discharges from municipal separate storm sewer systems.[7] Permits for discharges from municipal separate storm sewers:

- May be issued on a system- or jurisdiction-wide basis
- Shall include a requirement to effectively prohibit non-storm water discharges into the storm sewers
- Shall require controls to reduce pollutant discharges to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions determined appropriate for the control of such pollutants.

[7] The 1987 amendments to the CWA did not specifically address requirements for water quality-based permit conditions in NPDES permits for discharges from municipal separate storm sewer systems. EPA interprets the Act to require that permits for discharges from municipal separate storm sewers include any requirements necessary to achieve compliance with water quality standards.

Section 402(p)(4) of the CWA establishes statutory deadlines for the initial steps in implementing the Phase I program. Deadlines are established for the development of permit application regulations, submission of permit applications, issuance of permits for Phase I sources, and compliance with permit conditions.

The 1987 amendments did not identify what sources would be subject to the NPDES program after the temporary moratorium on permit requirements of Section 402(p)(1) expired. Rather, the amendments established a process for EPA to evaluate potential Phase II sources and designate sources for regulation to protect water quality. Section 402(p)(5) of the CWA requires EPA, in consultation with the States, to conduct a study of storm water discharges other than Phase I sources (i.e., potential Phase II sources). The study is to identify storm water discharges not covered under Phase I and determine, to the maximum extent practicable, the nature and extent of pollutants in such discharges. The study is also to establish procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality.

Section 402(p)(6) of the CWA requires EPA, in consultation with State and local officials, to issue regulations designating additional Phase II storm water discharges to be regulated to protect water quality and to establish a comprehensive program to regulate such designated sources. The comprehensive program to regulate such designated sources must, at a minimum, establish priorities, requirements for State storm water management programs, and expeditious deadlines. The program may include performance standards, guidelines, guidance, management practices, and treatment requirements, as appropriate.

1.2.3 Phase I Regulatory Framework

EPA promulgated regulations for Phase I storm water discharges on November 16, 1990 (55 *FR* 47990). These regulations clarified the scope of the Phase I storm water program by providing regulatory definitions for the major classes of storm water discharges identified under Section 402(p)(2)(B), (C), and (D) of the CWA:

- Storm water discharges associated with industrial activity
- Discharges from municipal separate storm sewer systems serving a population of 100,000 or more.[8]

In addition, the November 16, 1990, regulations established permit application requirements, including submittal deadlines, for these classes of discharges.

The November 16, 1990, regulations define municipal separate storm sewer systems serving a population of 100,000 or more to include municipal separate storm sewers within the boundaries of 173 incorporated cities and within unincorporated portions of 47 counties with populations of 100,000 or more in their unincorporated areas.[9] The regulations allowed for additional municipal separate storm sewers to be designated by the NPDES permitting authority (EPA or an authorized NPDES State) as being part of a municipal separate storm sewer system subject to Phase I requirements. In addition, the regulations established comprehensive two-part permit applications for discharges from municipal separate storm sewer systems serving a population of 100,000 or more. Among other things, the permit applications require municipal applicants to propose municipal storm water management programs to control pollutants to the maximum extent practicable and to effectively prohibit non-storm water discharges to the municipal system.[10] Municipal storm water management programs are a combination of source controls and management practices that address targeted sources within the boundaries of the municipal system. Under this program, EPA has defined the role of municipalities in a flexible manner that allows local governments to assist in defining priority pollutant sources within the municipality and to develop and

[8] Consistent with Section 402(p)(2) of the CWA, the November 16, 1990, regulations address two subclasses of municipal separate storm sewer systems serving a population of 100,000 or more. Large municipal separate storm sewer systems are defined as systems serving a population of 250,000 or more (40 *CFR* 122.26(b)(4)). Medium municipal separate storm sewer systems are defined as systems serving a population of 100,000 or more, but less than 250,000 (40 *CFR* 122.26(b)(7)).

[9] See Appendices F, G, H, and I to 40 *CFR* 122.

[10] See 40 *CFR* 122.26(d)(2)(iv).

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implement appropriate controls for such discharges. Municipal programs can establish requirements for the control of discharges to the municipal system from privately owned lands (e.g., sediment and erosion control for construction sites) and can address municipal activities that affect storm water quality (e.g., maintenance of leaking sanitary sewers, road de-icing and maintenance, operation of municipal landfills, and some flood control efforts).

Moreover, the November 16, 1990, regulations defined the term "storm water discharges associated with industrial activity" to include 11 categories of industrial facilities (see 40 *CFR* 122.26(b)(14)) and established application requirements for such discharges.[11] In light of concerns raised by the industrial community about the complexity of the November 1990 storm water regulations, the difficulty in determining whether particular facilities were subject to the new rules, and administrative delays in permit issuance, EPA issued a series of extensions to permit application deadlines for discharges associated with industrial activity.[12] With these extensions, October 1, 1992, was established as the date by which any facility with a storm water discharge associated with industrial activity must submit either an individual or group application or obtain coverage under an applicable general permit.

Congress also has acted to grant extensions to the application deadlines for selected classes of discharges associated with industrial activity. In March 1991, Congress adopted Section 307 of the Dire Emergency Supplemental Appropriations Act of 1991, which ratified EPA's extension of Part I of the group applications to September 30, 1991. On December 18, 1991, the Intermodal Surface Transportation Efficiency Act of 1991 (or Transportation Act), extended NPDES permit application deadlines for storm water discharges associated with industrial activity from facilities that are owned or operated by municipalities. In addition, Section 1068(c) of the Transportation Act amended the Clean Water Act to provide

[11] As discussed below, on June 4, 1992, the U.S. Court of Appeals for the Ninth Circuit found EPA's rationale for exempting construction sites of less than 5 acres and certain uncontaminated storm water discharges from light industrial facilities from Phase I of the storm water program to be invalid and has remanded these exemptions for further proceedings (see *NRDC v. EPA*, 966 F.2d 1292 (9th Cir. 1992)).

[12] See 56 *FR* 12098 (March 21, 1991), 56 *FR* 56548 (November 5, 1991), 57 *FR* 11524 (April 2, 1992).

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that EPA shall not require any municipality with a population of less than 100,000 to apply for or obtain a permit for any storm water discharge associated with industrial activity other than an airport, power plant, or uncontrolled sanitary landfill owned or operated by such municipalities before October 1, 1992. In response to this provision, EPA has reserved application deadlines for these facilities.[13]

EPA also has modified the NPDES regulations to provide a greater degree of emphasis on site inspections as an alternative or supplement to discharge monitoring in permits for storm water discharges associated with industrial activity.[14]

On June 4, 1992, the United States Court of Appeals for the Ninth Circuit issued an opinion granting in part a petition for review of EPA's 1990 storm water regulations (*NRDC* v. *EPA*, 966 F.2d 1292 (9th Cir. 1992)). The court upheld several provisions of the regulations, including the definition of municipal separate storm sewer system, the standards for municipal storm water controls, the scope of the permit exemption for oil and gas operations, and EPA's decision not to provide public comment on Part 1 of the group applications for storm water discharges associated with industrial activity.

The Court did declare EPA's extension of the statutory deadlines for storm water permit applications to be unlawful, but declined to strike down the deadlines as the plaintiff had requested. In addition, the Court struck down and remanded two exemptions from the definition of storm water discharges associated with industrial activity.

One of the remanded exemptions addressed construction activities that result in the disturbance of less than 5 acres of total land area which are not part of a larger common plan of development or sale. EPA noted that State and local sediment and erosion controls may

[13] See 57 *FR* 11524 (April 2, 1992), 40 *CFR* 122.26(e)(1)(ii).

[14] See 57 *FR* 11524 (April 2, 1992), 40 *CFR* 122.44(i).

address construction activities of less than 5 acres and that the acreage limit reflected land disturbances that were industrial in magnitude because disturbances on large tracts of land will employ more heavy machinery and industrial equipment. The Court noted that EPA had proposed to exempt only sites for commercial and industrial construction smaller than 1 acre and sites for residential construction smaller than 5 acres. In the final rule, the exemption was increased to 5 acres for all construction sites, based on the Agency's determination that smaller sites would not have levels of activity similar to other industrial activities. The court ruled, however, that the record did not indicate "that construction sites on less than five acres are non-industrial in nature" (966 F.2d at 1306). The court rejected EPA's argument that the 5-acre cutoff constituted a *de minimis* exemption, because the record lacked information to suggest whether smaller discharges would be *de minimis*.

A second remanded exemption addressed light manufacturing facilities where material handling equipment or activities, raw material, intermediate products, final products, waste materials, byproducts, or industrial machinery are not exposed to storm water. With respect to the light industry category, EPA had adopted the exemption based on the belief that if (1) the activities in the selected facilities are undertaken in buildings; (2) emissions from stacks are minimal or nonexistent; (3) there is no unhoused manufacturing and heavy industrial equipment, outside storage, disposal, or handling of raw, finished, or waste materials; (4) and the activities being performed do not generate significant dust or particulates, the facility posed a much smaller risk of storm water contamination. Based on these factors, the Agency believed that these facilities were similar to commercial businesses, such as retail and service facilities.

The court noted, however, that the statutory term associated with industrial activity was very broad and concluded that Congress intended only to exempt discharges from non-industrial facility areas such as parking lots. The court rejected EPA's argument that industrial pollutant levels in storm water would be minimal at light industrial facilities, finding nothing in the record to support that conclusion. Therefore, the court found this exemption to be arbitrary and capricious (966 F.2d at 1304-05).

In response to the Ninth Circuit decision, EPA promulgated rules on December 18, 1992, specifying dates for permit approval or denial and permit compliance. In the December 18, 1992, notice, EPA also noted that it did not believe that the court's opinion had the effect of automatically subjecting small construction sites and light industries to the existing application requirements and deadlines for storm water discharges associated with industrial activity. The Agency also indicated that it believed that additional notice and comment rulemaking was necessary to clarify the status of these facilities under the storm water program.

1.2.4 Phase I Implementation Activities

The initial efforts to implement the Phase I storm water program have focused on reviewing group applications for industrial storm water, issuing general permits for industrial storm water, publishing draft general permits for storm water discharges from 29 industrial sectors, reviewing applications for municipal separate storm sewer systems, issuing permits for municipal separate storm sewer systems, and conducting outreach activities. In addition, the Agency, in conjunction with the Rensselaerville Institute, completed a study to develop recommendations for making Phase I of the program more effective.

1.2.4.1 General Permits

In September 1992 (April 1993 for Puerto Rico) EPA issued general permits for storm water discharges associated with industrial activity in the 11 States without NPDES authority, as well as for Territories, States where EPA issues permits for Federal facilities, and Federal Indian Reservations. Unlike traditional NPDES permits, these permits generally do not establish numeric effluent limitations for most discharges authorized by the permits.[15] Rather, the permits establish requirements for notices of intent, site inspections conducted by dischargers, and site-specific pollution prevention plans. The requirements for pollution prevention plans provide a framework for dischargers to identify sources of pollution and best management practices to prevent, reduce and/or control such pollutant sources. In addition, targeted facilities are required to sample and analyze their storm water discharges.

When the storm water application rules were issued in November 1990, only 17 out of the 39 authorized States authorized to administer the NPDES program were also approved to issue NPDES general permits. Since then, an additional 21 States have requested and received EPA approval to issue general permits, and one additional State has received NPDES authorization, including general permit authority. All but one of the States that now have general permit authority have issued general permits for storm water discharges.

1.2.4.2 Group Applications

EPA has received more than 1,200 Part I group applications representing more than 60,000 industrial facilities with storm water discharges. EPA has requested public comment on draft permits to address discharges identified in these applications that are in States without authorized NPDES programs.[16] The draft general permits contain requirements for 29 different industrial sectors.

1.2.4.3 Municipal Applications

Permit applications have been received for almost all municipal separate storm sewer systems serving a population of 100,000 or more. This represents a substantial initial

[15] The permits do establish numeric effluent limitations for some classes of storm water discharges. These limitations are either based on best available technology or established pursuant to State certifications under Section 401 of the CWA.

[16] See 58 *FR* 61146 (November 19, 1993).

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investment into Phase I of the storm water program by municipalities.[17] At the heart of these applications are proposed municipal storm water management programs, which will identify a variety of site-specific pollution prevention measures, source controls, and best management practices to control pollutants from targeted sources within the municipality.[18] EPA and authorized NPDES States have started to issue permits for these municipal separate storm sewer systems. The Agency estimates that 263 permits will be issued for Phase I municipal separate storm sewer systems; as of May 1994, 24 permits have been issued.

1.2.4.4 Rensselaerville Phase I Effort

In 1992 EPA completed a study, in conjunction with the Rensselaerville Institute, to obtain direct public input and develop recommendations for improving Phase I of the storm water program. These studies are discussed in more detail in Appendix I. The study raised five key issues relating to Phase I sources:

- Study participants thought that EPA has not been clear enough about the intended goals of the regulations and should communicate storm water risks, objectives, and requirements more clearly to the general public, as well as to the regulated community.
- Participants noted that the cost of program implementation is significantly higher than original EPA estimates and that there is great concern regarding the real costs of the program and of achieving compliance.
- Participants agreed that EPA and States must accelerate general permit issuance and focus on general permits to achieve efficient implementation of the program.

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[17] The National Association of Flood and Stormwater Management Agencies estimates based on a 1992 survey that municipalities have spent more than $130 million on preparing NPDES permit applications for discharges from Phase I municipal separate storm sewer systems.

[18] A review of cost estimates for proposed municipal storm water management programs provided in 20 applications indicates that municipalities estimate the cost of program implementation (excluding permit application costs) to range from $23.91 to $37.00 per person. (See draft *Review of Program Costs in Part 2 NPDES Municipal Storm Water Permit Applications*, EPA, 1993.)

- Participants felt that technical outreach should be targeted at the State and local level rather than the national level and should provide better guidance on the regulations and their implementation.

- Participants noted that coverage under certain industrial storm water categories should be clarified.

EPA agreed with these recommendations and has taken steps to follow up in each area.

1.2.5 September 9, 1992 Notice—Phase II Issues

On September 9, 1992, EPA published a notice requesting information and public comment on the Phase II program. The notice is included in Appendix H of this report. The notice identified three sets of issues associated with developing Phase II regulations:

- How should sources that are to be subject to Phase II regulations be identified?
- What types of control strategies should be developed for these sources?
- What are appropriate deadlines for implementing Phase II requirements?

The September 9, 1992, notice presented a range of alternatives under each issue in an attempt to illustrate, and obtain input on, the full range of potential approaches for a Phase II strategy. The notice recognized that potential sources for coverage under Phase II fall into two main categories: municipalities; and individual sources (commercial and residential) activities. EPA recognized that a major distinction between most options for identifying Phase II commercial/residential sources was either to require targeted municipalities to develop source controls and management programs for storm water discharges within their jurisdictions or to require permits for discharges from individual facilities.

EPA received more than 130 comments on the September 9, 1992, notice. Approximately 43 percent of the comments were from municipalities, 29 percent from trade groups or industries, 24 percent from State or Federal agencies, and approximately 3 percent from other miscellaneous sources.[19] No comments were received from environmental groups. Appendix J contains a detailed summary of comments received as they relate to the specific issues raised in the notice.

1.2.6 Rensselaerville Phase II Effort

In early 1993, the Rensselaerville Institute and EPA held public and expert meetings to assist in developing and analyzing options for identifying Phase II sources and controls. These meetings and the resulting options are discussed in more detail in Appendix I of this report. The report on the effort indicates that the two options most favored by the various groups participating were:

- A program where States would select sources to be controlled in a manner that was consistent with criteria developed by EPA. The Phase II program would provide States with flexibility to either rely on NPDES requirements or other frameworks to control targeted sources.
- A tiered approach that would provide for EPA selection of high priority sources for control by NPDES permits and State selection of other sources for control under a State program other than the NPDES program.

1.2.7 President Clinton's Clean Water Initiative

On February 1, 1994, *President Clinton's Clean Water Initiative* was issued. The *President's Initiative* addresses a number of issues associated with NPDES requirements for storm water discharges, including:

- Compliance of discharges from municipal separate storm sewer systems with water quality standards
- Industrial facilities with no activities or significant materials exposed to storm water
- Deadline extensions for Phase II of the storm water program

[19] Percentages have been rounded off, and hence may not total 100 percent.

- Phase II storm water program requirements, including regulation of storm water from industrial facilities by municipalities
- Control of discharges from inactive and abandoned mines (IAMs) located on Federal lands.

To address municipal compliance with water quality standards, the *President's Initiative* recommends that the CWA be amended to establish a phased permit compliance approach that requires best management practices in first-round municipal storm water permits and improved best management practices in second-round permits, where necessary, to move towards compliance with water quality standards. In later permits, compliance with water quality standards will occur using water quality-based effluent limits, where necessary. This would give EPA and municipalities additional time to evaluate the technical feasibility of establishing numeric effluent limits to meet water quality standards and give States time to develop specific water quality standards appropriate for storm water discharges, if necessary. The *President's Initiative* further supports clarifying authority under section 402(p)(3)(B) concerning "maximum extent practicable" (MEP).

The *President's Initiative* recommends that EPA be authorized to exempt from individual storm water permitting requirements facilities that can certify that there is no—nor will there be—exposure of industrial or other activities or significant materials to rain water and snow melt. This change would ensure that several hundred thousand low-risk facilities are not subject to NPDES requirements, allowing allocation of resources to more critical areas. This would also effectively create incentives for facilities to eliminate contamination of storm water.

The *President's Initiative* recommends that the statutory deadline for EPA to issue Phase II regulations be extended. The *President's Initiative* also recommends that the deadline for Phase II sources to obtain a permit be extended. The *President's Initiative* indicated that extensions would allow EPA to work with States and municipalities in developing workable, effective regulations. A new deadline for permits would give municipalities an opportunity to begin to build institutional frameworks and provide the funding necessary to implement storm water management programs. It would also allow permits to be issued to Phase II municipalities at the same time Phase I permits are expiring. This would promote regional and watershed-wide permitting by allowing different municipalities to be co-applicants and to coordinate their storm water programs.

With respect to NPDES requirements for Phase II storm water discharges, the *President's Initiative* recommends[20] that NPDES Phase II requirements for storm water focus on system-wide permits for municipal separate storm sewer systems in Census-designated urbanized areas.[21] The *President's Initiative* recommends tiered permitting requirements. Storm water management programs would be developed for municipal separate storm sewer systems located within an urbanized area in which a municipal separate storm sewer system is already addressed under Phase I. The programs would, at a minimum, address non-storm water discharges into storm sewers and storm water runoff from growth and development and significant redevelopment. NPDES permitting authorities should be encouraged to implement watershed approaches which implement a more comprehensive municipal storm water management program where appropriate based on water quality impairments or other factors for municipal separate storm sewer systems in these urbanized areas. In the remaining Census-designated urbanized areas, municipal storm water management programs would be required which focus only on controlling non-storm water discharges into storm sewers and storm water runoff from growth, development, and significant redevelopment activities. The *President's Initiative* recommends that Phase II of the NPDES program not directly regulate Phase II light industrial, commercial, retail, and

[20] While the *President's Initiative* generally speaks to recommended statutory changes, EPA notes that under the existing CWA, with the exception of extending the deadline for permits for discharges from municipal separate storm sewer systems to comply with water quality-based requirements, EPA could issue Phase II regulations covering the same facilities to the same extent as suggested in the *President's Initiative*.

[21] The Bureau of the Census defines urbanized areas as a central city (or cities) with a surrounding area that is densely settled (i.e., urban fringe). The population of the entire urbanized area must be greater than 50,000 persons, and the urban fringe must have a population density generally greater than 1,000 persons per square mile (approximately 1.5 persons per acre). A complete description of the Bureau of the Census definition is provided in Chapter 3.

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institutional storm water discharges, and municipalities outside of Census-designated urbanized areas unless designated by the permitting authority for inclusion in the NPDES program under Section 402(p)(2)(E) of the CWA. Rather, such discharges, if a targeted source, should be addressed by Nonpoint Source programs.

The *President's Initiative* recommends authorizing municipalities to directly control Phase I industrial storm water facilities within their jurisdictions under the NPDES program. This recommendation is similar to the industrial pretreatment program currently authorized under the CWA. The *President's Initiative* recommends clarifying authority to issue permits on a statewide basis for IAMs, allowing Federal land managers to establish priorities and make the most effective use of available resources. Land managers would be allowed up to 10 years to meet appropriate water quality standards, while continuing to identify additional impacts from IAMs and implementing targeted controls once identified. A cost-benefit analysis was prepared for the *President's Initiative* and is summarized in Appendix L. No further cost-benefit analyses were conducted for this report.

1.2.8 NPDES Watershed Strategy

EPA issued the NPDES Watershed Strategy in March 1994. The Strategy discusses integration of NPDES program functions into a broader watershed protection approach and areas for coordination with stakeholders to promote implementation of the approach. The NPDES Watershed Strategy is based on the following principles:

- Watershed protection approaches may vary in terms of specific elements, timing, and resources, but all should share a common emphasis and insistence on integrated actions, specific action items, and measurable environmental and programmatic milestones.
- Related activities within a basin or watershed must be coordinated to achieve the greatest environmental benefit and most effective level of stakeholder involvement.

- Actions relating to restoration and protection of surface water, ground water, and habitat within a basin should be based upon an integrated decision-making process, a common information base, and a common understanding of the roles, priorities, and responsibilities of all stakeholders within a basin.
- Staff and financial resources are limited and must be allocated to address environmental priorities as effectively and efficiently as possible.
- Program requirements that interfere or conflict with environmental priorities should be identified and revised to the extent possible.
- Accurate information and high quality data are necessary for decision-making and should be collected on an incremental basis; interim decisions should be made based on available data to prevent further degradation and promote restoration of natural resources.

1.3 RELATED NONPOINT SOURCE PROGRAMS

1.3.1 Section 319 of the CWA

In 1987, Section 319 was added to the CWA to provide a framework for funding State and local efforts to address pollutant sources not addressed by the NPDES program (e.g., nonpoint sources). To obtain funding, States were required to submit Nonpoint Source Assessment Reports identifying State waters that, without additional control of nonpoint sources of pollution, could not reasonably be expected to attain or maintain applicable water quality standards or the goals and requirements of the CWA. States were also required to prepare and submit for EPA approval a statewide Nonpoint Source Management Program for controlling nonpoint source water pollution to navigable waters within the State and improving the quality of such waters. State program submittals were to identify specific best management practices (BMPs) and measures that the State proposes to implement in the first 4 years after program submission to reduce pollutant loadings from identified nonpoint sources to levels required to achieve the stated water quality objectives.

State programs funded under Section 319 can include both regulatory and nonregulatory State and local approaches. Section 319(b)(2)(B) specifies that a combination of "non-regulatory or regulatory programs for enforcement, technical assistance, financial assistance, education, training, technology transfer, and demonstration projects" may be used, as necessary, to achieve implementation of the BMPs or measures identified in the Section 319 submittals.

Although most States have generally emphasized the use of voluntary approaches in their 319 programs, some States and local governments have implemented regulations and policies to control pollution from urban runoff. States such as Delaware and Florida, as well as local jurisdictions such as the Lower Colorado River Authority, are pursuing storm water management goals through numerical treatment standards for new development. Many States and local governments have enforceable erosion and sediment control regulations. On a broader scale, nonpoint source pollution is being addressed at the watershed level by programs such as those being implemented by the State of Wisconsin, the Puget Sound Water Quality Authority, the States that are parties to the Great Lakes Water Quality Agreement, and other States. A number of individual States and local communities have adopted legislation or regulations similar to Maryland's Critical Areas Act, which limits development and/or requires special management practices in areas surrounding water resources of special concern.

1.3.2 Section 6217 of CZARA

Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 provides that States with approved coastal zone management programs must develop and submit coastal nonpoint pollution control programs to EPA and the National Oceanic and Atmospheric Administration (NOAA) for approval. Failure to submit an approvable program will result in a reduction of Federal grants under both the Coastal Zone Management Act and Section 319 of the CWA.

State coastal nonpoint pollution control programs under CZARA must include enforceable policies and mechanisms that ensure implementation of the management measures throughout the coastal management area. Section 6217(g)(5) defines management measures as "economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives." Congress mandated a technology-based approach based on technical and economic achievability under the rationale that neither States nor EPA have the money, time, or other resources to create and expeditiously implement a program that depends on establishing cause and effect linkages among particular land use activities and specific water quality problems. If this technology-based approach fails to achieve and maintain applicable water quality standards and to protect designated uses, CZARA Section 6217(b)(3) requires additional management measures.

EPA issued *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* under Section 6217(g) in January 1993. The Guidance identifies management measures for five major categories of nonpoint source pollution: Agriculture, Forestry, Urban, Marinas and Recreational Boating, and Hydromodification. The management measures reflect the greatest degree of pollutant reduction that is economically achievable for each of the listed sources. These management measures provide reference standards for the States to use in developing or refining their coastal nonpoint programs. In general, the management measures were written to describe systems designed to reduce the generation of pollutants. A few management measures, however, contain quantitative standards that specify pollutant loading reductions.[22] The management measures approach was adopted to provide State officials flexibility in selecting strategies and management systems and practices that are appropriate for regional or local conditions, provided that equivalent or higher levels of pollutant control are achieved. Appendix K of this report summarizes the management measures for urban areas, animal feedlots, and marinas that were identified in the guidance.

[22] For example, the New Development Management Measure, which is applicable to construction in urban areas, requires: (1) that by design or performance that the average annual total suspended solid loadings be reduced by 80 percent; and (2) to the extent practicable, that the predevelopment peak runoff rate and average volume be maintained.

Storm water discharges regulated under Phase I of the NPDES program, such as discharges from municipal separate storm sewers serving a population of 100,000 or more and construction activities that disturb 5 or more acres, do not need to be addressed in Coastal Nonpoint Pollution Control Programs. However, potential Phase II sources, such as urban development adjacent to or surrounding Phase I municipal systems, smaller urbanized areas, and construction sites that disturb less than 5 acres, that are identified in management measures under Section 6217 guidance need to be addressed in Coastal Nonpoint Pollution Control Programs until such discharges are issued an NPDES permit. EPA and NOAA have worked, and continue to work, together in their activities to ensure that there is not an overlap of authorities between NPDES and CZARA.

EPA and NOAA published *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*, which addresses such issues as the basis and process for EPA/NOAA approval of State Coastal Nonpoint Pollution Control Programs; how EPA and NOAA expect State programs to implement management measures in conformity with EPA guidance; and procedures for reviewing and modifying State coastal boundaries to meet program requirements. The guidance clarifies that States generally must implement management measures for each source category identified in the guidance developed under Section 6217(g). This guidance sets quantitative performance standards for some measures. Coastal Nonpoint Pollution Control Programs are not required to address sources that are clearly regulated under the NPDES program as point source discharges. The guidance also clarifies that regulatory and nonregulatory mechanisms may be used to meet the requirement for enforceable policies and mechanisms, provided that nonregulatory approaches are backed by enforceable State authority ensuring that the management measures will be implemented. Backup authority can include sunset provisions for incentive programs. For example, a State may provide additional incentives if too few operators participate in a tax incentive program or develop mandatory requirements to achieve the necessary implementation of management measures.

1.3.3 President Clinton's Clean Water Initiative—Nonpoint Source Programs

President Clinton's Clean Water Initiative proposes a fundamental restructuring and strengthening of the nonpoint source pollution (NPS) control programs under Section 319 of the CWA. The *President's Initiative* proposes legislative changes that will result in upgraded and strengthened existing State NPS management programs within seven and one-half years of reauthorization of the CWA. These programs will implement best available management measures for nonpoint sources causing, contributing to, or threatening water quality impairments and for new nonpoint sources, except for new sources in States with an approved watershed management program. The *President's Initiative* recommends that the initial implementation period be followed by a second, five-year period to implement further measures where necessary (considering the actual and expected environmental benefits of the original management measures) to achieve water quality standards.

The *President's Initiative* recommends that strengthened Section 319 State programs rely on a mix of voluntary and regulatory approaches and that State programs include enforcement authorities to be used as needed to ensure implementation of management measures. Under the proposal, State authorities will be backed by Federal enforcement authorities to be exercised if a State should fail to implement the management measures. Where States do not develop an approvable program, Section 319 grants will be withheld from the State and EPA will be authorized to establish enforceable minimum NPS controls. The *President's Initiative* proposes that funding be increased for State implementation of NPS programs and that State revolving loan fund eligibility be clarified for NPS projects whose principal purpose is protecting and improving water quality. The *President's Initiative* also proposes that the CWA be clarified to require that Federal agencies comply with State or local requirements in nonpoint source programs to the same extent as non-Federal parties.

1.3.4 President Clinton's Clean Water Initiative—Watershed Management

President Clinton's Clean Water Initiative proposes that provisions for comprehensive watershed management be added to the CWA. Under the proposal, States can choose to implement comprehensive watershed programs which will be approved by EPA after conference with other Federal agencies. The States will determine the boundaries for all watersheds in the State and set a schedule for addressing them. States will oversee watershed management entities with appropriate representation of stakeholder interests and approve their watershed management plans. State watershed plans will include rankings based on environmental objectives as well as evidence of enforceable policies and mechanisms needed to implement the plans.

The *President's Initiative* proposes other changes to the CWA that: (1) provide guidelines for States wishing to adopt market-based approaches to point and NPS pollution controls within watersheds; (2) promote the development of wetland management plans that lead to increased flexibility and predictability of the wetlands permit process on a watershed basis; and (3) create comprehensive State inventories of waters that are threatened, impaired, or in need of special protection. The *President's Initiative* also recommends that States give urban watersheds a high level of priority in their State-wide ranking of watershed initiatives.

1.4 DEVELOPMENT OF THIS REPORT

A Draft of this report was circulated extensively in November 1993. Copies were distributed to States, EPA Regions, the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), and other interested parties. Comments received on that draft have been reviewed and appropriate changes to the Report have been made.

1.5 ORGANIZATION OF THIS REPORT

Chapter 2 of this report presents the approach and methodology for identifying categories of storm water sources and methods for estimating the distribution and content of these discharges. The next two chapters identify storm water discharges not regulated by the current program and discusses the nature of such discharges and the extent of pollutant loadings from these sources, as well as their geographic distribution for municipalities (Chapter 3) and industrial and commercial facilities (Chapter 4).

CHAPTER 2. APPROACH

This chapter describes the approach taken by the U.S. Environmental Protection Agency (EPA) to identify and characterize storm water discharges that are not subject to the first phase of the National Pollutant Discharge Elimination System storm water permit requirements under Section 402(p) of the Clean Water Act (CWA).

The study considered two major classes of storm water discharges: (1) discharges from municipal separate storm sewer systems (addressed in Section 2.2) and (2) industrial and commercial discharges (Section 2.3). EPA relied on existing information and data, particularly the 1990 U.S. census, and on a number of previous studies, as described in the literature review (Section 2.4). As a part of this study, EPA developed estimates of annual loadings for discharges from municipal separate storm sewer systems. Section 2.1 gives a brief overview of the approach.

2.1 OVERVIEW OF APPROACH

A main purpose of this report is to identify storm water discharges not addressed by Phase I of the NPDES program for storm water discharges and to determine the nature and extent of pollutants in these discharges. The analytical approach to this objective followed two separate paths—one for Phase II discharges from municipal separate storm sewer systems and another for individual Phase II sources. This section briefly summarizes both aspects of the approach. Sections 2.2 and 2.3 provide more detailed explanation.

In the analysis of municipal separate storm sewer systems, municipal systems addressed by Phase I of the NPDES program had to be identified to allow identification of the remaining potential Phase II municipal systems. EPA limited the analysis of potential Phase II municipal separate storm sewer systems to those municipalities that had populations that were classified as urban by the Bureau of the Census. Census information was used to identify the type of municipality, geographic location, and urban population. Selected geographic areas of potential concern, such as urbanized areas, coastal areas, and fast growing areas, were identified and evaluated following the procedures described below.

Pollutant loading estimates were developed for populations located in urbanized areas that were designated by the Bureau of the Census, including both Phase I and Phase II discharges. Pollutant loadings were estimated by using a simplified loadings model described in Section 2.2.2. Pollutant concentration data for seven pollutants, including conventional pollutants, nutrients, and metals, were taken from the results of the National Urban Runoff Program (NURP) (EPA, 1983). Runoff volume was estimated as the product of land area, the annual amount of precipitation, and the "runoff coefficient" (a fraction that indicates the proportion of precipitation that runs off the land and enters receiving waters). Land area for urbanized areas was provided by the 1990 U.S. census. Precipitation estimates were based on the rainfall zones established in the NPDES Permit Application Requirements for Storm Water Discharges (November 16, 1990). The runoff coefficient is a function of the imperviousness of the land surface, which is related to the density of roads, buildings, and other paved surfaces in an urban area. The amount of impervious area in urban settings can be estimated from population densities. The runoff coefficient used in this analysis was estimated by using a relationship based on population density (calculated from census data) that was published in the technical literature and in EPA documents (Heaney et al., 1977).

In the analysis of individual Phase II sources, identification of potential sources also proceeded in two steps. First, a review of the regulatory definition identified which types of facilities were clearly regulated under Phase I. This review aided the development of a list of facilities similar or identical to Phase I industrial facilities that were not covered under Phase I for a variety of statutory and regulatory reasons. Second, a literature review (see Section 2.4) identified, in general terms, additional commercial and retail sources of potential concern, based on the types of pollutants used or activities conducted. These potential Phase II sources were specified in detail using the Standard Industrial Classification (SIC) code system of the Office of Management and Budget. The use of SIC codes for identification of

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potential Phase II sources also facilitated the quantitative analysis performed in Chapter 4. Thus, the identification step covered the full range of industrial and commercial business activities that may be contributing to storm water pollution. A complete listing of industries classified within the SIC code system is provided later in this section.

The nature and extent of pollutants from individual Phase II sources were determined in two parts. The nature of pollutants was addressed qualitatively in two steps. First, pollutant sampling data from Phase I industrial sources was evaluated, summarized, and compared to previous studies of urban storm water content. This formed a basic reference on the nature of discharges from a wide variety of specific industrial categories. Second, potential Phase II sources were classified into groups and compared with Phase I sectors, where possible, to enable comparison to the pollutant concentration data from Phase I facilities and to determine the types and quantities of pollutants likely to be associated with unregulated discharges. This qualitative assessment of potential pollutant associations was supplemented with information documented in State and local nonpoint source programs, urban runoff programs, estuary programs, and technical articles identified through the literature review.

The extent of potential Phase II individual discharges was addressed by determining the geographic location and distribution of facilities that may contribute pollutants to storm water, rather than calculating pollutant loads as in the municipal analysis. The analysis focused on location rather than loadings because data on industrial and commercial pollutant discharges was insufficient to allow estimation of loadings on a national basis. Moreover, an attempt to estimate loads for industrial and commercial sources would lead to double counting, because many potential Phase II facilities are located in municipal or urban areas and the loading analysis for municipal sources already accounts for some of their contributions.

Using EPA's Facility and Company Tracking System (FACTS) computer file based on Dun & Bradstreet information about economic activity, the number of facilities in each SIC code was found for each county in the country.[1] From the 1990 census for each county, the proportion of population associated with geographic jurisdictions of interest was calculated. For each county and each SIC code, the number of facilities was multiplied by the proportion of population in each geographic area to yield an estimate of the number of facilities in that portion of the county. Summing over all counties provides an estimate of the proportion of facilities in each SIC code nationally that are located in the geographic jurisdictions of interest.

The two paths, municipal separate storm sewer systems and individual sources, were related through the geographical analysis of extent of discharges, which shows the proportion of pollutant loadings from municipal separate storm sewers and the proportion of individual facilities associated with various areas of concern. Although the effect cannot be quantified, the nature and extent of pollutants from industrial and commercial sources overlaps with the nature and extent of pollutant loadings calculated in the municipal analysis.

2.2 ANALYSIS OF MUNICIPAL SEPARATE STORM SEWER SYSTEMS

This section describes the procedure used to identify potential Phase II municipal separate storm sewer systems. The section also explains how the pollutant load estimates were developed for discharges from municipal separate storm sewer systems in urbanized areas.

2.2.1 Identifying Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems addressed by Phase I of the NPDES program had to be identified to allow identification of the remaining potential Phase II municipal systems. EPA limited the analysis of potential Phase II municipal separate storm sewer

[1] The FACTS data base is leased by EPA from Dun & Bradstreet Information Services, which created, maintains, and annually updates the information based on State and industry reports and on primary data collection in the business community, including detailed surveys and personal interviews. It has been estimated that this data base accounts for more than 96 percent of the U.S. Gross National Product (Caskins, 1992). FACTS was made available for this study through EPA's National Computer Center in North Carolina.

systems to populations that were classified as urban by the Bureau of the Census. The only other population classification available from the Bureau of the Census was rural populations. Rural populations and rural areas were generally excluded from this part of the analysis because the Agency was generally unable to tie these areas to development patterns and demographics that were thought to result in the installation of municipal separate storm sewer systems. Census information was used to identify the type of municipality, geographic location, and urban population.

2.2.1.1 Phase I Definitions

Section 402(p) of the CWA identifies discharges from municipal separate storm sewer systems serving a population of more than 100,000 people as requiring permit coverage under the first phase of the NPDES program. Phase I municipal systems are defined in the NPDES regulations at 40 *CFR* 122.26(b)(4) and (7) and explained in the preamble to include:

- Incorporated cities with populations greater than 100,000 served by separate storm sewers, according to the latest Decennial Census by the Bureau of the Census
- Counties with a population of 100,000 or more in unincorporated, urbanized areas, according to the latest Decennial Census by the Bureau of the Census (excluding the population of towns and townships)
- Municipalities that are designated by EPA or an authorized NPDES State.[2]

Phase I municipal systems also include systems that are designated by EPA or an authorized NPDES State under section 402(p) of the CWA as needing an NPDES permit because they are significant contributors of pollutants to waters of the United States or contribute to a violation of water quality standards.

[2] Designation of a Phase I municipal system is based on one of the following factors: physical interconnections with a municipal separate storm sewer system serving a population of 100,000 or more identified in the NPDES regulations, discharges from several municipal separate storm sewer systems, the quantity and nature of pollutants in the discharge, and the nature of the receiving waters.

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For the purposes of determining Phase I populations, the NPDES regulations allow municipalities to reduce the population of the municipality to account for populations served by combined sewers.[3]

Census definitions data from the 1990 census was used to identify urban populations of potential Phase II municipal separate storm sewer systems. The Bureau of the Census organizes population information according to political and demographic factors. Political jurisdictions include entities with governmental structures, such as States, counties, incorporated places (e.g., cities, towns, villages), and minor civil divisions (MCDs), which include towns and townships in 20 States. Table 2-1 summarizes the definitions of these political entities.

Table 2-1. Bureau of the Census Definitions of Municipal Entities

Incorporated Places—Places incorporated under the laws of their States as cities, boroughs, towns, and villages, with the following exceptions: boroughs in Alaska and New York, and towns in the six New England States, New York, and Wisconsin.
Minor Civil Divisions—Minor civil divisions are primary divisions of counties established under State law in 20 States. Townships are minor civil divisions in 12 States (Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, New Jersey, North Dakota, Ohio, Pennsylvania, and South Dakota). Towns are recognized as minor civil divisions in eight States (Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont, and Wisconsin).
Counties—In most States, the primary divisions are termed counties. In Louisiana, these divisions are known as parishes. In Alaska, which has no counties, the county equivalents are the organized boroughs. In four States (Maryland, Missouri, Nevada, and Virginia), there are one or more cities that are independent of any county organization and thus constitute primary divisions of their States.

Source: Census of Population and Housing, 1990.

[3] See 40 *CFR* 122.26(f)(3). Combined sewers are conveyances that are designed to collect and convey both storm water and sanitary sewage. Combined sewers are not regulated under the storm water permitting program because they are regulated as part of the total discharge from the combined system under the existing NPDES permit conditions for that system. Combined sewers are addressed in this report only as an adjustment factor used to estimate storm water flows from urban areas.

Two additional geographical classifications were evaluated in the report, urbanized areas designated by the Bureau of the Census and metropolitan areas (MAs) defined by the Office of Management and Budget (OMB). The definitions of these terms are summarized in Table 2-2. Census-designated urbanized areas are based primarily on demographics and represent densely settled areas of 50,000 or more people. OMB identifies metropolitan areas based on economics and social trends, in addition to population densities. Metropolitan areas are defined based on county boundaries and are significantly more inclusive than urbanized areas, which more closely follow population distributions.

Table 2-2. Population Classifications of Bureau of the Census

URBANIZED AREAS—An urbanized area (UA) comprises an incorporated place and adjacent densely settled surrounding area that together have a minimum population of 50,000. The densely settled surrounding areas consists of: 1. Contiguous incorporated places or census designated places having: a. A population of 2,500 or more; or b. A population of fewer than 2,500 but having either a population density of 1,000 persons per square mile, a closely settled area containing a minimum of 50 percent of the population, or a cluster of at least 100 housing units. 2. Contiguous unincorporated area which is connected by road and has a population density of at least 1,000 persons per square mile. 3. Other contiguous unincorporated area with a density of less than 1,000 per square mile, provided that it: a. Eliminates an enclave of less than 5 square miles which is surrounded by built-up area. b. Closes an indentation in the boundary of the densely settled area that is no more than 1 mile across the open end and encompasses no more than 5 square miles. c. Links an outlying area of qualifying density, provided that the outlying area is: (1) Connected by road to, and is not more than 1.5 miles from, the main body of the UA. (2) Separated from the main body of the UA by water or other undevelopable area, is connected by road to the main body of the UA, and is not more than 5 miles from the main body of the UA. 4. Large concentrations of nonresidential urban area (such as industrial parks, office area, and major airports) which have at least one-quarter of their boundary contiguous to a UA.
URBAN POPULATIONS—All persons living in urbanized areas and in places of 2,500 or more inhabitants outside of urbanized areas. The urban population consists of all persons living in (1) places of 2,500 or more inhabitants incorporated as cities, villages, boroughs (except in Alaska and New York), and towns (except in the New England States, New York, and Wisconsin), but excluding those persons living in the rural portions of extended cities; (2) census designated places of 2,500 or more inhabitants; and (3) other territory, incorporated or unincorporated, included in urbanized areas.
RURAL POPULATIONS—Population not classified as urban.

The following information was obtained from the 1990 census data (Summary Tape File-1A) for all parts of the United States[4]:

- State and County location
- Population
- Land Area
- Population Density
- Growth Projections.

Information on urbanized areas, urban populations, and metropolitan areas was obtained from documents published by the Census Bureau.

2.2.1.2 Identification of Phase I and Phase II Municipalities

The following steps were taken to identify municipalities with Phase I municipal separate storm sewer systems:

- **Cities Specifically Identified in Phase I Regulations:** Based on the 1980 census, 173 cities were originally identified as having populations exceeding 100,000. Of these, a survey of authorized NPDES States and EPA Regions indicated that 30 cities with populations of 100,000 or more have been exempted from Phase I storm water requirements due to populations served by combined sewers. An additional 5 cities' populations dropped below 100,000 based on the 1990 census. Permit applications have not been required from these cities unless they have been designated for inclusion in Phase I by EPA or a State. For the purposes of this report, 140 of the 173 cities identified in the Phase I regulations are considered to be Phase I.
- **Counties Specifically Identified in Phase I Regulations:** Based on the 1980 census, 47 counties were originally identified as having populations in urbanized, unincorporated areas that exceeded 100,000 after the population in the incorporated places, townships, or towns was excluded. Incorporated places with a population of less than 100,000 that were located in these counties were treated as potential Phase II municipalities unless they were identified as being designated into Phase I by an authorized NPDES State or EPA Region. The population of 2 of these counties had

[4] Information obtained for Guam, the Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands was limited to population and growth projections. For the Commonwealth of Puerto Rico and the District of Columbia, all information described above was obtained and used in the analysis.

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dropped below 100,000 based on the 1990 census, leaving 45 Phase I counties specifically identified in Phase I regulations for the purposes of this report.

- Municipalities Designated by NPDES Authorities: Authorized NPDES States and EPA Regions have the authority to designate additional municipalities as subject to Phase I. A survey of authorized NPDES States and EPA Regions was used to identify designated municipalities. This report identifies designations that occurred before January 1994 and considers them to be Phase I sources for the purposes of this analysis.

All remaining municipalities with urban populations not identified as a part of Phase I of the NPDES storm water program were considered to be potential Phase II sources. Chapter 3 provides the specific numbers of municipal entities in various categories. Municipalities were differentiated based on characteristics such as size, density, or association with other levels and types of geographical and political jurisdictions. The designation of municipalities as Phase I vs. Phase II in this report is based on a "snapshot" of currently regulated municipalities as of January 1994.

2.2.2 Determining the Nature and Extent of Pollutants Associated With Municipal Separate Storm Sewer Systems

A review of the literature on urban runoff, including past studies conducted by EPA and the USGS, was used to develop a general descriptive profile of the nature of discharges from municipal separate storm sewer systems. Section 2.4 discusses this review.

Estimates of loads were developed for selected pollutants in runoff from urbanized areas. The approach used to estimate loadings of pollutants associated with discharges from municipal separate storm sewer systems was based on existing data and follows standard engineering practice (McCuen, 1989; American Society of Civil Engineers, 1969).

These estimates were developed to provide an overview of the extent of pollutant discharges associated with urban runoff and a relative ranking of the pollution potential from urbanized areas. The results can be used to compare potential Phase II municipal systems in urbanized areas with Phase I municipal systems. This approach was not designed to estimate actual loads for any specific locality.[5] Thus, it would not be appropriate to use load estimates generated as part of this study in assessing potential storm water impacts within a specific receiving water body.

To estimate pollutant loadings from municipal separate storm sewer systems, the following equation was used for each pollutant of concern and for each urbanized area:

Load = Pollutant Concentration × Land Area × Rainfall × Runoff Coefficient × Conversion Factor,

where:

Load = Storm water pollutant load in thousands of pounds per year[6]

Concentration = Mean pollutant concentrations determined from NURP (mg/l)

Area = Land area for the urban site or place from the U.S. census (square miles)

Rainfall = Average annual rainfall, based on rainfall zone (inches per year)

Runoff Coefficient = A fraction that represents the proportion of rainfall that runs off the land to surface waters. It is related to the amount of land covered by impervious surfaces, such as roads and buildings

Conversion Factor = Adjusts units into pounds per year.

2.2.2.1 Pollutant Concentrations

A review of the literature showed that data from NURP (EPA, 1983) are the most frequently cited and often used reference values for urban runoff pollutant concentrations. NURP data were used as the basis for loadings calculations for this study after evaluating the procedures used in NURP and comparing the results with other independent studies of urban runoff undertaken by USGS.

[5] In particular, rainfall and concentration data were not site-specific.

[6] The units of the final loading estimate were converted to thousands of pounds per year so that the results could be simplified.

NURP, which was conducted during the early 1980s, remains the most comprehensive assessment of pollutants in runoff from residential and commercial areas. The program was developed in the late 1970s, after EPA reviewed State 208 Water Quality Management Plan Reports and determined that additional and consistent data were needed to describe pollutants in urban runoff.

Under NURP, EPA provided direction and assistance to 28 planning projects located throughout the United States (Figure 2-1) that were selected from 93 area-wide agencies that had identified urban runoff as a potentially significant problem. (Table 2-3 lists the 28 NURP project locations according to EPA Regions.) Each project was separate and distinct but shared the common goal of conducting field monitoring to characterize pollutants in runoff from residential and commercial areas. The sampling locations within the 28 NURP projects included 81 specific sites and more than 2,300 separate storm events. The resulting data base represented a cross section of regional climatology, residential and commercial land use types, slopes, and soil conditions and, thereby, provided a basis for identifying patterns of similarities or differences and testing their significance.

Table 2-3. NURP Project Locations

EPA Region	NURP Code	Project Name/Location	EPA Region	NURP Code	Project Name/Location
I	MA1	Lake Quinsigamond (Boston Area)	V	IL1	Champaign-Urbana, Illinois
	MA2	Upper Mystic (Boston Area)		IL2	Lake Ellyn (Chicago Area)
	NH1	Durham, New Hampshire		MI1	Lansing, Michigan
				MI2	SEMCOG (Detroit Area)
II	NY1	Long Island (Nassau and Suffolk Counties)		MI3	Ann Arbor, Michigan
				WI1	Milwaukee, Wisconsin
	NY2	Lake George	VI	AR1	Little Rock, Arkansas
	NY3	Irondequoit Bay (Rochester Area)		TX1	Austin, Texas
			VII	KS1	Kansas City
III	DC1	WASHCOG (D.C. Metropolitan Area)	VIII	CO1	Denver, Colorado
	MD1	Baltimore, Maryland		SD1	Rapid City, South Dakota
				UT1	Salt Lake City, Utah
IV	FL1	Tampa, Florida	IX	CA1	Coyote Creek (San Francisco Area)
	NC1	Winston-Salem, North Carolina		CA2	Fresno, California
	SC1	Myrtle Beach, South Carolina	X	OR1	Springfield-Eugene, Oregon
	TN1	Knoxville, Tennessee		WA1	Bellevue (Seattle Area))

Source: U.S. Environmental Protection Agency, 1983

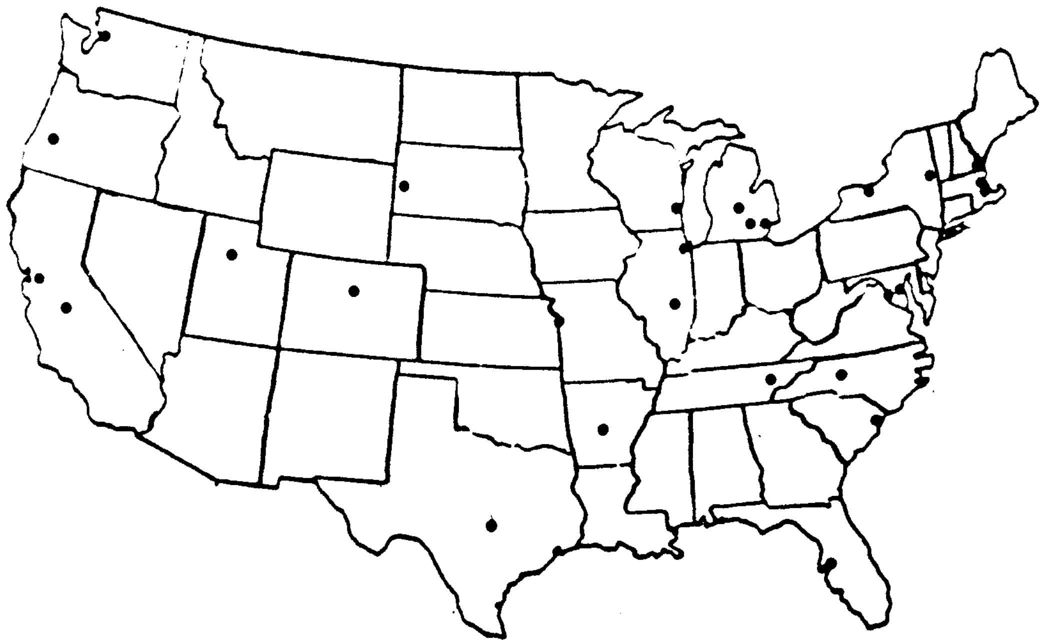

Figure 2-1. Location of NURP Sites

NURP focused on the following ten constituents, which were considered standard pollutants characterizing urban runoff:

- Total Suspended Solids (TSS)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total phosphorus (TP)
- Soluble phosphorus (SP)
- Total Kjeldahl Nitrogen (TKN)
- Nitrate + nitrite (N)
- Total copper (Cu)
- Total lead (Pb)
- Total zinc (Zn).

These pollutants are commonly associated with urban runoff and are often targets of point and nonpoint source studies. In addition, some of these pollutants can be surrogates for larger categories of pollutants such as oxygen consuming constituents and nutrients. NURP also examined coliform bacteria and priority pollutants (other than oil and grease). However, these parameters were only evaluated for a subset of sites and were not the primary focus of the NURP study. Moreover, they were not presented in a summary fashion suitable for estimating loadings. Soluble phosphorus is not discussed in this report because it was not addressed in USGS results or NPDES permit applications for industrial facilities (addressed later in this chapter).

NURP attempted to characterize the nature of storm water from residential and commercial areas. The data summaries excluded monitoring sites that were downstream of storm water controls. Sites were selected to focus on runoff from residential areas (primarily low density) and to avoid heavy industrial areas. NURP commercial site results did not include heavy industrial sites but in several cases reflected industrial park type use. Sites were also selected so that there were no extraneous sources of pollutants in the storm water discharge, such as illicit connections to the storm sewers. In addition, unusually high pollutant concentrations were eliminated from the data base as being atypical of storm water discharges.

Because of its site selection approach, NURP results represent normal or baseline urban runoff conditions from residential and commercial areas, not actual urban conditions which could include heavy industrial activities which were avoided by NURP. Because the NURP sites represent average runoff conditions from a mix of residential, commercial, and industrial park sites, loading estimates based on the NURP concentrations (described earlier in this Chapter and in Chapter 3) will be influenced by loadings from some of the sources considered in the industrial and commercial analysis (see Section 2.3 and Chapter 4) that were located in the catchments monitored.

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NURP showed that the concentrations of pollutants in urban runoff vary considerably from site to site. Concentrations at individual sites also varied through the course of a storm event and between events. This variability is the natural result of variations in rainfall intensity, occurrence, and site-specific factors (e.g., slope, land use) that affect runoff quantity and quality. NURP data were summarized using average values for storm events, with an event mean concentration (EMC, i.e., the total pollutant mass discharged divided by the total runoff volume). To determine typical storm water concentrations, NURP researchers examined the data in various ways using standard statistical procedures, each exploring the effects of different factors (e.g., slope, land use category) on final concentration values. Based on these statistical tests, NURP concluded that geographic location, land use categories, or other factors appear to be of little utility in explaining the overall site-to-site variability, and the best general characterization of urban runoff is obtained by pooling the site data for all sites (except the open/non-urban ones). NURP recommended the total pollutant mass discharged divided by the total runoff volume (i.e., the event mean concentration [EMC]) as the best single measure for characterizing overall storm water pollutant concentrations. The data summarized from NURP are recommended for planning purposes rather than site-specific characterization. Table 2-4 presents summary statistics from NURP for different sites and results from other USGS studies, discussed below.

Comparison to USGS Urban Storm Water Data Base

In addition to EPA's efforts to characterize urban runoff, USGS has collected urban rainfall, runoff, and water quality data nationally for several decades. In the mid-1980s, much of this information was compiled into a national data base. This data base contains information on 717 storms at 99 stations in 22 metropolitan areas throughout the United States (Driver et al., 1985). The USGS examined a set of constituents similar to those used in NURP. The USGS also reported its data in terms of flow-weighted samples so that concentration and loading values could be compared directly to NURP results.

Table 2-4. NURP and USGS Summary Statistics— Water Quality Characteristics of Urban Runoff

Pollutants	units/notes	NURP (1983) Median Urban Site (d) EMC Mean	NURP (1983) Median Urban Site (d) EMC Median	NURP (1983) Median Urban Site (d) 90th %-ile	NURP (1983) Commercial EMC Median	USGS (various years) Residential Mean	USGS Residential Median	USGS Commercial Sites Mean	USGS Commercial Sites Median	USGS Industrial Sites Mean	USGS Industrial Sites Median
		a	b	b	b	c	c	c	c	c	c
BOD5	mg/l	12	9	15	9	12	7	16	8	NR	NR
COD	mg/l	82	65	140	57	NR	NR	NR	NR	NR	NR
$NO_2 + NO_3 - N$	mg/l	0.86	0.68	1.75	0.57	0.57	0.46	0.38	0.25	1.71	1.20
TKN	mg/l	1.90	1.50	3.30	1.18	NR	NR	NR	NR	NR	NR
Total P	mg/l	0.42	0.33	0.70	0.20	0.46	0.36	0.31	0.18	6.61	6.40
TSS	mg/l	180	100	300	69	1163	[illegible]	248	109	671	492
Copper	µg/l	43	34	93	29	43	20	28	16	89	74
Lead	µg/l	182	144	350	104	222	120	215	73	97	78
Zinc	µg/l	202	160	500	226	145	100	311	110	706	550

a - EMC mean reported on page 6-60 of NURP report in the context of loading estimate comparisons. EMC should be used when comparing cumulative effects such as WQ impacts in lakes or when comparing loads on a long-term basis.

b - EMC median reported on 6-43 of NURP as the best description of urban runoff characteristics in terms of water assessing short-term water quality impacts in rivers and streams.

c - Simple mean and median calculated from raw data from USGS. Because the data were not normally distributed, the median is the best measure of central tendency.

d - NURP's "median urban site" is a composite of land use types.

NR - Not Reported.

To provide a comparison to the NURP data for this study, the USGS data were analyzed statistically to develop mean and median pollutant concentration values for 7 of the 10 NURP pollutants. (The USGS data did not include COD, TKN, or soluble P. As previously noted, soluble phosphorus is not discussed in this report because it is not addressed in USGS or NPDES permit applications for industrial facilities.) To provide some perspective on NURP, different land use categories (i.e., residential, commercial, and industrial park sites) were analyzed separately. Table 2-4 summarizes the results from the USGS data base next to the NURP results. Although NURP results (for the median) are higher for BOD, nitrate + nitrite, copper, lead, and zinc, most of the results differ by less than 50 percent, except for TSS results, which are highly variable. Both sets of results are in the same range,

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supporting the idea that these values are representative of the nature of urban runoff. This determination is consistent with the findings of Driver and Lystrom (1986), who also compared certain aspects of the two data sets.

As described in this chapter and in Chapter 3, this report uses historical data, generated by the Nationwide Urban Runoff Program (NURP) and by the U.S. Geological Survey (USGS), to generally and comparatively characterize metal contamination in storm water runoff from urban areas.

Recently, concerns have been raised regarding the validity and use of historical data for metals where adequate QA/QC cannot be properly documented (USGS, 1992). The quality of trace level metal data, especially at levels in the 1-5 part per billion (ppb) range, may be compromised due to contamination of samples during collection, preparation, storage, and analysis. These concerns have also been expressed as applying to the NURP metals data.

EPA believes that the metals data for urban runoff from USGS and NURP as used in this report are valid. Mean concentrations of copper, lead, and zinc observed under NURP and USGS were found to be in the range of 30 to 700 ppb (see Table 2-4), well above the 1-5 ppb range that has been identified as questionable. Furthermore, in dealing with the metals issue generally, EPA believes that most historical data for metals collected and analyzed with appropriate QA and QC at levels of 1 ppb or higher are reliable (EPA, 1993).

It should also be pointed out that the historical sampling data presented in this report is intended to provide a general, qualitative characterization of urban storm water runoff rather than a precise empirical relationship. The metals loadings estimated using NURP data are only used to illustrate relative loadings contributions from different geographical areas of the country. Quantitative loadings estimates, which could possibly be affected by suspect data, have not been presented in this report.

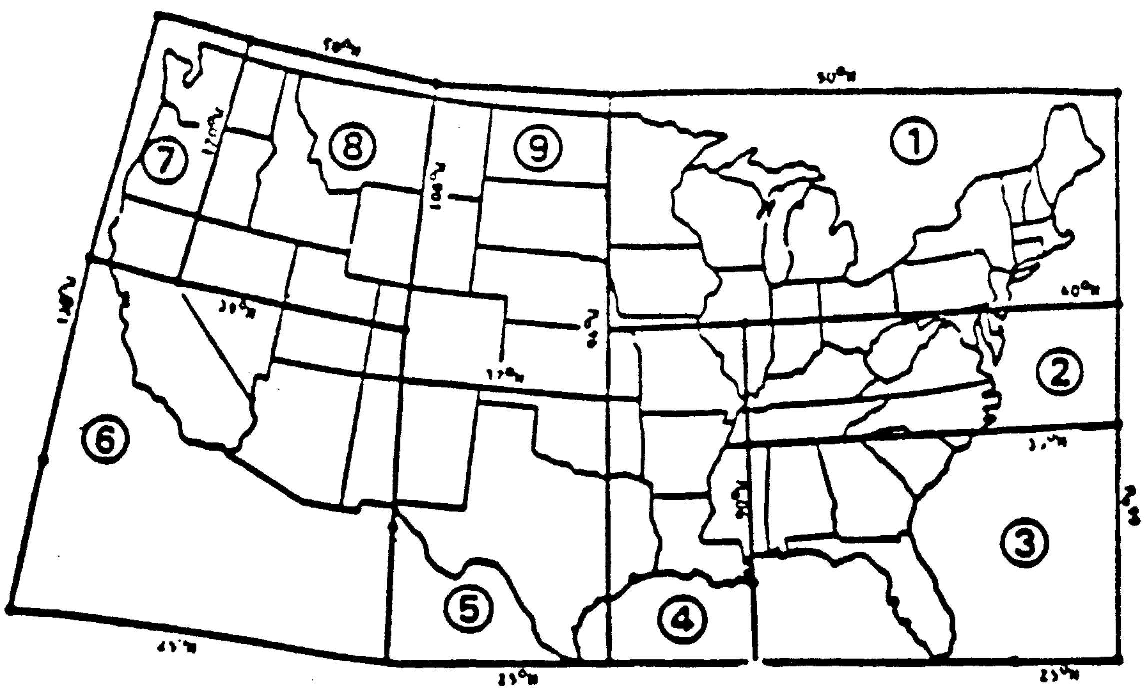
2.2.2.2 Land Area

Population and land area data (or population density) for all urbanized areas were obtained from the 1990 census. Phase I sources and potential Phase II sources were identified based on the procedure described in Section 2.2.1. An adjustment factor was developed to address combined sewer systems. Combined sewer systems are not considered to be part of the storm water regulatory program (although combined sewer overflows from combined sewer systems are addressed by the NPDES program). Therefore, storm water volume estimates in this report were adjusted to account for the flows entering combined sewers. Estimates of the land area served by combined sewer systems were based on data reported by the States for *The 1984 Needs Survey Report to Congress* (EPA, 1985).

2.2.2.3 Rainfall

Annual rainfall estimates were obtained from *Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality* (Driscoll et al., 1986). This document identifies 9 rainfall zones in the United States (see Figure 2-2). Although these rainfall zones have been updated in *Analysis of Storm Event Characteristics for Selected Rainfall Gauges Throughout the United States* (Driscoll et al., 1989), (see Appendix B of this report) to include 15 more precisely defined rainfall zones, the 9 rainfall zones from the earlier report were used to simplify estimation procedures.

For each of the 3,141 counties in the country, the appropriate rainfall zone was identified, along with the average annual rainfall for that zone. This information was merged with the larger census data base at the county level to provide rainfall estimates for each municipality.



Not Shown: Alaska (Zone 7); Hawaii (Zone 7); Northern Mariana Islands (Zone 7); Guam (Zone 7); American Samoa (Zone 7); Puerto Rico (Zone 3); Virgin Islands (Zone 3).

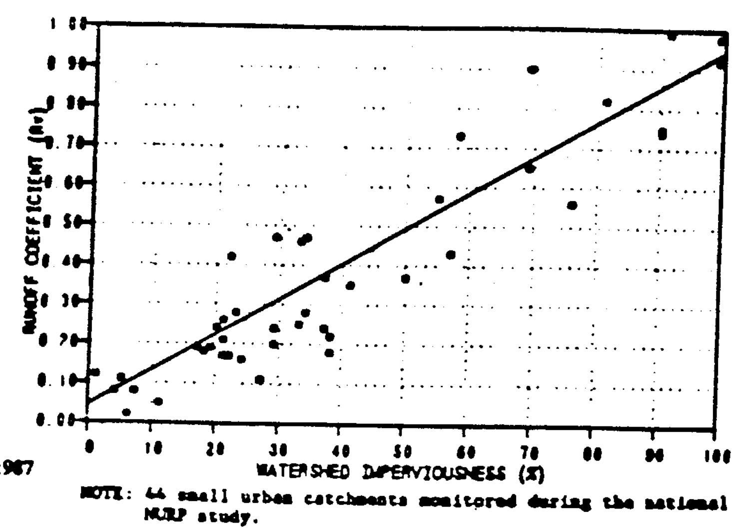
Zone 1	33.1	Zone 4	41.2	Zone 7	23.0
Zone 2	39.6	Zone 5	19.2	Zone 8	11.0
Zone 3	50.9	Zone 6	7.5	Zone 9	14.3

Source: 55 *FR* 47990, 1990
EPA, 1990

Figure 2-2. National Distribution of Rainfall Zones and Average Annual Precipitation (inches/year)

2.2.2.4 Runoff Coefficient

The runoff coefficient represents the portion (percentage) of total precipitation reaching the ground that becomes runoff to surface waters. A number of factors, such as the nature of the soils, topography, and amount or type of vegetative cover, can affect the runoff coefficient. However, the most important factor in determining the quantity of runoff from a given storm in a given area is the amount of impervious area (MWCOG, 1987). Impervious areas include all types of paved areas (e.g., streets, sidewalks, parking lots, driveways), buildings, roof tops, and other similar structures. The extent of impervious area is a function of many local considerations, such as the density and type of development. Generally, the runoff coefficient is directly related to watershed imperviousness, as illustrated in Figure 2-3, which contains data from 44 small urban catchments monitored during the national NURP study.



Source: MWCOG, 1987

Figure 2-3. Relationship of Watershed Imperviousness to Runoff Coefficient

The runoff coefficient used in the analysis of this report was estimated as a function of population density, based on equations that are widely used in the engineering literature, in previous studies by EPA's Office of Research and Development, and in the Corps of Engineers' Storage, Treatment, Overflow and Runoff Model (STORM) (which was designed for planning purposes and simulation of storm events [Heaney et al., 1977]). The two equations are:

$$\text{Impervious Proportion} = 0.096 \times \text{population density}^{(0.573 - 0.0391 \times \log(\text{Population Density}))}$$
$$\text{Runoff Coefficient} = 0.15\ (1 - \text{impervious proportion}) + 0.90\ (\text{impervious proportion}).$$

Combining the two equations yields:

$$\text{Runoff Coefficient} = 0.15 + 0.75 \times [0.096 \times \text{population density}^{(0.573 - 0.0391 \times \log(\text{Population Density}))}]$$
where population density is in persons per acre.

The first equation estimates the site-specific level of imperviousness from population density. This empirical equation is based on data from another study of hundreds of municipalities in New Jersey (Stankowski, 1974). The second equation estimates a runoff coefficient from an empirical equation that depends on the level of imperviousness. Using this model, an area with no impervious surfaces would be assigned a runoff coefficient of 0.15, while a completely impervious area would have a runoff coefficient of 0.90. These equations produce results that are similar to those presented in Figure 2-3.

The model can be used to estimate runoff coefficients when only population density is known. Figure 2-4 shows how the model predicts the relationship between population density, expressed in persons per acre and the runoff coefficient. For example, for an urban area with 10 people per acre (or 6,400 people per square mile), the model estimates a runoff coefficient of 0.4, meaning that, on average, 40 percent of the rainfall runs off to surface water. The model estimates that places with higher population densities will have higher runoff coefficients. Although limitations are associated with this relationship (e.g., the original equation is based on land use conditions in the 1960s and the estimates are limited by the uncertainty of the assumed variables), the model can make use of population density data from the 1990 census in estimating runoff coefficients for different municipalities for comparative purposes.

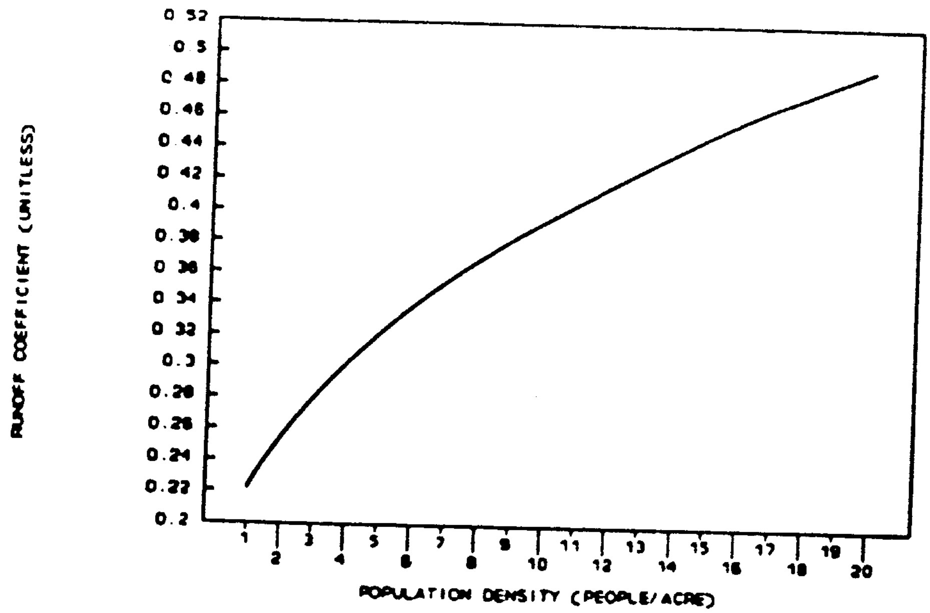


Figure 2-4. Runoff Coefficient Calculated as a Function of Population Density

2.3 ANALYSIS OF INDIVIDUAL PHASE II DISCHARGES

The second major focus of this study was to (1) identify types of industrial, commercial, and institutional storm water discharges for which permits are not already required as part of Phase I and (2) determine, to the maximum extent practical, the nature and extent of pollutants in such discharges. This section explains the approach used to select classes of facilities for study and the data analyses undertaken to develop the information presented in Chapter 4.

To develop information on remaining unregulated sources, sources regulated under Phase I were clearly defined and eliminated from consideration along with sources that have been statutorily exempted from both Phase I and Phase II. Then, from the remaining set of sources and facilities, classes of facilities with the potential to contribute pollutants to storm water discharges were identified. The analysis of the nature and extent of individual Phase II discharges addresses both pollutant concentrations and the geographic distribution of facilities. The geographical analysis was developed to determine the distribution and location of individual Phase II facilities in relation to Urbanized Areas and the Phase II municipalities identified in the first part of this study. Although there was not enough data available on a national basis to estimate pollutant loadings from individual Phase II sources, the approach taken could later be related to an assessment of water quality conditions at the local, regional, or State level.

2.3.1 Identifying Individual Phase II Storm Water Discharges

The storm water discharge regulations (Phase I) require permit applications from facilities with "storm water discharges associated with industrial activity," as defined in 40 *CFR* 122.26(b)(14) (55 *FR* 47990). This definition describes the 11 specific categories of industrial activities which are regulated. For the categories of industries identified, the term includes storm water discharges from:

> . . . industrial plant yards; immediate access roads and rail lines used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters . . .; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water [40 *CFR* 122.26(b)(14)].

The definitions of the 11 categories include both narrative descriptions of activities and specific designations of industrial operations based on Standard Industrial Classification (SIC) code.[7] For example, category (i) mentions facilities subject to effluent limitations guidelines

[7] The SIC code is the statistical classification standard underlying all Federal economic statistics classified by industry (OMB, 1987).

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developed by EPA, while category (xi) designates many specific SIC codes. Because of the comprehensiveness of the SIC system, even narrative descriptions can be correlated with SIC designations. For example, category (vii) covers steam electric power generating facilities, which are included primarily in SIC 4911, and category (ix) covers domestic treatment works, which are included primarily in SIC 4952. The practical effect of these narrative definitions and specific SIC code designations is that most of the industrial facilities subject to permit application requirements are represented by major SIC groupings 10 through 45.[8]

As a basis for identifying Phase II facilities and obtaining information about their distribution and abundance, this study focused on SIC codes. Major sectors of the economy are defined on the basis of the two-digit SIC code group. The two-digit code is a relatively general categorization of the Nation's economic activity; all industrial, commercial, and retail activities are organized into less than 100 two-digit SIC codes, which are listed in Table 2-5. The more specific four-digit SIC code provides a more detailed breakdown of these enterprises and is much more descriptive of the activities conducted at the establishment. The SIC code identifies facilities based on the "primary activity" in which a facility is engaged. Chapter 4 discusses selected advantages and disadvantages of using the SIC code system for identification of storm water sources. Focusing on SIC codes for the purposes of this study does not imply that EPA must regulate on a SIC code basis. Also, although some potential Phase II categories or concerns may be defined or discussed in terms of narrative descriptions, these can be evaluated in terms of SIC code designations.

Although all unregulated facilities which have point source discharges of storm water are potential Phase II sources, in practical terms, only a subset of four-digit SIC codes have real

[8] The NPDES regulations specifically exempt some categories of activity from the definition of point source, including storm water runoff from agricultural sources and silviculture activities (mostly in SIC codes 01 through 09) (40 *CFR* Part 122.3(e)), irrigation return flows (40 *CFR* Part 122.3(f)), and uncontaminated runoff from mining sites and oil and gas facilities (40 *CFR* 122.26(a)(2)). In addition, construction activities are regulated based on the site where activity is occurring, not based on the SIC code for contractors and builders that may participate in the construction (SIC 15 - 17).

Table 2-5. List of All Two-Digit SIC Code Groups and Industry Description

SIC CODE	DESCRIPTION	SIC CODE	DESCRIPTION
01	Ag. Product.-Crops	50	Wholesale-Durables
02	Ag. Product.-Livestock	51	Wholesale-Nondurables
07	Ag. Services	52	Bldg. & Gard. Mats.
08	Forestry	53	General Stores
09	Fishing, Hunting	54	Food Stores
10	Metal Mining	55	Auto Dealers & Service
12	Coal & Lignite Mining	56	Apparel Stores
13	Oil & Gas Extraction	57	Furniture Stores
14	Nonmetallic Minerals	58	Eat & Drink Places
15	Building Contractors	59	Misc. Retail
16	Heavy Const. Contractors	60	Banking
17	Spec. Trade Contractors	61	Credit Agencies
20	Man. Food, etc.	62	Security Brokers
21	Man. Tobacco	63	Insurance Carriers
22	Man. Textile	64	Insurance Agents
23	Man. Apparel	65	Real Estate
24	Lumber & Wood	67	Investment Offices
25	Furniture & Fixtures	70	Hotels & Lodging
26	Paper & Allied Prod.	72	Personal Services
27	Printing & Publish.	73	Business Services
28	Chemicals & Allied	75	Auto Repair Services
29	Petroleum & Coal	76	Misc. Repair
30	Rubber & Plastic Products	78	Motion Pictures
31	Leather/Products	79	Amusement Services
32	Stone, Clay & Glass	80	Health Services
33	Primary Metal Ind.	81	Legal Services
34	Fab. Metal Products	82	Educational Services
35	Machinery-electric	83	Social Services
36	Electronic Equip.	84	Museums
37	Transportation Equip.	86	Membership Orgs.
38	Instrument & Related	87	Research & Development
39	Misc. Manufacturing	88	Households w/Employees
40	Railroad Transport	89	Services, NEC
41	Local Pass. Transit	91	Executive, Gen'l Govt.
42	Trucking	92	Justice, Public Order
43	U.S. Postal Service	93	Public Finance, Taxes
44	Water Transport	94	Human Resource Admin
45	Air Transport	95	Env. Qual. & Housing Admin.
46	Pipe Lines-Nat. Gas	96	Economic Program Admin.
47	Transport Services	97	National Security
48	Communication	99	Non-Classifiable
49	Electric, Gas & Sanitation		

potential to use, process, or store sources of pollutants, or engage in activities that could lead to contamination of storm water. In addition, there are many general sources of storm water contamination such as parking lots, trash dumpsters, and failing septic systems which could be associated with almost any commercial or residential activity. Some general information on these sources is presented in Chapter 4; however, the focus of this report is in identifying specific classes of facilities with greater than average potential for contribution of pollutants to storm water discharges based on their activities.

EPA identified two major groups of facilities for potential inclusion in Phase II. The first group of potential Phase II facilities identified (Group A) consists of facilities in the same SIC code groups as Phase I facilities (SICs 10-45) that are conducting activities that are essentially the same as Phase I industrial activities but that were not included in Phase I due to the specific language of the statute or EPA's regulatory specificity in defining the universe of Phase I industrial activities. The second major group (Group B) consists of facilities in all other SIC code groups where discharges of pollutants are suspected based on case studies, expert opinions, literature reviews, and other sources of information such as experience with Phase I of the storm water program.[9]

2.3.1.1 Group A Facilities

Group A is comprised of facilities which are generally identical to regulated Phase I industrial activities but that have been excluded from Phase I due to the specific language of the statute or EPA's regulatory specificity. While some of the facilities that make up Group A are obvious, (i.e., those with a specific statutory exemption from Phase I), others are more difficult to identify. Because these facilities may be described by SIC codes identical to Phase I regulated facilities, the FACTS data base was of little use in identifying these

[9] Although some sources similar to Phase I industrial activities were not identified in the 1990 application regulations (55 FR 47990) directly. EPA or an authorized NPDES State has the authority under Section 402(p)(2)(E) to designate individual facilities as needing an NPDES permit. Although some designations of this type have been made, this report bases the distinction of individual Phase I and Phase II facilities based on the regulatory definition and not on any individual designations which may have been made.

facilities. Instead, each of the 11 industrial categories that make up Phase I (see Chapter 4, Table 4-2) was examined for possible omissions and discrepancies. The result of this effort was a list of sources that are *not* covered under Phase I but that are closely related to one of the eleven categories of industrial activity. This list appears in Table 4-3. In order to help define these facilities, sources on the list were categorized into three major groups. Group A sources are described in Chapter 4.

2.3.1.2 Group B Facilities

The second general class of facilities were identified on the basis of potential activities and pollutants that may contribute to storm water contamination (Group B). Unlike Group A facilities which are generally represented by the same range of SIC code groups as Phase I facilities (SICs 10-45), Group B facilities have distinctly different SIC codes but may be performing similar activities or using similar materials as Phase I facilities. Based on the review and analysis of the types of industrial sources not covered under Phase I, several categories of Group B facilities were identified that have activities inherently similar to Phase I but are not currently regulated. Some SIC code groups were also identified using other criteria, described below.

Commercial facilities were specifically excluded from Phase I by Congress. However, many commercial sources represent an important environmental concern. These concerns are documented in State and local nonpoint source programs, urban runoff programs, and estuary programs identified through the literature review (see Section 2.4). The Rensselaerville Study (1992) reflected this view by identifying "gas, auto, service stations, transportation related activities, highway systems, land development, agricultural sources and related activities, commercial activities with industrial components, and large retail complexes" as sources of concern.[10]

[10] No SIC codes specifically identify all large retail complexes. However, these complexes are partially addressed through the loading analysis of storm water from urban/urbanized areas in the municipal section (Chapter 3).

Another class of facilities included in Group B is commercial agricultural-related activities. Categories that are specifically exempted from regulation under Section 402 of the CWA (or, in certain cases, under existing NPDES regulations) were eliminated from consideration in Group B as potential Phase II sources. (These include agriculture and most silviculture activities generally included in SIC code groups 01, 02, 07, 08, and 09.[11]) However, several specific SIC codes were retained on the list as potential Phase II sources because they are not specifically included under the agricultural exemption. These include nurseries, feedlots (the larger of which are already regulated under the NPDES permitting program),[12] some forestry operations, and miscellaneous others.[13]

A final review of other miscellaneous sources that have been identified as potential contributors to storm water pollution was conducted to reveal any sources not addressed by the criteria discussed above. The facilities identified use or handle materials containing pollutants of concern to publicly owned treatment works (POTWs). To the extent that these materials are used, stored, processed, or disposed of outdoors at Group B facilities, they may also represent a source of storm water contamination.

The procedure used to identify specific SIC codes with significant potential to discharge pollutants to storm water resulted in the identification of 90 categories of facilities. Table 4-4 lists the subset of 90 four-digit SIC codes identified from this analysis. The analysis was comprehensive and inclusive, while at the same time carefully determining whether a category had the potential to contribute pollution to storm water.

[11] The NPDES regulations at 40 *CFR* 122.27 cover discharges from certain types of silviculture activities but do not cover other discharges that are nonpoint in nature.

[12] Feedlots that are not contained within the regulatory definition of concentrated animal feeding operation (CAFO) are not point sources unless designated on a case-by-case basis under 40 *CFR* 122.23(c).

[13] Under 402(p)(6), EPA may establish regulations that could include sources that are not currently defined as point sources or examined as potential Phase II sources in this report, including some operations related to silviculture.

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The geographic distribution analysis was completed for all major two-digit SIC code groups and for the 90 specific four-digit SIC codes identified in Table 4-4. Information about the distribution of all facilities is presented in the report, even for categories that are not among the 90 potential Phase II categories, including all Phase I facilities, financial and service groups, and agricultural activities.

2.3.1.3 Service Sectors

Major SIC code groups in the service sectors, such as banking, finance, insurance firms, and food services were not considered to be potential Phase II sources. The activities of these enterprises are generally conducted indoors and do not inherently use or produce contaminants that may enter storm water. Although these facilities may have general sources such as parking lots or trash dumpsters which could contaminate storm water discharges, the municipal analysis considers pollutant loadings from these types of sources. All of the major SIC groups excluded on this basis are listed in Table 4-6. Regardless, the geographic and distributional analysis was conducted for these facilities at the major group (two-digit SIC) level. These results are presented in Appendix G.

2.3.2 Determining the Nature and Extent of Pollutants Associated With Industrial and Commercial Discharges

The nature and extent of discharges from potential Phase II industrial and commercial discharges were analyzed in a manner that allows comparison with the municipal analysis in terms of geographic distribution. The potential pollutant content of storm water from industrial and commercial sites was characterized and the locations of these potential discharges were analyzed with respect to urbanized areas. The nature of discharges was evaluated by comparison to existing studies (i.e., NURP and USGS), by analysis of discharge data from Phase I sources, and by compilation of qualitative information from a literature survey. The geographic extent of discharges was evaluated by analyzing the location of facilities using the FACTS data base in conjunction with information from the census, as explained below.

2.3.2.1 Identifying Pollutants Associated With Industrial and Commercial Discharges

Storm water discharged from industrial, commercial, and retail facilities has the potential to come into contact with raw materials, products, and waste streams, which can result in pollutant contamination of storm water discharges. A number of general categories of activities and conditions that have the potential to generate contaminants in storm water have been identified in both the proposed and final NPDES Permit Application Regulations for Storm Water Discharges (53 *FR* 49416; 55 *FR* 47990):

- Outside loading of dry bulk or liquid materials that may be spilled or accumulated and washed with rainfall into storm sewers or receiving waters
- Outside storage of raw materials, wastes, or products
- Outside processing of materials where rainfall may come into contact with materials in the process stream
- Practices with the potential for spills to the storm sewer or wash down of processing areas to floor drains
- High volume water use in material processing
- Direct application of wastes to the ground
- Dust and particulate generating processes
- Vehicle and equipment maintenance activities.

Most of these activities are specifically mentioned in the definition of discharges associated with industrial activity (40 *CFR* 122.26(b)(14)).

To characterize potential industrial and commercial storm water discharges, data on industrial and commercial sites and land uses were taken from the NURP and USGS studies and analyzed statistically and presented for comparison purposes. Chapter 4 provides further comparison and discussion. The results provide general insight into the nature of storm water runoff from light industrial areas.

The nature of industry-specific storm water quality data was characterized by analyzing sampling data submitted by group permit applicants under Phase I. These sampling results provide insight into the nature of storm water from these industrial sites and storm water from potential Phase II facilities which may have similar characteristics.

This analysis focused on the pollutants that were required to be analyzed for in the Part II NPDES storm water permit group application plus copper, lead, and zinc. For each pollutant and each industrial sector, the mean, median, and 95th percentile were calculated for both grab and composite samples, where the pollutant was identified. Where applicants reported none detected, the result was treated as zero, an approach consistent with the analysis of data from Phase I industrial facilities as presented in Appendix F. Chapter 4 summarizes these data. Appendix F contains detailed data summaries for each of 29 industrial sectors developed for the group application process.

To facilitate characterization of the nature of discharges from potential Phase II sources, similarities between Phase I and Phase II facilities were highlighted by comparing categories with similar activities, where possible. For facilities in Group A, comparison to Phase I sectors is generally straightforward and yields valuable information about these potential Phase II facilities. For Group B facilities, the corresponding Phase I activity may not be as similar. Comparisons were made only in general terms at the industrial sector level and not at the level of specific SIC codes or facilities. The resulting information presented in Chapter 4, therefore, can only be used as a guide to the general types and levels of pollutants that may be found at facilities of a given category, rather than a definitive determination of the degree of contamination at a particular site. These results are presented in Chapter 4.

To supplement the Phase I data analysis, a literature review was conducted to locate and summarize the available information on the nature of pollutants with emphasis on the groups of categories selected by the screening procedure outlined above. The literature review focused on identifying the types of pollutants that may be associated with particular categories of facilities. General qualitative information on storm water discharges and potential pollutants is available in the literature from a number of case studies and assessments of specific locations and types of facilities. Although providing useful background information, it is usually not comprehensive for any one category and may not be comparable across categories.

2.3.2.2 Determining the Extent of Individual Phase II Sources

The extent of storm water discharges from Phase II sources was determined by identifying the locations of the facilities in those categories, rather than the pollutant loads associated with them, as in the municipal analysis. Nation-wide information on the extent of pollutants from these facilities is limited. However, detailed quantitative information on the geographic extent and distribution of these facilities can be developed by combining two data sources[14]:

- FACTS provides data, including name and address, county affiliation, primary business activity (SIC), employment, and sales, on more than 7.7 million industrial, commercial, retail, and government facilities.
- The 1990 Census of Population and Housing, discussed previously, provides detailed information on population and area for most political subdivisions in the country. County-level information on population associated with urbanized areas was used in this analysis.

An analysis was conducted to determine the distribution of individual Phase II facilities and categories in relation to population patterns. To develop information comparable to the municipal analysis, the analysis of individual sources was conducted at the county level. This analysis was conducted to examine the distribution of industrial, commercial, and retail enterprises to determine how they are distributed relative to jurisdictions of potential interest in development of potential Phase II regulatory approaches.

[14] Information on number and location of facilities was limited to the 50 States and the District of Columbia. Analysis of these statistics in relation to urbanized areas was not performed for the facilities and urbanized areas in the Commonwealth of Puerto Rico.

The geographic analysis involved developing, for each county, population, and area, data for all the same political and geographic jurisdictions studied in the municipal analysis, based on the 1990 census data base. Jurisdictions of interest included urbanized areas and Phase I cities, as discussed in Section 2.2, for municipal discharges. For each county, then, the proportion of individual facilities within urbanized areas could be calculated, and the number of facilities located in Phase I and Phase II areas could be determined.

Because the facility location data was not available at the same level of detail as census data used in the municipal analysis, the next step of the procedure made use of the approximate correlation between the location of business and economic activity and the distribution of population. Specifically, the analysis relies on the premise that industrial and commercial facilities are distributed similarly to population within county jurisdictional boundaries. For example, the percentage of facilities estimated to be in the urbanized area of a county is allocated based on the percentage of population in the urbanized area of the county. The premise may be more valid for urban retail activities, such as automobile service activities, and less valid for agricultural activities, which are generally less likely to be associated with urban areas. However, when considering all counties together, as shown in Chapter 4, this procedure produces reasonable results, even for rural businesses, because they are more often located in counties with small urban populations.

Using FACTS, individual facilities were counted for each SIC code and for each county.[15] By basing the distribution of facilities on the distribution of population within a county, it was possible to allocate a portion of the facilities in each county to urbanized areas. The national total for each jurisdictional class was obtained by summing over all counties.

[15] A few facilities had incomplete records for county name and so could not be analyzed using this procedure. Given the intensive data collection activities of Dun & Bradstreet and the focus on economic activity for marketing purposes, the largest and most economically important facilities probably have the most complete records. Thus, the types of facilities with incomplete records are probably small and economically less significant.

2.4 LITERATURE REVIEW PROCESS

The literature review for information about storm water discharges, sources, and pollutants was fundamental to the approach. The following sections describe the activities conducted during the literature search.

2.4.1 Libraries

An extensive literature search was conducted at several libraries, including the University of Maryland and George Washington University, the Library of Congress, the USGS library, and the National Agricultural Library. The On-Line Computer Library Center (OCLC), a national bibliographic data base of 27 million records representing the holdings of more than 15,000 libraries worldwide, was accessed at the University of Maryland. Libraries that use OCLC primarily include public libraries, university libraries, and governmental agency libraries, such as the Department of Interior, Department of Agriculture, and the USGS. The system enables the user to search for periodicals, books, and other publications by using author, title, or subject key words. Numerous key words and phrases were searched, including key words associated with the activities of industries selected for the Phase II analysis. General terms such as storm water, industrial pollution, and names of products or contaminants thought to be associated with particular industries were also searched using OCLC.

At the Library of Congress, a data base search was conducted for information in trade association journals and other publications, environmental engineering journals and periodicals, environmental business journals and periodicals, and other publications that potentially have information related to the industrial analysis. Many of the trade association publications are only available to association members. For those publications found in library holdings, a search was conducted for articles that did not show up during the OCLC search. The data base used at the Library of Congress comprises numerous computerized disk files, each containing information on various subjects, such as science and engineering. The science and engineering disk (the most closely related topic area) was used to search for periodicals available through local libraries. Back-issues of many of the more topical publications were scanned for information relevant to the industrial analysis. The majority of periodicals searched are included in the list given in Table 2-6. At each library, library-specific data bases were searched for documents located in the individual library but not entered into the OCLC data base.

Table 2-6. List of Periodicals and Journals Searched

Autoracing Digest	*Water/Engineering and Management*
Automotive Industries	*Waste Age*
Automotive Repair News	*Modern Casting*
Automotive Review	*Journal of Environmental Quality*
Automotive Week	*Journal of Water Pollution Control Federation*
Chemical Business	*Journal of Water Resource Planning and Management*
Chemical Industry Notes	*Journal of Transportation Engineering*
Chemical Engineering	*Journal of Irrigation and Drainage Engineering*
Chemical Marketing	*Science*
American Petroleum Institute's Annual Report	*Pipeline and Gas Journal*
Service Station Management	*American Industrial Hygiene Association Journal*
Petroleum Independent	*Pipe Line Industry*
Petroleum Marketer	*JAPCA*
Environmental Progress	*Material Handling Engineering*
Environmental Pollution	*Engineering News Record*
Environmental Research	*The Engineer*
Environmental Science and Technology	*Highway and Heavy Construction*
Water Research	*Plastics World*
Water Resources Bulletin	*ISA Transactions*
Water Resources Research	*Chemical and Engineering News*
Oil and Gas Journal	*Biocycle*
Water Science and Technology	*The Management of World Wastes*
Pollution Engineering	*Metal Finishing*
Journal of Testing and Evaluation	
Successful Farming	
Plant Engineering	

2.4.2 Additional Resources

Other resources used in the literature search included EPA documents and periodicals in the Pollution Prevention Information Clearinghouse and Toxic Release Information System, documents available through EPA, EPA's docket, topic-related development documents and effluent guidelines limitations, and publications from State offices related to potential Phase II industries. Additional organizations and individuals were contacted to obtain information on pollutant concentrations in storm water discharges from industrial facilities, especially potential Phase II sources. Only a few documents obtained contained industry-specific pollutant concentration data. The rest provided background information on potential Phase II sources. Organizations contacted specifically for information include the U.S. Department of Defense, the number and a list of military bases; the U.S. Department of Transportation, for an estimate on the acreage or miles of road disturbed per year; the Forest Service at the U.S. Department of Agriculture, for data on storm water discharges from the construction of roads for logging and related activities; and the National Estuary Program, to ascertain data on storm water impacts outlined in estuary management programs.

A list of the documents obtained from the various sources mentioned above is included in the bibliography at the end of this report. Other documents available in the EPA docket (Record For Proposed NPDES Storm Water Implementation Package) were also reviewed.

2.4.3 Potential for Obtaining Additional Information

Based on research efforts for the Report to Congress, quantitative information on pollutant concentrations (and loadings) from industrial activities, especially potential Phase II (unregulated) categories, is limited. EPA's literature search for information on industrial sources identified many major categories of information. Pursuing additional sources of information and extending the literature review effort would probably yield more qualitative information to enhance the existing information on industrial sources. In particular, information on the processes and activities associated with the facilities and a better idea of the types of pollutants involved could potentially be documented. By focusing on particular industry sectors, it may be possible to get more information on the number and size of facilities, as well as information on quantities of products mined, distributed, etc.

CHAPTER 3. MUNICIPAL SEPARATE STORM SEWER SYSTEMS

Section 402(p)(2) of the Clean Water Act (CWA) requires the control of discharges from municipal separate storm sewer systems serving a population of 100,000 or more under Phase I of the NPDES storm water program. This chapter identifies municipal separate storm sewer systems not identified in Phase I that potentially may be subject to requirements under Phase II of the NPDES storm water program. In addition, this chapter describes the nature and extent of pollutants associated with municipal separate storm sewer systems, with an emphasis on potential Phase II sources. To provide an appropriate context for the discussion of potential Phase II sources, this chapter also discusses Phase I municipal systems.

Municipal separate storm sewer systems are comprised of conveyances designed to collect and convey storm water (but not sanitary sewage[1]) that are owned or operated by a municipality. Section 402(p)(3) of the CWA authorizes EPA and NPDES States to issue system-wide or jurisdiction-wide permits for discharges from municipal separate storm sewer systems. NPDES permits for discharges from municipal separate storm sewer systems are to contain requirements to reduce the discharge of pollutants to the maximum extent practicable (MEP) and to effectively prohibit non-storm water discharges to the municipal system in order to meet water quality standards. These requirements can be implemented through municipal storm water management programs to control pollutants from targeted commercial, residential, industrial, and other sources that discharge storm water (or other non-storm water discharges) through the municipal system.

3.1 IDENTIFICATION OF MUNICIPAL SEPARATE STORM SEWER SYSTEMS

The Bureau of the Census estimates that the population of the United States and associated territories was more than 252.2 million in 1990.[2] There are 19,289 incorporated

[1] Combined sewers are conveyances designed to collect and convey both storm water and sanitary sewage. This report generally does not address combined sewers.

[2] Population estimates based on the 50 states, the District of Columbia, Guam, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands.

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places and 17,796 minor civil divisions in the continental United States, Alaska, and Hawaii. These incorporated places and minor civil divisions are located in 3,141 counties or county equivalents. As discussed in Chapter 2, Table 2-2 provides the Bureau of the Census definitions for the major forms of municipal government.

3.1.1 Population Distributions

The Bureau of the Census defines two classes of population: urban and rural. The majority of the population in the United States is classified as urban (188 million or 75 percent of the total U.S. population), with only 25 percent of the population classified as rural.

3.1.1.1 Urbanized Areas

To provide a better separation of urban and rural population and housing in the vicinity of large cities, the Bureau of the Census defines an urbanized area as a central city (or cities) with a surrounding area that is densely settled (i.e., urban fringe). The population of the entire urbanized area must be greater than 50,000 persons, and the urban fringe must have a population density generally greater than 1,000 persons per square mile (just over 1.5 persons per acre). As discussed in Chapter 2, Table 2-2 provides the definitions of urban populations, rural populations, and urbanized areas used in the 1990 census.

The Bureau of the Census identified 405 urbanized areas of 50,000 or more people based on the 1990 census. The combined population of these areas was more than 160 million people (63 percent of the total U.S. population and 85 percent of the urban population). However, these areas occupy less than 2 percent of the Nation's total land area. Figure 3-1 shows the location of the 405 urbanized areas.

Table 3-1 gives the number of urbanized areas in different size classes. Table 3-2 provides the distribution of urbanized populations and municipalities by State.

Table 3-1. Size Distribution of Urbanized Areas in 1990

Urbanized Area Population Range	Number of Urbanized Areas	Total Population	Total Area (sq.mi.)	Average Area (sq.mi.)	Average Population Density (pop./sq.mi.)
Over 1,000,000	34	95,237,380	27,749	816	3,432
500,000 - 999,999	26	17,955,916	8,122	312	2,211
250,000 - 499,999	44	15,470,005	7,732	176	2,001
150,000 - 249,999	62	11,945,413	5,877	95	2,033
100,000 - 149,999	63	7,538,363	4,366	69	1,727
75,000 - 99,999	58	5,045,917	3,058	53	1,650
60,000 - 74,999	55	3,705,855	2,375	43	1,560
50,000 - 59,999	63	3,485,284	2,241	36	1,555
TOTALS	405	160,384,133	61,520		

Source: *1990 Census of Population and Housing*, Bureau of the Census, U.S. Dept. of Commerce

3.1.1.2 Metropolitan Areas

The Office of Management and Budget (OMB) identifies metropolitan areas based on economic and social trends, as well as population densities. The general concept of a metropolitan area is one of a large population nucleus, together with adjacent communities which have a high degree of economic and social integration. Metropolitan areas have a total population of 100,000 or more (75,000 in New England) and contain either a place with a population of 50,000 or more or an urbanized area of 50,000 or more. A metropolitan area is comprised of one or more central counties and outlying counties that have close economic and social relationships with the central county. Unlike a Census-designated urbanized area with boundaries that follow population patterns, the boundaries of a metropolitan area follow county boundaries[3] and can contain significant tracts of rural land.

[3] In New England, metropolitan areas follow town boundaries.

Figure 3-1. Urbanized Areas of the United States

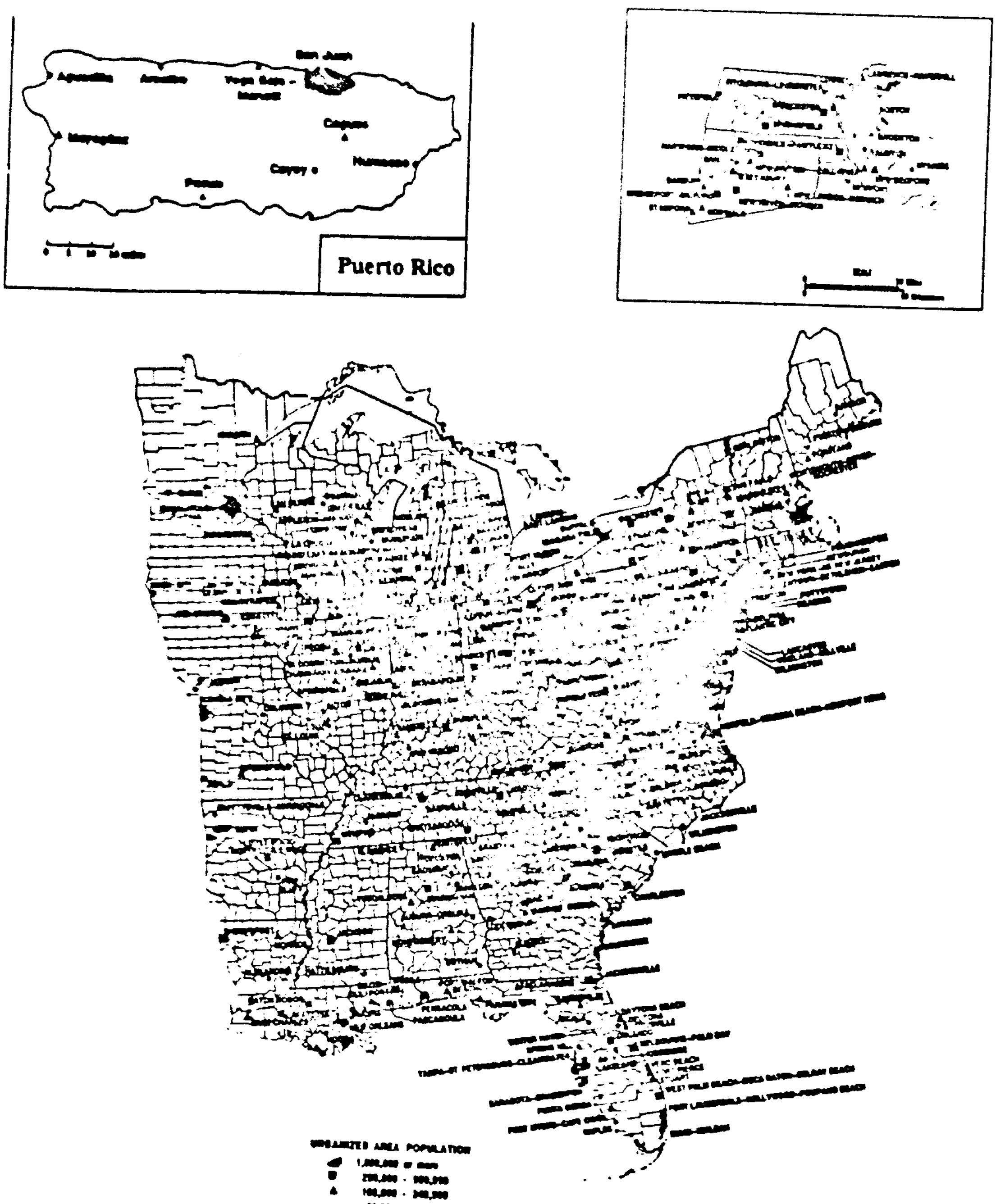

Figure 3-1. Urbanized Areas of the United States (continued)

Table 3-2. Populations in Urbanized Areas

State	Urbanized Area Population	Number of Urbanized Areas
Alaska	221,883	1
Alabama	1,839,966	12
Arkansas	591,420	6
Arizona	2,655,997	3
California	25,466,131	38
Colorado	2,377,820	8
Connecticut	2,455,697	12
District of Columbia	606,900	1
Delaware	458,749	2
Florida	10,177,624	27
Georgia	3,260,674	11
Hawaii	747,109	2
Iowa	942,653	8
Idaho	278,200	3
Illinois	8,478,687	18
Indiana	2,692,676	13
Kansas	1,018,604	5
Kentucky	1,276,855	7
Louisiana	2,228,018	9
Massachusetts	4,730,382	13
Maryland	3,581,461	7
Maine	266,732	4
Michigan	5,812,473	16
Minnesota	2,370,935	7
Missouri	2,782,738	6
Mississippi	617,412	5
Montana	208,883	3
North Carolina	2,512,866	17
North Dakota	202,334	3
Nebraska	687,875	3
New Hampshire	339,454	5
New Jersey	6,629,540	7
New Mexico	649,793	4
Nevada	911,095	2
New York	14,116,042	14
Ohio	6,656,974	20
Oklahoma	1,354,343	4
Oregon	1,420,059	5
Pennsylvania	7,207,497	20
Puerto Rico	2,125,255	9
Rhode Island	824,534	3
South Carolina	1,426,739	10
South Dakota	163,986	3
Tennessee	2,218,007	9
Texas	11,372,246	32
Utah	1,319,551	4
Virginia	3,829,739	11
Vermont	87,088	1
Washington	3,214,738	10
Wisconsin	2,464,721	15
West Virginia	388,840	7
Wyoming	114,138	2
TOTAL	160,384,133	467*

*Urbanized areas which crossed state boundaries were counted more than once. There are 405 distinct urbanized areas nationwide.

Source: 1990 Census of Population and Housing, Bureau of the Census, U.S. Dept. of Commerce

OMB has defined 284 metropolitan areas based on the 1990 census. Figure 3-2 shows the location of the 284 metropolitan areas. These areas have a combined population of 192.7 million or 77 percent of the total U.S. population. This total includes rural populations of 26.5 million (14 percent of the metropolitan area population). Metropolitan areas occupy about 16.6 percent of the land area of the United States (about 88 percent of which is rural). There are 6,998 incorporated places (2,732 of which are rural) and 823 counties located in metropolitan areas. Table 3-3 provides a distribution of population inside and outside of metropolitan areas.

Table 3-3. Populations Inside and Outside of Metropolitan Areas in 1990

	Population	Area (sq.mi.)
Inside Metropolitan Area		
Urban in Urbanized Area	159,624,517	66,311
Urban Not in Urbanized Area	8,854,157	9,507
Rural	27,032,065	551,310
Outside Metropolitan Area		
Urban in Urbanized Area	1,537,739	1,394
Urban Not in Urbanized Area	19,583,295	18,023
Rural	35,701,936	3,136,894

Source: Bureau of the Census

3.1.2 Identification of Phase I Municipal Systems

Section 402(p) of the CWA identifies discharges from municipal separate storm sewer systems serving a population of 100,000 or more as Phase I sources under the NPDES storm water program. Municipal separate storm sewer systems serving a population of 100,000 or more are defined in the NPDES regulations at 40 *CFR* 122.26(b)(4) and (7) to include:

- Incorporated cities with a population of 100,000 or more
- Counties with populations of 100,000 or more in unincorporated, urbanized areas (excluding the population of towns and townships)
- Municipalities designated by EPA or an authorized NPDES State as having Phase I municipal separate storm sewer systems.

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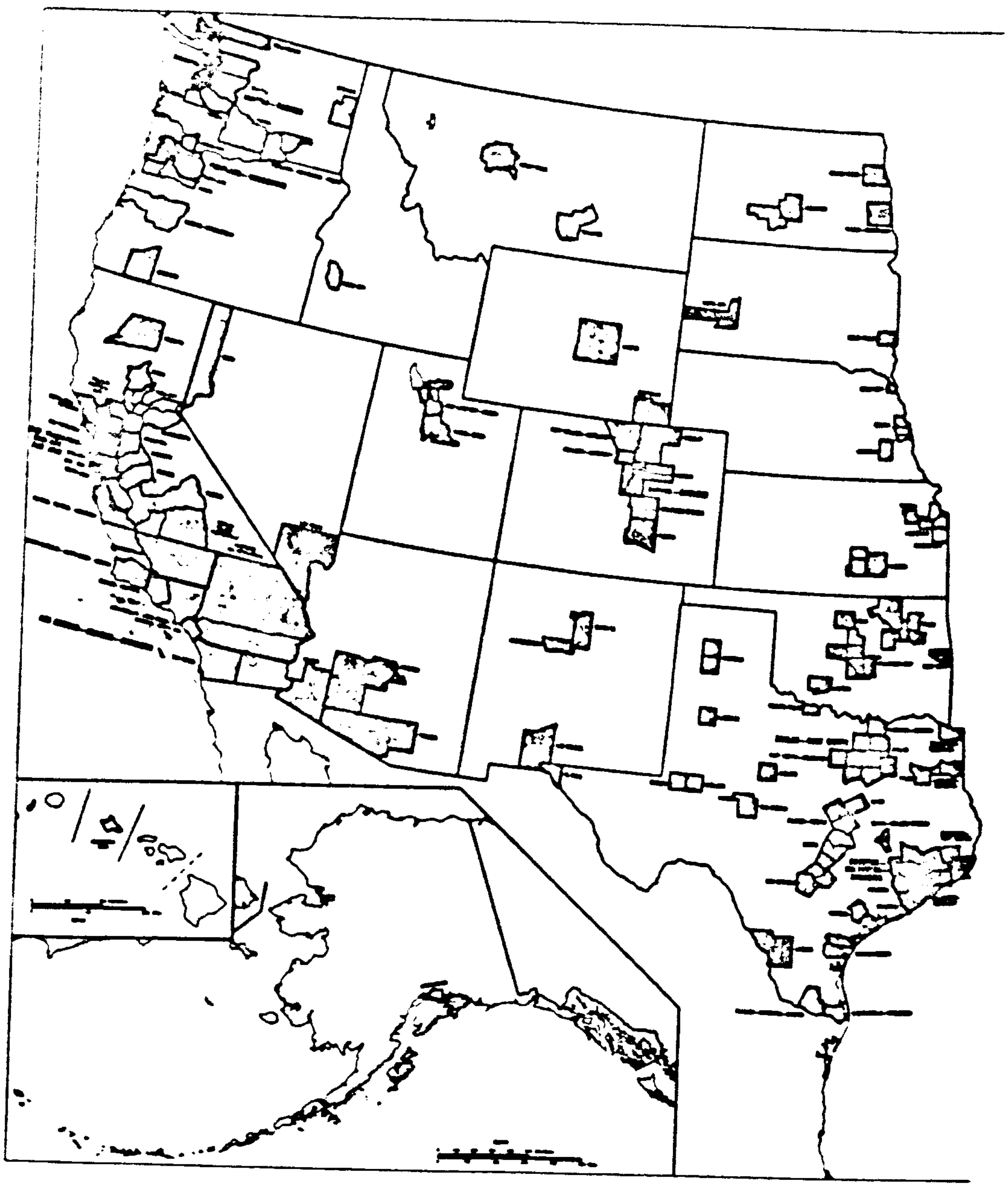

Figure 3-2. Metropolitan Areas of the United States

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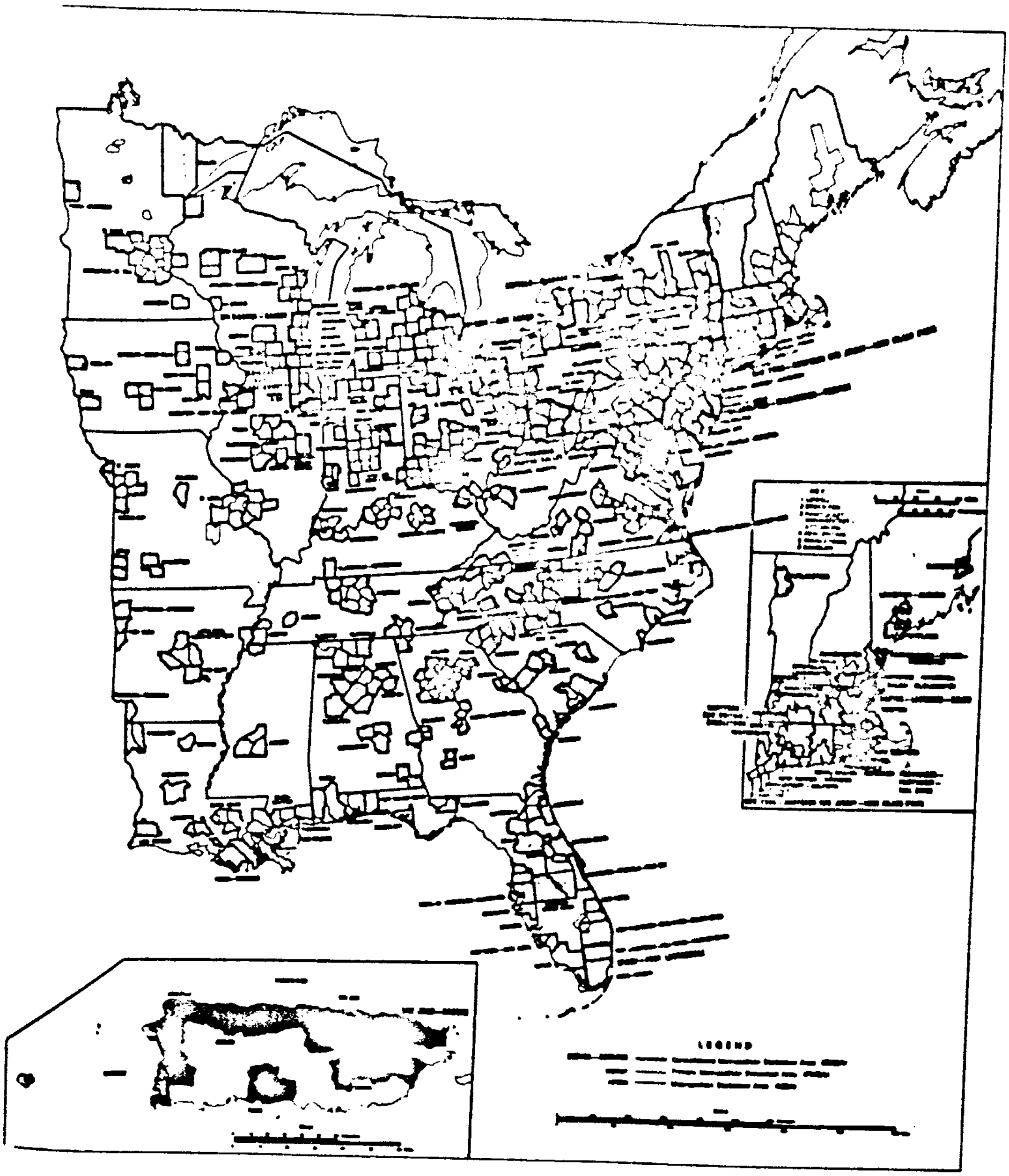

Figure 3-2. Metropolitan Areas of the United States (continued)

In addition, discharges from municipal separate storm sewer systems can be addressed under Phase I of the NPDES program if they are designated under Section 402(p)(2)(E) of the CWA as significant contributors of pollutants to waters of the United States or if they have contributed to a violation of a water quality standard.

Table 3-4 summarizes population and area estimates for municipalities with separate storm sewer systems subject to Phase I of the NPDES program. Appendix A lists Phase I municipal separate storm sewer systems. All but eight States (i.e., Maine, Montana, North Dakota, New Hampshire, New Jersey, Rhode Island, Vermont, and Wyoming) have one or more Phase I municipal separate storm sewer system. Table 3-5 summarizes Phase I municipal separate storm sewer systems by State.

Table 3-4. Municipalities Addressed by Phase I of the NPDES Storm Water Program

Phase I Municipalities		Number	Population (millions)	Area (sq.mi.)
Identified by Regulation*	Cities	140	50.9	17,634
	Counties	45	17.1 **	83,254 **
Designated by EPA/States	Cities	481	14.5	5,017
	Counties	32	3.5 **	27,862 **
	Other ***	60	NA	NA

* These counts exclude cities with a population of 100,000 or more that are exempted from Phase I of the water program due to populations served by combined sewers.

** Includes all of regulated counties. Of the 17.1 million people in counties identified by regulation, 14.6 are in urbanized unincorporated areas. Of the 3.5 million people in designated counties, 2.1 million are in urbanized unincorporated areas.

*** "Other" pertains to a municipality that is not defined by U.S. census political boundaries (i.e., State DOTs, drainage districts, universities, etc.).

Table 3-5. Summary of Phase I Municipalities (by State)

State / Territory	Identified by Regulation		Designated		Phase I Population
	Incorporated Places	Counties	Incorporated Places	Counties	
Alaska	1	0	0	0	226,338
Alabama	4	0	35	5	1,233,803
American Samoa	0	0	0	0	0
Arkansas	1	0	0	0	175,795
Arizona	4	1	0	0	2,066,289
California	25	9	217	6	23,496,438
Colorado	4	0	1	1	1,330,143
Connecticut	1	0	0	0	108,056
District of Columbia	1	0	0	0	606,900
Delaware	0	1	13	0	441,946
Florida	8	9	126	4	8,824,892
Georgia	4	4	35	5	2,870,325
Guam	0	0	0	0	0
Hawaii	0	1	0	0	847,952
Iowa	2	0	1	0	397,271
Idaho	1	0	1	0	132,107
Illinois	1	0	0	0	139,426
Indiana	2	0	0	0	904,399
Kansas	3	0	0	0	573,661
Kentucky	2	1	0	0	753,618
Louisiana	3	1	4	1	1,498,681
Massachusetts	2	0	1	0	847,481
Maryland	1	4	6	6	3,809,266
Maine	0	0	0	0	0
Michigan	5	0	0	0	702,153
Minnesota	2	0	0	0	640,618
Missouri	3	0	0	0	687,941
Mississippi	1	0	0	0	196,637
Montana	0	0	0	0	0

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Table 3-5. Summary of Phase I Municipalities (by State) (continued)

State / Territory	Identified by Regulation		Designated		Phase I Population
	Incorporated Places	Counties	Incorporated Places	Counties	
North Carolina	5	1	1	0	1,325,072
North Dakota	0	0	0	0	0
Nebraska	2	0	0	0	527,767
Nevada	2	1	3	1	981,688
New Hampshire	0	0	0	0	0
New Jersey	0	0	0	0	0
New Mexico	1	0	0	0	384,736
New York	5	0	0	0	7,322,564
Northern Mariana Islands	0	0	0	0	0
Ohio	6	0	0	0	2,240,572
Oklahoma	2	0	0	0	812,021
Oregon	3	1	23	2	1,349,799
Palau	0	0	0	0	0
Pennsylvania	2	0	0	0	1,690,667
Puerto Rico	0	0	0	0	0
Rhode Island	0	0	0	0	0
South Carolina	0	2	0	0	397,573
South Dakota	1	0	0	0	100,814
Tennessee	4	0	9	0	1,484,247
Texas	15	1	4	0	7,843,991
Utah	1	1	0	0	434,446
Virgin Islands	0	0	0	0	0
Virginia	6	4	1	1	2,909,207
Vermont	0	0	0	0	0
Washington	2	3	0	0	1,895,943
Wisconsin	2	0	0	0	819,350
West Virginia	0	0	0	0	0
Wyoming	0	0	0	0	0
TOTAL	140	45	481	32	86,032,593

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3.1.2.1 Incorporated Cities With a Population of 100,000 or More

The Phase I NPDES storm water regulations initially specifically identified 173 incorporated places with a population of more than 100,000.[4] However, 30 of the 173 cities with a population of 100,000 or more have been excluded from Phase I of the NPDES storm water program because, after the population served by combined sewers is subtracted from the total city population, the population served by separate storm sewers is less than 100,000.[5] Table 3-6 lists the cities excluded from Phase I because of populations served by combined sewers.

The description of Phase I sources presented in this report includes available information on cities given exemptions from Phase I because of populations served by combined sewers.

3.1.2.2 Counties With Urbanized, Unincorporated Populations of 100,000 or More

Phase I of the NPDES storm water regulations specifically identify municipal separate storm sewer systems in unincorporated portions of 45 counties as needing an NPDES permit.[6] Counties specifically identified in the Phase I regulations were described as having 100,000 or more people (based on the 1980 census) who live in unincorporated areas and are part of an urbanized area designated by the Bureau of the Census. EPA identified counties with large unincorporated, urbanized populations for regulation under Phase I of the NPDES

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[4] The specific cities listed in the current NPDES storm water regulations were based on 1980 census data. Thirty-five cities had populations of less than 100,000 under the 1980 census but have populations of 100,000 or more based on the 1990 census. Five cities had populations of more than 100,000 under the 1980 census but have populations of less than 100,000 based on the 1990 census. For the purposes of this Report, these 40 cities are not addressed as Phase I municipalities, unless they have been designated by EPA or an authorized NPDES State as needing a permit as of January 1994.

[5] To account for populations served by combined sewers, 40 *CFR* 122.26(f)(3) allows municipalities to petition EPA or an authorized NPDES State to reduce their population for the purpose of Phase I population determinations.

[6] The specific counties listed in the current NPDES storm water regulations were based on 1980 census data. Thirteen counties had unincorporated, urbanized populations of less than 100,000 under the 1980 census but have unincorporated, urbanized populations of 100,000 or more based on the 1990 census. Two counties had unincorporated, urbanized populations of more than 100,000 under the 1980 census but have unincorporated, urbanized populations of less than 100,000 based on the 1990 census. For the purposes of this Report, these 15 counties are not addressed as Phase I municipalities, unless they have been designated by EPA or an authorized NPDES State as needing a permit.

Table 3-6. Cities With Populations of 100,000 or More Given Exemption Under Phase I of the NPDES Storm Water Regulations Due to Combined Sewers

State	City	City Population	CSO Service Population
California	San Francisco	723,959	723,959
Connecticut	Bridgeport	141,686	50,000
	Hartford	139,739	110,000
	New Haven	130,474	84,300
	Waterbury	108,961	99,947
Illinois	Chicago	2,783,726	2,783,726
	Peoria	113,504	77,000
Indiana	Evansville	126,272	50,425
	Gary	116,646	116,646
	South Bend	105,511	100,000
Massachusetts	Springfield	156,983	156,983
Michigan	Detroit	1,027,974	1,017,880
	Livonia	100,850	100,850
	Lansing	127,321	50,000
Missouri	St. Louis	396,685	396,685
New Jersey	Elizabeth	110,002	107,000
	Jersey City	228,537	223,532
	Newark	275,221	275,221
	Paterson	140,891	140,891
New York	Buffalo	328,123	328,123
	Albany	101,082	96,500
	Rochester	231,636	231,636
	Syracuse	163,860	140,800
	Yonkers	188,082	184,812
Pennsylvania	Pittsburgh	369,879	369,879
	Erie	108,718	108,719
Rhode Island	Providence	160,728	160,728
Virginia	Alexandria	111,183	66,000
	Richmond	203,056	352,775
Washington	Spokane	177,196	135,600
TOTAL		9,198,485	8,840,617

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storm water program because they were the primary municipal entity governing unincorporated areas. Because they are the primary municipal entity, these counties are the functional equivalent to an incorporated city for the purposes of a storm water program (i.e., the county generally performs many of the same functions and has the same legal and land use authority as incorporated cities). The 45 counties identified in this manner are located in 17 States, with the majority of the counties (33) being located in 6 States—Florida (9 counties), California (9 counties), Georgia (4 counties), Maryland (4 counties), Virginia (4 counties), and Washington (3 counties).

In 20 States, unincorporated portions of counties or county equivalents are divided into minor civil divisions. The criteria used to define Phase I municipal separate storm sewer systems did not address systems in counties with a population of 100,000 or more in these States, even where the unincorporated portions of the county were heavily urbanized. The Agency did not address such areas under Phase I of the program because of the complexities of the intergovernmental relationship between the county and incorporated places and minor civil divisions.

3.1.2.3 Designated Municipalities

The NPDES regulations authorize EPA or NPDES States to designate additional municipal systems as needing a permit under Phase I of the storm water program.[7] To date, 481 incorporated places and 32 counties have been designated by EPA and authorized NPDES States. These designated municipalities have a combined population of more than 18

[7] Designations can occur under two authorities. 40 *CFR* 122.26(b)(4) and (7) provide that additional municipal separate storm sewers may be designated as part of a system serving a population of 100,000 or more because of the interrelationship between the discharges of the designated storm sewers and the discharges from municipal separate storm sewers located in an incorporated place with a population of 100,000 or more or a county with an urbanized, unincorporated population of 100,000 or more. Additional municipal separate storm sewers within a region defined by a storm water management regional authority can be designated based on a jurisdictional, watershed, or other appropriate basis that includes an incorporated place with a population of 100,000 or more or a county with an urbanized, unincorporated population of 100,000 or more. Section 402(p)(2)(E) of the CWA provides that storm water discharges, including discharges from municipal separate storm sewer systems, that are a significant contributor of pollutants to waters of the United States or that have contributed to a violation of a water quality standard can be designated as needing a permit.

million. The majority of the designations (464 incorporated places and 28 counties) are in eight States (Alabama, California, Delaware, Florida, Georgia, Maryland, Oregon, and Tennessee). Municipalities have been designated as part of the Phase I NPDES storm water program in seven other States.

3.1.3 Identification of Potential Phase II Municipal Systems

Municipal separate storm sewer systems that are potentially subject to requirements under Phase II of the NPDES storm water program will be identified in terms of the following classes:

- Municipalities not addressed by Phase I, but located in an urbanized area with one or more Phase I municipalities
- Municipalities associated with an urbanized area without a Phase I municipality
- Urban populations outside of urbanized areas
- Rural populations
- Populations not addressed in the census.

3.1.3.1 Potential Phase II Municipalities Associated With Urbanized Areas With One or More Phase I Municipalities

Of the 405 urbanized areas designated by the Bureau of the Census, 136 have one or more municipalities with a separate storm sewer system addressed by Phase I of the NPDES storm water program. In most of these 136 urbanized areas, municipalities not addressed under Phase I are also found in the urbanized area. Table 3-7 lists the 136 urbanized areas with one or more Phase I municipalities. Table 3-8 summarizes the number of municipalities associated with different sizes of urbanized areas with a municipality with separate storm sewers subject to Phase I of the storm water program. Note that some urbanized areas cross state lines and are listed in the table in multiple states. In those cases, the portion of the urbanized area in each state is listed, rather than the total population within the urbanized area.

Table 3-7. Urbanized Areas With One or More Municipality in Phase I of the NPDES Storm Water Program

State	Urbanized Area	Total Population	Phase I Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
AK	Anchorage, AK	[illegible]	[illegible]	1	0	1
AL	Birmingham, AL	622,774	577,979	25	0	2
	Columbus, GA—AL	32,288	0	1	0	2
	Huntsville, AL	180,315	173,623	2	0	1
	Mobile, AL	300,912	255,494	6	0	1
	Montgomery, AL	210,007	187,106	2	0	3
AR	Little Rock—North Little Rock, AR	305,353	175,795	7	0	2
	Memphis, TN—AR—MS	34,600	0	3	0	1
AZ	Phoenix, AZ	2,006,239	1,410,951	15	0	2
	Tucson, AZ	579,235	567,493	3	0	1
CA	Antioch—Pittsburg, CA	153,768	146,205	3	0	1
	Bakersfield, CA	302,605	302,605	1	0	1
	Fairfield, CA	99,964	99,897	2	0	1
	Fresno, CA	453,388	403,065	2	0	1
	Hemet—San Jacinto, CA	90,929	90,929	2	0	1
	Hesperia—Apple Valley—Victorville, CA	153,176	66,646	3	0	1
	Indio—Coachella, CA	56,038	2,624	2	0	1
	Lancaster—Palmdale, CA	187,190	21,990	2	0	1
	Los Angeles, CA	11,402,946	11,402,946	115	0	4
	Modesto, CA	230,609	164,730	2	0	1
	Oxnard—Ventura, CA	480,482	387,907	7	0	2
	Palm Springs, CA	129,025	13,200	6	0	1
	Riverside—San Bernardino, CA	1,170,196	1,170,196	13	0	2
	Sacramento, CA	1,097,005	100,4620	5	0	3
	Salinas, CA	122,225	108,777	1	0	1
	San Diego, CA	2,348,417	2,348,417	18	0	1
	San Francisco—Oakland, CA	3,629,516	2,644,467	63	0	7
	San Jose, CA	1,435,019	1,411,091	14	0	1
	Simi Valley, CA	128,043	128,043	2	0	1
	Stockton, CA	262,046	210,943	1	0	1
CO	Colorado Springs, CO	352,989	280,995	3	0	1
	Denver, CO	1,517,977	918,955	23	0	7
	Pueblo, CO	106,155	98,640	1	0	1
CT	Stamford, CT—NY	187,180	108,056	1	4	1
	Worcester, MA—CT	555	0	0	1	1
DC	Washington, DC—MD—VA	606,900	606,900	1	0	1
DE	Wilmington, DE—NJ—MD—PA	407,962	407,962	9	0	1
FL	Fort Lauderdale—Hollywood—Pompano Beach, FL	1,238,134	1,183,036	27	0	1
	Fort Myers—Cape Coral, FL	220,552	102,337	2	0	1
	Jacksonville, FL	738,413	627,128	6	0	3
	Lakeland, FL	147,628	147,628	2	0	1
	Miami—Hialeah, FL	1,914,660	1,902,397	25	0	1
	Orlando, FL	887,126	746,006	17	0	2
	Pensacola, FL	253,558	225,628	2	0	2
	Sarasota—Bradenton, FL	444,385	375,194	8	0	3
	Spring Hill, FL	52,056	3,463	1	0	2
	Tallahassee, FL	155,884	124,773	1	0	1

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Table 3-7. Urbanized Areas With One or More Municipality in Phase I of the NPDES Storm Water Program (continued)

State	Urbanized Area	Total Population	Phase I Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
FL	Tampa—St.Petersburg—Clearwater, FL	1,708,710	1,6[illegible],343	28	0	3
	West Palm Beach—Boca Raton—Delray Beach, FL	794,848	791,286	34	0	2
	Winter Haven, FL	86,427	86,427	4	0	1
GA	Atlanta, GA	2,157,806	2,031,973	38	0	11
	Augusta, GA—SC	217,002	151,214	2	0	2
	Chattanooga, TN—GA	46,194	0	4	0	3
	Columbus, GA—AL	188,410	173,196	2	0	2
	Macon, GA	129,496	125,952	2	0	2
	Savannah, GA	198,630	194,888	7	0	1
HI	Honolulu, HI	632,603	632,603	0	0	1
	Kailua, HI	114,506	114,506	0	0	1
IA	Cedar Rapids, IA	136,190	108,751	4	0	1
	Davenport—Rock Island—Moline, IA—IL	128,950	94,942	6	0	1
	Des Moines, IA	293,666	193,187	9	0	3
	Omaha, NE—IA	59,890	0	2	0	1
ID	Boise City, ID	167,941	132,107	2	0	1
IL	Davenport—Rock Island—Moline, IA—IL	135,068	0	11	10	2
	Rockford, IL	207,826	139,426	5	5	1
IN	Fort Wayne, IN	248,424	173,072	2	9	1
	Indianapolis, IN	914,761	731,327	24	20	6
	Louisville, KY—IN	100,159	0	4	5	2
KS	Kansas City, MO—KS	480,249	149,767	17	3	2
	Topeka, KS	132,711	119,883	1	5	1
	Wichita, KS	338,789	304,011	6	10	1
KY	Cincinnati, OH—KY	236,349	0	33	0	3
	Lexington-Fayette, KY	220,701	218,925	1	0	2
	Louisville, KY—IN	654,797	508,493	97	0	2
LA	Baton Rouge, LA	365,943	322,070	5	0	3
	New Orleans, LA	1,040,226	938,384	5	0	5
	Shreveport, LA	256,489	198,525	2	0	2
MA	Boston, MA	2,775,370	574,283	19	76	7
	Lowell, MA-NH	180,716	103,439	1	8	1
	Worcester, MA—CT	315,111	169,759	1	18	1
MD	Annapolis, MD	78,590	78,488	2	0	1
	Baltimore, MD	1,889,873	1,889,873	2	0	5
	Frederick, MD	58,393	14,100	2	0	1
	Hagerstown, MD—PA—WV	68,226	28,321	4	0	1
	Washington, DC—MD—VA	1,420,999	1,169,907	39	0	4
	Wilmington, DE—NJ—MD—PA	13,732	0	1	0	1
MI	Ann Arbor, MI	222,061	109,592	3	7	2
	Detroit, MI	3,697,529	262,674	76	33	5
	Flint, MI	326,023	140,761	8	12	1
	Grand Rapids, MI	436,336	189,126	7	8	2
	Toledo, OH—MI	18,817	0	0	3	1
MN	Minneapolis—St.Paul, MN	2,079,676	640,618	92	3	8

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Table 3-7. Urbanized Areas With One or More Municipality in Phase I of the NPDES Storm Water Program (continued)

State	Urbanized Area	Total Population	Phase I Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
MO	Kansas City, MO—KS	795,068	545,1[illegible]	31	20	4
	Springfield, MO	159,086	140,494	2	9	2
MS	Jackson, MS	289,285	196,637	8	0	3
	Memphis, TN—AR—MS	29,341	0	2	0	1
NC	Charlotte, NC	455,597	395,934	6	0	2
	Durham, NC	205,355	136,611	3	0	2
	Fayetteville, NC	241,763	222,522	3	0	2
	Greensboro, NC	194,508	183,521	1	0	1
	Raleigh, NC	305,925	207,951	4	0	1
	Winston-Salem, NC	185,184	143,485	4	0	2
NE	Lincoln, NE	192,558	191,972	1	0	1
	Omaha, NE—IA	484,402	335,795	6	0	2
NH	Lowell, MA-NH	935	0	0	1	1
NJ	Allentown—Bethlehem—Easton, PA—NJ	24,817	0	2	2	1
	New York, NY—Northeastern New Jersey	5,113,880	0	192	96	12
	Philadelphia, PA—NJ	944,875	0	43	37	3
	Wilmington, DE—NJ—MD—PA	26,043	0	1	2	1
NM	Albuquerque, NM	497,120	384,736	4	0	2
	El Paso, TX—NM	8,179	0	1	0	1
NV	Las Vegas, NV	697,348	697,348	3	0	1
	Reno, NV	213,747	213,747	2	0	1
NY	New York, NY—Northeastern New Jersey	10,930,132	7,322,564	125	36	10
	Stamford, CT—NY	20	0	0	1	1
OH	Akron, OH	527,863	223,019	20	14	5
	Cincinnati, OH—KY	976,326	364,040	40	20	4
	Cleveland, OH	1,677,492	505,616	76	16	7
	Columbus, OH	945,237	632,910	24	24	5
	Dayton, OH	613,467	182,044	17	16	4
	Toledo, OH—MI	470,338	332,943	12	7	3
OK	Oklahoma City, OK	784,425	438,922	23	0	5
	Tulsa, OK	474,668	367,302	6	0	5
OR	Eugene—Springfield, OR	189,192	112,669	2	0	1
	Portland—Vancouver, OR—WA	1,004,676	978,531	22	0	3
	Salem, OR	157,079	94,983	2	0	2
PA	Allentown—Bethlehem—Easton, PA—NJ	385,619	105,090	18	18	2
	Hagerstown, MD—PA—WV	1,212	0	0	1	1
	Philadelphia, PA—NJ	3,277,336	1,585,577	67	84	5
	Wilmington, DE—NJ—MD—PA	1,879	0	0	4	2
SC	Augusta, GA—SC	69,536	0	3	0	2
	Columbia, SC	328,349	130,589	9	0	2
	Greenville, SC	248,173	147,464	6	0	3
SD	Sioux Falls, SD	100,843	100,814	1	3	2
TN	Chattanooga, TN—GA	250,761	152,466	9	0	1
	Knoxville, TN	304,466	165,121	5	0	4
	Memphis, TN—AR—MS	761,252	637,326	3	0	1
	Nashville, TN	573,294	508,828	10	0	4

Table 3-7. Urbanized Areas With One or More Municipality in Phase I of the NPDES Storm Water Program (continued)

State	Urbanized Area	Total Population	Phase I Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
TX	Abilene, TX	107,836	106,654	3	0	2
	Amarillo, TX	157,934	157,615	1	0	2
	Austin, TX	562,008	465,622	7	0	2
	Beaumont, TX	122,841	114,323	3	0	2
	Corpus Christi, TX	270,006	257,453	2	0	3
	Dallas—Fort Worth, TX	3,198,259	2,493,364	56	0	9
	El Paso, TX—NM	562,838	515,187	3	0	1
	Houston, TX	2,901,851	2,468,419	34	0	7
	Laredo, TX	123,651	122,899	1	0	1
	Lubbock, TX	187,906	186,206	1	0	1
	San Antonio, TX	1,129,154	935,933	18	0	3
	Waco, TX	144,372	103,590	8	0	1
UT	Salt Lake City, UT	789,447	430,716	16	0	2
VA	Norfolk—Virginia Beach—Newport News, VA	1,323,098	1,204,925	10	0	12
	Petersburg, VA	103,526	12,115	3	0	6
	Richmond, VA	589,980	363,740	1	0	4
	Roanoke, VA	178,277	96,397	3	0	5
	Washington, DC—MD—VA	1,335,132	1,088,797	8	0	9
WA	Portland—Vancouver, OR—WA	167,482	0	1	0	1
	Seattle, WA	1,744,086	1,193,945	30	0	3
	Tacoma, WA	497,210	435,194	11	0	2
WI	Madison, WI	244,336	191,262	7	6	1
	Milwaukee, WI	1,226,293	628,088	35	11	5
WV	Hagerstown, MD—PA—WV	768	0	0	0	1

Table 3-8. Municipalities in Urbanized Areas With One or More Phase I Municipalities

Urbanized Area Population	Number of Urbanized Areas	Phase I Municipalities			Portions of Urbanized Areas Not in Phase I				
		Incorp. Places	Counties	Phase I Population	Incorp. Places	Minor Civil Divisions	Counties	Phase II Population	Total Population
50,000 - 74,999	4	0	4	48,508	9	1	3	188,185	236,693
75,000 - 99,999	4	9	2	355,741	1	0	1	169	355,910
100,000 - 124,999	8	6	2	778,728	7	3	14	122,855	901,583
125,000 - 149,999	7	8	2	747,047	17	5	4	200,418	947,465
150,000 - 249,999	32	37	9	4,780,942	45	50	44	1,542,672	6,323,614
Over 250,000	81	504	53	75,004,440	1,508	575	239	33,650,057	108,654,497
TOTALS	136	564	72	81,715,406	1,587	634	305	35,704,356	117,419,762

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The 136 urbanized areas with one or more municipality with a separate storm sewer system addressed by Phase I have a total population of 117.5 million (47 percent of the total U.S. population). The portions of these urbanized areas currently not addressed by Phase I of the NPDES storm water program have a combined population of 35.7 million people. Of the 35.7 million people, 32.9 million people live in 1,587 incorporated places and 634 minor civil divisions. The remaining 2.9 million people live in unincorporated areas. EPA estimates that 305 counties currently not addressed by Phase I of the NPDES storm water program are part of an urbanized area in which one or more municipalities are in Phase I.

Two general patterns of municipal governments can be used to describe the 136 urbanized areas that have one or more Phase I municipalities. Most of the 136 urbanized areas can be described as having a large core city with a population of 100,000 that is addressed by Phase I of the program, with a large number of smaller potential Phase II incorporated places and minor civil divisions surrounding the core city. Figure 3-3 provides an example of this pattern, which illustrates the Milwaukee, Wisconsin, urbanized area.

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The second pattern of municipal government for the 136 urbanized areas consists of counties that do not have minor civil divisions. Urbanized areas that follow this pattern are comprised of a core city (which is usually addressed by Phase I) surrounded by a combination of unincorporated portions of counties and incorporated places. In urbanized areas that follow this pattern, unincorporated portions of one or more of the counties surrounding the core city may be in Phase I, while the smaller incorporated places surrounding the core city are generally not addressed by Phase I. Figure 3-4 gives an example of this pattern, which illustrates the Washington, D.C., urbanized area. Figure 3-4 also shows that Phase I jurisdiction for this urbanized area generally extends beyond the 1990 boundaries of the urbanized area. In this manner, Phase I addresses much of the new development associated with the expanding urbanized population, even though it occurs outside of the 1990 urbanized area boundary.

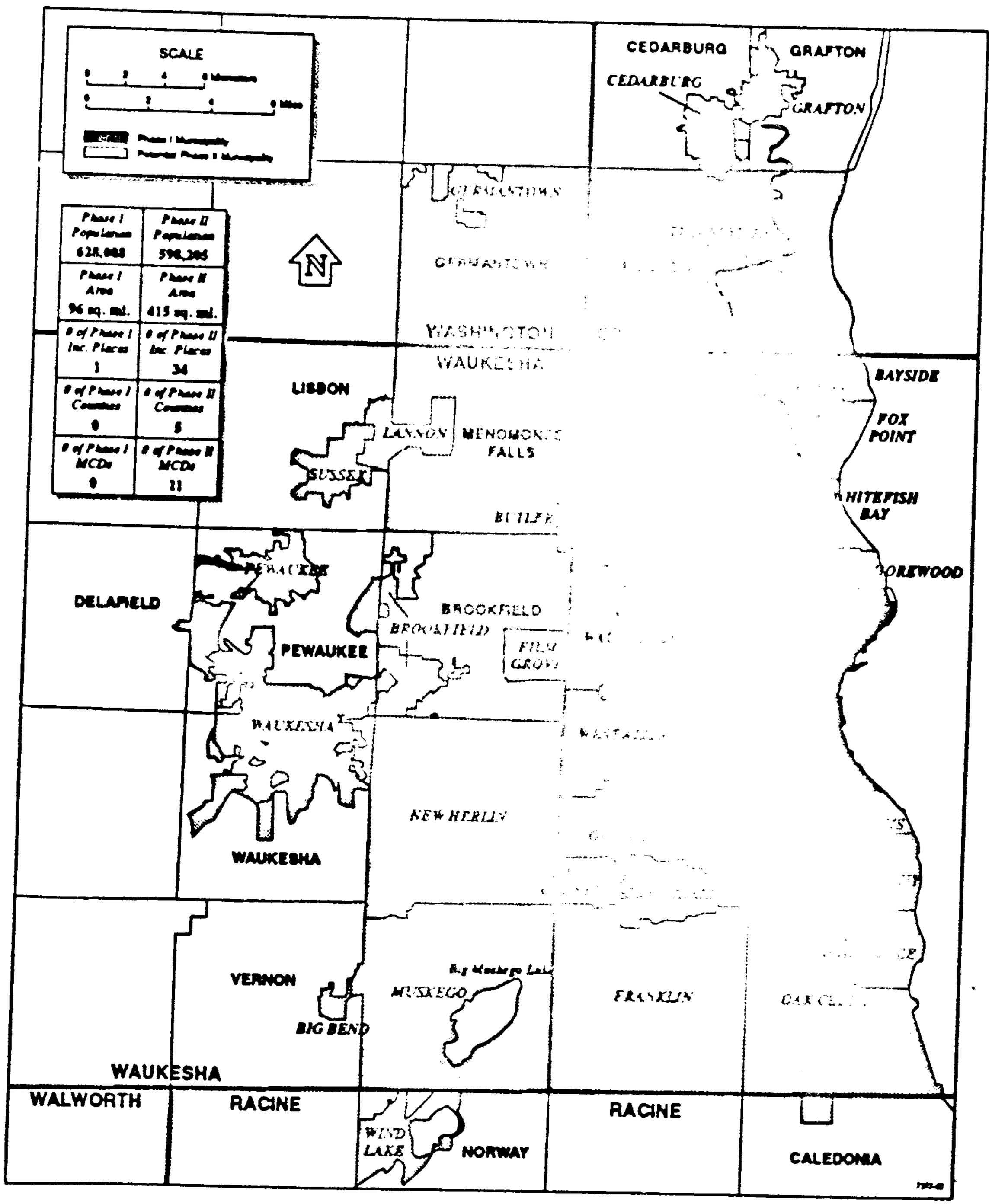

Figure 3-3. Phase I and Phase II Portions of Milwaukee, Wisconsin, Urbanized Area

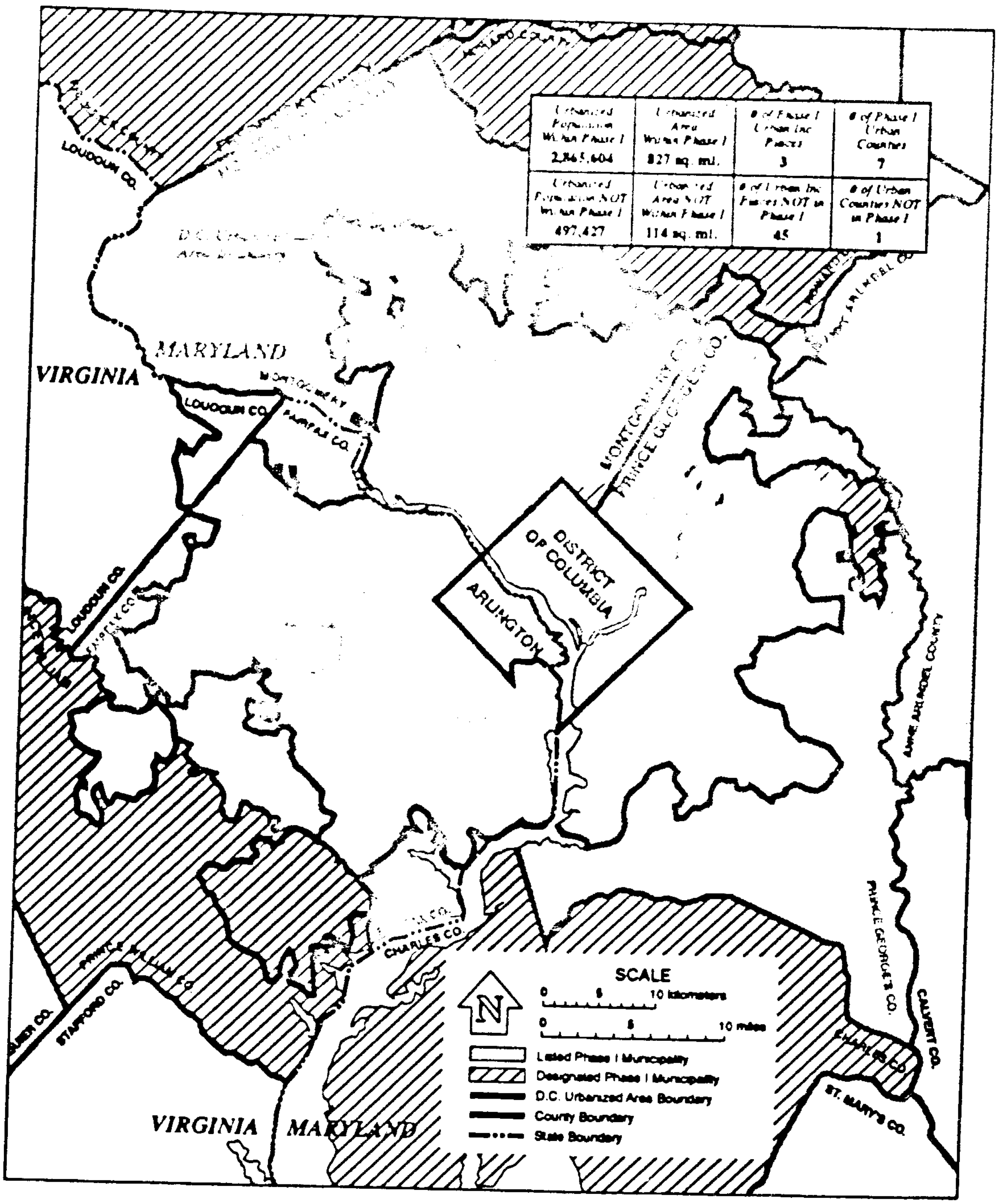

Figure 3-4. Phase I and Phase II Portions of Washington, DC, Urbanized Area

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3.1.3.2 Potential Phase II Municipalities Associated With Urbanized Areas Without a Phase I Municipality

A total of 269 of the Census-designated urbanized areas currently do not have any municipalities with separate storm sewers subject to Phase I of the storm water program. Table 3-9 lists these urbanized areas. As in Table 3-7, note that some urbanized areas cross state lines and are listed in the table in multiple states along with the portion of the population in that state. Table 3-10 summarizes the population and number of municipalities associated with different classes of urbanized areas without a municipality with separate storm sewers subject to Phase I of the storm water program. Of the 269 urbanized areas, 101 (more than a third) have a population of more than 100,000 and 23 have a population of more than 250,000. These 269 urbanized areas without a Phase I municipal separate storm sewer system have a combined population of 42.9 million people (16 percent of the total U.S. population). Of the 42.9 million people, 37.1 million people live in 1,470 incorporated places and 966 minor civil divisions. The remaining 5.8 million people live in unincorporated areas. EPA estimates that 380 counties that are part of an urbanized area do not have a municipality addressed by Phase I of the NPDES storm water program.

Twenty-one urbanized areas have an incorporated city with a population of 100,000 or more that are not subject to Phase I of the NPDES storm water program because of populations served by combined sewers. Table 3-11 lists these urbanized areas. The 21 urbanized areas have a combined population of 17.5 million people, of which an estimated 11.7 million people are served by separate storm sewers. Three of these urbanized areas (i.e., Chicago, St. Louis, and Pittsburgh) have populations of more than a million people that are served by separate storm sewers. Of the remaining urbanized areas, 10 have a population of more than 250,000 and 7 have a population of more than 175,000, but less than 250,000. Of the 17.5 million people that live in the 21 urbanized areas, 6.0 million people live in cities with a population of 100,000 or more.

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Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
AL	Anniston, AL	68,150	5	0	2
	Auburn—Opelika, AL	56,510	2	0	1
	Decatur, AL	63,541	4	0	2
	Dothan, AL	58,925	5	0	2
	Florence, AL	69,186	4	0	2
	Gadsden, AL	71,630	6	0	2
	Tuscaloosa, AL	106,428	2	0	1
AR	Fayetteville—Springdale, AR	74,880	5	0	2
	Fort Smith, AR—OK	91,870	3	0	2
	Pine Bluff, AR	61,941	2	0	1
	Texarkana, TX—Texarkana, AR	22,776	1	0	1
AZ	Yuma, AZ-CA	70,523	1	0	1
CA	Chico, CA	71,831	1	0	1
	Davis, CA	52,711	1	0	1
	Lodi, CA	55,590	1	0	1
	Lompoc, CA	56,591	1	0	1
	Merced, CA	64,742	1	0	1
	Napa, CA	68,049	1	0	1
	Redding, CA	78,364	1	0	1
	San Luis Obispo, CA	50,305	1	0	1
	Santa Barbara, CA	182,163	2	0	1
	Santa Cruz, CA	152,355	3	0	1
	Santa Maria, CA	88,989	1	0	1
	Santa Rosa, CA	194,560	3	0	1
	Seaside—Monterey, CA	133,188	7	0	1
	Vacaville, CA	71,535	1	0	1
	Visalia, CA	83,594	1	0	1
	Watsonville, CA	51,378	1	0	2
	Yuba City, CA	77,167	2	0	2
	Yuma, AZ—CA	432	0	0	1
CO	Boulder, CO	98,910	1	0	1
	Fort Collins, CO	105,809	1	0	1
	Grand Junction, CO	71,938	1	0	1
	Greeley, CO	71,578	4	0	1
	Longmont, CO	52,464	1	0	1
CT	Bridgeport—Milford, CT	413,863	6	14	2
	Bristol, CT	92,418	1	7	3
	Danbury, CT—NY	112,647	1	7	2
	Hartford—Middletown, CT	546,198	2	19	3
	New Britain, CT	143,064	1	5	1
	New Haven—Meriden, CT	451,486	3	16	3
	New London—Norwich, CT	156,286	3	13	1
	Norwalk, CT	108,888	1	5	1
	Springfield, MA—CT	68,045	0	6	2
	Waterbury, CT	175,067	2	8	2
DE	Dover, DE	50,787	3	0	1
FL	Daytona Beach, FL	221,341	9	0	1
	Deltona, FL	58,053	0	0	1
	Fort Pierce, FL	126,342	3	0	1
	Fort Walton Beach, FL	112,522	7	0	3

Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
FL	Gainesville, FL	126,215	1	0	1
	Kissimmee, FL	55,419	1	0	1
	Melbourne—Palm Bay, FL	305,978	13	0	1
	Naples, FL	94,344	1	0	1
	Ocala, FL	68,004	1	0	1
	Panama City, FL	103,667	6	0	1
	Punta Gorda, FL	67,033	1	0	1
	Stuart, FL	80,069	3	0	1
	Titusville, FL	51,549	1	0	2
	Vero Beach, FL	64,707	2	0	1
GA	Albany, GA	87,223	1	0	2
	Athens, GA	73,282	2	0	2
	Brunswick, GA	50,066	1	0	1
	Rome, GA	51,589	1	0	1
	Warner Robins, GA	60,976	2	0	1
IA	Dubuque, IA—IL	61,048	2	0	1
	Iowa City, IA	71,372	3	0	1
	Sioux City, IA—NE—SD	83,277	2	0	1
	Waterloo—Cedar Falls, IA	108,260	5	0	1
ID	Idaho Falls, ID	56,356	3	0	1
	Pocatello, ID	53,903	2	0	2
IL	Alton, IL	86,236	7	8	1
	Aurora, IL	192,043	7	10	3
	Beloit, WI—IL	13,371	3	3	1
	Bloomington—Normal, IL	94,186	2	4	1
	Champaign—Urbana, IL	115,524	3	7	1
	Chicago, IL—Northwestern Indiana	6,301,112	179	61	5
	Crystal Lake, IL	72,498	7	6	3
	Decatur, IL	96,039	4	8	1
	Dubuque, IA—IL	2,657	1	1	1
	Elgin, IL	123,899	7	6	2
	Joliet, IL	170,717	8	9	1
	Kankakee, IL	59,695	4	5	1
	Peoria, IL	242,353	12	16	3
	Round Lake Beach—McHenry, IL—WI	112,640	14	10	2
	Saint Louis, MO-IL	328,299	26	19	3
	Springfield, IL	124,524	5	7	1
IN	Anderson, IN	74,037	7	7	2
	Bloomington, IN	71,440	1	4	1
	Chicago, IL—Northwestern Indiana	490,975	19	12	2
	Elkhart—Goshen, IN	98,787	2	6	1
	Evansville, IN—KY	156,570	2	7	2
	Kokomo, IN	57,146	1	5	1
	Lafayette—West Lafayette, IN	100,103	2	6	1
	Muncie, IN	88,073	3	5	1
	South Bend—Mishawaka, IN—MI	215,182	5	9	2
	Terre Haute, IN	77,019	3	6	1

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Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
KS	Lawrence, KS	65,755	1	1	1
	St. Joseph, MO—KS	1,100	1	1	1
KY	Clarksville, TN—KY	21,724	1	0	1
	Evansville, IN—KY	26,517	1	0	1
	Huntington—Ashland, WV—KY—OH	56,122	8	0	2
	Owensboro, KY	60,645	1	0	1
LA	Alexandria, LA	86,001	3	0	1
	Houma, LA	65,879	1	0	2
	Lafayette, LA	129,592	4	0	1
	Lake Charles, LA	119,067	3	0	1
	Monroe, LA	110,737	3	0	1
	Slidell, LA	54,084	1	0	1
MA	Brockton, MA	160,910	1	9	3
	Fall River, MA—RI	126,508	1	4	1
	Fitchburg—Leominster, MA	82,249	2	2	1
	Hyannis, MA	66,713	0	5	1
	Lawrence—Haverhill, MA—NH	212,000	2	7	1
	New Bedford, MA	139,082	1	3	1
	Pittsfield, MA	55,047	1	3	1
	Providence—Pawtucket, RI—MA	93,090	1	10	3
	Springfield, MA—CT	464,702	5	14	2
	Taunton, MA	58,884	1	3	1
MD	Cumberland, MD—WV	51,648	2	0	1
ME	Bangor, ME	61,402	3	2	1
	Lewiston—Auburn, ME	71,598	2	2	1
	Portland, ME	120,220	3	4	1
	Portsmouth—Dover—Rochester, NH—ME	13,512	0	5	1
MI	Battle Creek, MI	77,921	2	4	2
	Bay City, MI	74,118	2	5	1
	Benton Harbor, MI	57,744	4	4	1
	Holland, MI	62,418	2	4	2
	Jackson, MI	78,126	1	4	1
	Kalamazoo, MI	164,430	3	7	1
	Lansing—East Lansing, MI	265,095	2	7	3
	Muskegon, MI	106,252	5	5	1
	Port Huron, MI	62,774	3	7	1
	Saginaw, MI	140,079	2	8	1
	South Bend—Mishawaka, IN—MI	22,750	1	3	2
MN	Duluth, MN—WI	95,356	3	1	1
	Fargo—Moorhead, ND—MN	34,923	2	2	1
	Grand Forks, ND—MN	8,658	1	0	1
	LaCrosse, WI—MN	4,725	1	1	1
	Rochester, MN	73,560	1	3	1
	St. Cloud, MN	74,037	4	5	3
MO	Columbia, MO	75,854	1	4	1
	Joplin, MO	60,208	15	5	2
	St. Joseph, MO—KS	74,295	2	4	2
	St. Louis, MO—IL	1,618,227	95	39	4

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Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
MS	Biloxi—Gulfport, MS	179,643	8	0	3
	Hattiesburg, MS	59,757	2	0	2
	Pascagoula, MS	59,386	3	0	1
MT	Billings, MT	88,181	1	0	1
	Great Falls, MT	63,506	1	0	1
	Missoula, MT	57,196	1	0	1
NC	Asheville, NC	110,429	7	0	2
	Burlington, NC	74,053	6	0	3
	Gastonia, NC	113,637	9	0	1
	Goldsboro, NC	60,230	1	0	1
	Greenville,NC	55,884	2	0	1
	Hickory, NC	69,914	6	0	2
	High Point, NC	108,686	4	0	4
	Jacksonville, NC	101,297	1	0	1
	Kannapolis, NC	78,177	4	0	2
	Rocky Mount, NC	50,870	1	0	2
	Wilmington, NC	101,357	4	0	2
ND	Bismarck, ND	66,476	3	2	2
	Fargo—Moorhead, ND—MN	86,413	2	2	1
	Grand Forks, ND—MN	49,445	1	1	1
NE	Sioux City, IA—NE—SD	10,915	1	0	1
NH	Lawrence—Haverhill, MA—NH	25,362	0	3	1
	Lowell, MA—NH	935	0	1	1
	Manchester, NH	114,918	1	6	3
	Nashua, NH	96,791	1	5	1
	Portsmouth—Dover—Rochester, NH—ME	101,448	4	6	2
NJ	Atlantic City, NJ	169,993	11	3	2
	Trenton, NJ—PA	255,696	4	7	2
	Vineland—Millville, NJ	94,236	4	5	4
NM	Las Cruces, NM	81,471	2	0	1
	Santa Fe, NM	63,023	1	0	1
NY	Albany—Schenectady—Troy, NY	509,106	11	19	4
	Binghamton, NY	158,405	4	10	2
	Buffalo—Niagara Falls, NY	954,332	14	16	2
	Danbury, CT—NY	3,593	0	1	1
	Elmira, NY	66,612	3	6	1
	Glens Falls, NY	56,475	4	4	3
	Ithaca, NY	50,132	3	3	1
	Newburgh, NY	71,584	2	4	1
	Poughkeepsie, NY	148,527	4	8	2
	Rochester, NY	619,653	6	12	1
	Syracuse, NY	388,918	11	12	2
	Utica—Rome, NY	158,553	9	11	2
OH	Canton, OH	244,576	6	8	1
	Hamilton, OH	118,315	4	7	2
	Huntington—Ashland, WV—KY—OH	33,791	6	6	1
	Lima, OH	68,621	3	5	2
	Lorain—Elyria, OH	224,087	10	8	2

Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
OH	Mansfield, OH	76,521	3	5	1
	Middletown, OH	98,822	6	8	3
	Newark, OH	54,063	2	5	1
	Parkersburg, WV—OH	6,840	1	1	1
	Sharon, PA—OH	6,229	0	2	1
	Springfield, OH	88,649	1	3	1
	Steubenville—Weirton, OH—WV—PA	38,855	4	4	1
	Wheeling, WV—OH	25,255	5	4	1
	Youngstown—Warren, OH	361,627	12	13	2
OK	Fort Smith, AR—OK	2,616	2	0	2
	Lawton, OK	92,634	1	0	1
OR	Longview, WA—OR	2,138	1	0	1
	Medford, OR	66,974	3	0	1
PA	Altoona, PA	76,551	3	6	1
	Erie, PA	177,668	2	6	1
	Harrisburg, PA	292,904	17	16	5
	Johnstown, PA	77,841	14	10	2
	Lancaster, PA	193,583	7	13	2
	Monessen, PA	65,072	20	6	3
	Pittsburgh, PA	1,678,745	136	73	5
	Pottstown, PA	53,371	2	8	3
	Reading, PA	186,267	16	12	1
	Scranton—Wilkes-Barre, PA	388,225	44	19	2
	Sharon, PA—OH	46,587	6	2	1
	State College, PA	61,239	1	4	1
	Steubenville—Weirton, OH—WV—PA	392	0	1	1
	Trenton, NJ—PA	42,906	2	3	1
	Williamsport, PA	57,425	4	5	1
	York, PA	142,675	11	10	1
PR[1]	Aquadilla, PR	99,936			
	Arecibo, PR	88,967			
	Caguas, PR	190,922			
	Cayey, PR	53,945			
	Humacao, PR	57,144			
	Mayaguez, PR	110,904			
	Ponce, PR	190,079			
	San Juan, PR	1,221,086			
	Vega Baja-Manatil, PR	112,272			
RI	Fall River, MA—RI	17,850	0	2	1
	Newport, RI	53,481	1	3	1
	Providence--Pawtucket, RI—MA	753,203	7	17	4
SC	Anderson, SC	52,492	1	0	1
	Charleston, SC	393,956	10	0	3
	Florence, SC	54,659	2	0	2
	Myrtle Beach, SC	58,384	2	0	2
	Rock Hill, SC	58,757	2	0	1
	Spartanburg, SC	104,801	2	0	1
	Sumter, SC	57,632	1	0	1

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Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
SD	Rapid City, SD	61,124	1	0	1
	Sioux City, IA—NE—SD	[illegible]	1	1	1
TN	Bristol, TN—Bristol, VA	33,790	1	0	1
	Clarksville, TN—KY	75,857	1	0	1
	Jackson, TN	53,031	1	0	1
	Johnson City, TN	82,382	3	0	3
	Kingsport, TN—VA	83,174	3	0	3
TX	Brownsville, TX	117,676	1	0	1
	Bryan—College Station, TX	107,599	2	0	1
	Denton, TX	66,445	1	0	1
	Galveston, TX	58,263	1	0	1
	Harlingen, TX	79,309	5	0	1
	Killeen, TX	137,876	4	0	3
	Lewisville, TX	79,433	7	0	3
	Longview, TX	76,429	2	0	2
	McAllen—Edinburg—Mission, TX	263,192	9	0	1
	Midland, TX	91,999	1	0	2
	Odessa, TX	113,672	1	0	2
	Port Arthur, TX	109,560	4	0	1
	San Angelo, TX	85,408	1	0	1
	Sherman—Denison, TX	55,522	3	0	1
	Temple, TX	58,710	2	0	1
	Texarkana, TX—Texarkana, AR	42,310	3	0	1
	Texas City, TX	128,211	9	0	2
	Tyler, TX	79,703	1	0	1
	Victoria, TX	55,122	1	0	1
	Wichita Falls, TX	97,151	2	0	2
UT	Logan, UT	50,401	7	0	1
	Ogden, UT	259,147	20	0	2
	Provo—Orem, UT	220,556	10	0	1
VA	Bristol, TN—Bristol, VA	18,773	1	0	2
	Charlottesville, VA	67,553	1	0	2
	Danville, VA	54,315	1	0	2
	Fredericksburg, VA	56,718	1	0	3
	Kingsport, TN—VA	4,229	2	0	1
	Lynchburg, VA	98,138	1	0	4
VT	Burlington, VT	87,058	4	4	1
WA	Bellingham, WA	59,317	1	0	1
	Bremerton, WA	112,977	2	0	1
	Longview, WA—OR	54,985	2	0	1
	Olympia, WA	95,471	3	0	1
	Richland—Kennewick—Pasco, WA	116,118	4	0	2
	Spokane, WA	279,038	2	0	1
	Yakima, WA	88,054	3	0	1
WI	Appleton—Neenah, WI	160,918	7	8	3
	Beloit, WI—IL	42,705	1	3	1
	Duluth, MN—WI	27,615	2	0	1
	Eau Claire, WI	80,293	3	7	2

Table 3-9. List of Urbanized Areas Not Associated With a Phase I Municipality (continued)

State	Urbanized Area	Total Population	No. of Incorporated Places	No. of Minor Civil Divisions	No. of Counties
WI	Green Bay, WI	161,931	5	4	1
	Janesville, WI	52,995	1	3	1
	Kenosha, WI	94,292	2	2	1
	LaCrosse, WI—MN	74,203	3	4	1
	Oshkosh, WI	58,935	1	4	1
	Racine, WI	121,788	5	2	1
	Round Lake Beach—McHenry, IL—WI	53	0	1	1
	Sheboygan, WI	61,012	3	4	1
	Wausau, WI	57,352	3	3	1
WV	Charleston, WV	164,418	14	0	3
	Cumberland, MD—WV	3,007	1	0	1
	Huntington—Ashland, WV—KY—OH	79,681	4	0	2
	Parkersburg, WV—OH	51,843	3	0	1
	Steubenville—Weirton, OH—WV—PA	29,871	2	0	2
	Wheeling, WV—OH	59,252	8	0	2
WY	Casper, WY	52,248	3	0	1
	Cheyenne, WY	61,890	1	0	1

1 Puerto Rico does not use the designations of "incorporated place," "minor civil division," or "county" for any of its municipalities; therefore the table has been left intentionally blank under these headings.

Table 3-10. Urbanized Areas Without a Municipality in Phase I of the NPDES Storm Water Program

Urbanized Area Population	Number of Urbanized Areas	Incorp. Places	Minor Civil Divisions	Counties	Total Population
50,000 - 74,999	114	287	162	159	6,954,446
75,000 - 99,999	54	156	122	83	4,690,007
100,000 - 124,999	36	132	82	43	4,050,106
125,000 - 149,999	12	48	38	9	1,639,209
150,000 - 249,999	30	191	177	39	5,621,799
Over 250,000	23	656	385	47	20,008,804
TOTALS	269	1,470	966	380	42,964,371

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Table 3-11. Urbanized Areas With a City With a Population of 100,000 or More but Without a Phase I Municipality

Urbanized Area	Urbanized Area Population	Core City	Core City Population	Population Served by Combined Sewer *
Albany—Schenectady—Troy, NY	509,106	Albany	101,082	96,500
Bridgeport—Milford, CT	413,863	Bridgeport	141,686	50,000
Buffalo—Niagara Falls, NY	954,332	Buffalo	328,123	328,123
Chicago, IL—Northwestern Indiana	6,792,087	Chicago	2,783,726	2,783,726
Erie, PA	177,668	Erie	108,718	108,719
Evansville, IN—KY	183,087	Evansville	126,272	50,425
Hartford-Middletown, CT	546,198	Hartford	139,739	110,000
Lansing—East Lansing, MI	265,095	Lansing	127,321	50,000
New Haven—Meriden, CT	451,486	New Haven	130,474	84,300
Peoria, IL	242,353	Peoria	113,504	77,000
Pittsburgh, PA	1,678,745	Pittsburgh	369,879	369,879
Ponce, PR	190,079	Ponce	159,151	NA **
Providence—Pawtucket, RI—MA	846,293	Providence	160,728	160,728
Rochester, NY	619,653	Rochester	231,636	231,636
San Juan, PR	1,221,086	San Juan	426,832	NA **
Santa Rosa, CA	194,560	Santa Rosa	113,313	0
South Bend—Mishawaka, IN—MI	237,932	South Bend	105,511	100,000
Spokane, WA	279,038	Spokane	177,196	135,600
Springfield, IL	124,524	Springfield	105,227	75,000
Springfield, MA—CT	532,747	Springfield	156,983	156,983
St. Louis, MO-IL	1,946,526	St. Louis	396,685	396,685
Syracuse, NY	388,918	Syracuse	163,860	140,800
Waterbury, CT	175,067	Waterbury	108,961	99,947

* Population served by combined sewers within the core city of the urbanized area.

** Information on combined sewers in Puerto Rico not available.

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3.1.3.3 Urban Populations Outside of Urbanized Areas

The Bureau of the Census defines urban populations to consist of persons living in any densely settled place of 2,500 or more inhabitants. Urban populations outside of urbanized areas are comprised of distinct population centers of more than 2,500 but less than 50,000 people. The total urban population outside of urbanized areas is 29.0 million people. Of this total, 25.1 million people live in 3,689 incorporated places. The remaining 3.9 million people live in either minor civil divisions or unincorporated portions of counties. The urban population outside of urbanized areas but inside a metropolitan areas as defined by OMB is 10.8 million.

3.1.3.4 Rural Populations

The census population data base classifies any population other than urban populations as rural populations. In 1990, the rural population totalled 61.5 million people. Of this total, 8.8 million live in 13,044 incorporated places; the remaining 52.7 million people live in either minor civil divisions or unincorporated portions of counties.

3.1.3.5 Populations Not Addressed in Census

The census data does not address certain classes of development, including resort towns and second home development. The census population data base generally does not reflect seasonal populations, such as people that only live in a resort town during peak seasons, second home development, people staying in rental units, or tourists. For example, on some peak weekends, more than 250,000 people may visit Ocean City, Maryland. According to the census, however, the permanent population of Ocean City, Maryland, is only 5,146. It has been estimated that more than two-thirds of recreational subdivisions are situated near water, often on artificially constructed lakes (Reilly, *The Use of Land*, 1973).

3.1.4 Development Trends

New development is widely recognized as providing some of the best opportunities for implementing cost-effective storm water management controls. This section identifies major trends of new development.

During the twentieth century, the U.S. population has become increasingly urbanized. The rate of growth occurring over the last four decades is exemplified by Bureau of the Census data on urbanized areas with a population of 50,000 or more. Table 3-12 shows two important trends that have occurred since 1950:

- The total populations in urbanized areas have been rapidly increasing.
- Most of this growth has been occurring outside larger central cities in urban fringe areas.

Table 3-12. Growth of Urbanized Areas in the United States Between 1950 and 1990

Year	Number of Urbanized Areas	Population in Urbanized Areas (millions)			Land Area (sq.mi.)
		Total	Central Cities	Urban Fringe	
1950	157	69.2	48.4	20.9	19,728
1960	213	95.8	57.9	37.8	25,544
1970	273	120.7	65.1	55.6	35,081
1980	366	139.2	67.0	72.1	52,017
1990	405	160.4	79.7	80.7	61,520

Source: Bureau of the Census, U.S. Dept. of Commerce

Between 1980 and 1990, the population of Census-designated urbanized areas increased by 21.2 million[8] and the cumulative size increased by 9,000 square miles. During the same period, the rural population of the United States increased by 2.2 million, and the urban population that lived outside of urbanized areas increased by 0.9 million.

[8] About 7 percent of this increase (1.5 million people) is associated with the net addition of 30 new urbanized areas between 1950 and 1990. Another part of this increase which has not been estimated here is associated with the increase in land area of pre-existing urbanized areas.

Cities with a population of 100,000 or more with municipal systems already addressed by Phase I of the NPDES storm water program increased in population by about 4.9 million people (or an increase of 9 percent) between 1980 and 1990.[9] Between 1980 and 1990, the population of urbanized areas with one or more municipal systems addressed by Phase I of the NPDES storm water program increased by 16.4 million (or 67 percent of the total national growth). This represented a 25 percent increase in the population of these areas. The population of urbanized areas without a Phase I municipal system increased by 4.8 million. This represents 20 percent of the total national growth and an 11 percent increase in the population of these areas.

Population increase is only one indicator of new development. Significant development can occur, particular in some of the larger urbanized areas experiencing migration from core cities to suburban areas. For example, between 1970 and 1990, the total population of the Chicago urbanized area was relatively stable, increasing by only 77,509 people. However, during this time significant migration was occurring from the core city to surrounding suburban areas. The population of the city of Chicago decreased by 583,257 while the population of suburban areas increased by 660,766. The Chicago urbanized area increased in land area by 307 square miles, or by 25 percent of its 1970 size.

The migration away from central business districts to the suburbs has been occurring at high rates since the late 1970s. By the mid-1980s, approximately 57 percent of the office space in the country was located in the suburbs; before that time, central business districts within the urban core contained the majority of office space (Cooper, 1986).

Growth is concentrated in certain geographic regions of the country. For example, the most growth in urbanized areas is occurring mainly in the south and west. High rates of growth are occurring in coastal and estuarine areas. Population in these areas has increased

[9] The 4.9-million increase does not include increases associated with unincorporated, urbanized portions of Phase I counties and designated municipalities.

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by about 30 million people during the last 3 decades (almost half the total U.S. population increase) and is expected to increase, although at reduced levels (Culliton et al., 1990). The Bureau of the Census projects that most growth by 2010 will occur on the Pacific, Atlantic, and Gulf Coasts (Figure 3-5). High growth areas include California and Washington State in the West, all of the coastal States south of New Jersey in the East, and Florida and Texas in the Gulf Coast region.

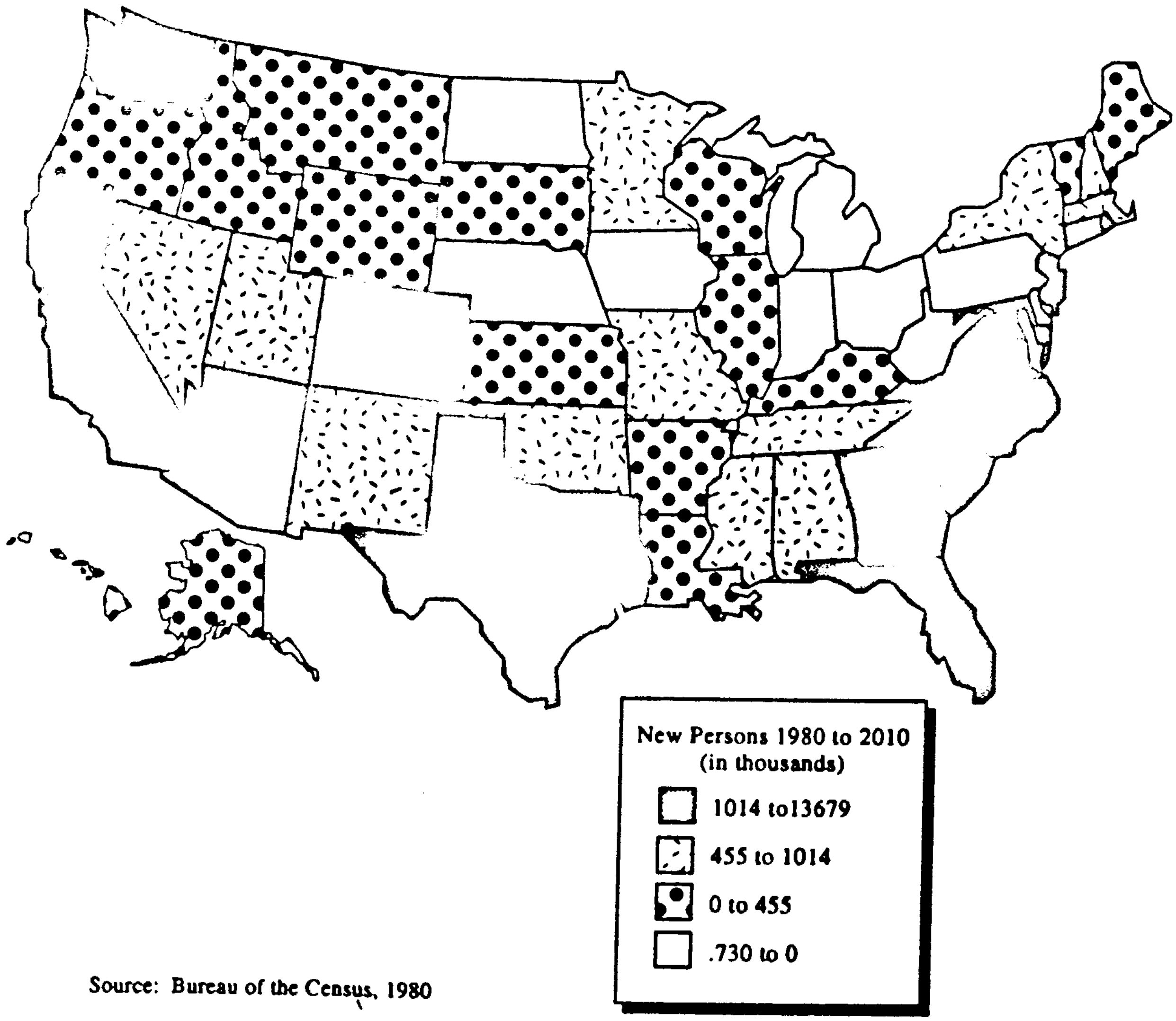
A comparison of 1990 census data to 1980 data supports these projections (Table 3-13). Twenty-five of 30 coastal States have seen dramatic population increases since 1980 (Bureau of the Census, 1991). The largest increases occurred in California (6.1 million people), Florida (3.2 million people), and Texas (2.7 million people). While the major population corridors extend from New York to Washington, DC, Los Angeles to San Diego, and within the San Francisco Bay metropolitan area, estuaries in the Middle Atlantic contain the greatest percentage of urban land and is the most densely populated among regions (NOAA, 1990).

3.2 NATURE OF DISCHARGES FROM MUNICIPAL SYSTEMS

A number of features of the urban environment affect the manner in which discharges from municipal separate storm sewers may affect surface water resources, including:

- Urban activities and sources that generate or contribute to pollutants
- Increased levels of imperviousness
- Modifications and destruction of natural drainage features, including removal of riparian vegetation
- Design objectives of drainage system.

The degree of impact on a receiving water can also depend on other factors, including the frequency and duration of the storm water discharges, the quality and quantity of storm water discharges, the occurrence of other wet weather discharges (e.g., combined sewer



Source: Bureau of the Census, 1980

Figure 3-5. Population Growth Forecast Between 1980 and 2010

Table 3-13. Total Resident Population by State: 1990 and 1980

1990 Total Population Rank	State	1990 Total Population	1980 Total Population	Number Change 1980 to 1990	Percent Change 1980 to 1990
1	California	29,760,021	23,667,902	6,092,119	25.7
2	New York	17,990,455	17,558,072	432,383	2.5
3	Texas	16,986,510	14,229,191	2,757,319	19.4
4	Florida	12,937,926	9,746,324	3,191,602	32.7
5	Pennsylvania	11,881,643	11,863,895	17,748	0.1
6	Illinois	11,430,602	11,426,518	4,084	0.0
7	Ohio	10,847,115	10,797,630	49,485	0.5
8	Michigan	9,295,297	9,262,078	33,219	0.4
9	New Jersey	7,730,188	7,364,823	365,365	5.0
10	North Carolina	6,628,637	5,881,766	746,871	12.7
11	Georgia	6,478,216	5,463,105	1,015,111	18.6
12	Virginia	6,187,358	5,346,818	840,540	15.7
13	Massachusetts	6,016,425	5,737,037	279,388	4.9
14	Indiana	5,544,159	5,490,224	53,935	1.0
15	Missouri	5,117,073	4,916,686	200,387	4.1
16	Wisconsin	4,891,769	4,705,767	186,002	4.0
17	Tennessee	4,877,185	4,591,120	286,065	6.2
18	Washington	4,866,692	4,132,156	734,536	17.8
19	Maryland	4,781,468	4,216,975	564,493	13.4
20	Minnesota	4,375,099	4,075,970	299,129	7.3
21	Louisiana	4,219,973	4,205,900	14,073	0.3
22	Alabama	4,040,587	3,893,888	146,699	3.8
23	Kentucky	3,685,296	3,660,777	24,519	0.7
24	Arizona	3,665,228	2,718,215	947,013	34.8
25	Puerto Rico	3,522,037	3,196,520	325,517	10.2
26	South Carolina	3,486,703	3,121,820	364,883	11.7
27	Colorado	3,294,394	2,889,964	404,430	14.0
28	Connecticut	3,287,116	3,107,576	179,540	5.8
29	Oklahoma	3,145,585	3,025,290	120,295	4.0
30	Oregon	2,842,321	2,633,105	209,216	7.9
31	Iowa	2,776,755	2,913,808	-137,053	-4.7
32	Mississippi	2,573,216	2,520,638	52,578	2.1
33	Kansas	2,477,574	2,363,679	113,895	4.8
34	Arkansas	2,350,725	2,286,435	64,290	2.8
35	West Virginia	1,793,477	1,949,644	-156,167	-8.0
36	Utah	1,722,850	1,461,037	261,813	17.9
37	Nebraska	1,578,385	1,569,825	8,560	0.5
38	New Mexico	1,515,069	1,302,894	212,175	16.3
39	Maine	1,227,928	1,124,660	103,268	9.2
40	Nevada	1,201,833	800,493	401,340	50.1
41	New Hampshire	1,109,252	920,610	188,642	20.5
42	Hawaii	1,108,229	964,691	143,538	14.9
43	Idaho	1,006,749	943,935	62,814	6.7
44	Rhode Island	1,003,464	947,154	56,310	5.9
45	Montana	799,065	786,690	12,375	1.6
46	South Dakota	696,004	690,768	5,236	0.8
47	Delaware	666,168	594,338	71,830	12.1
48	North Dakota	638,800	652,717	-13,917	-2.1
49	District of Columbia	606,900	638,333	-31,433	-4.9
50	Vermont	562,758	511,456	51,302	10.0
51	Alaska	550,043	401,851	148,192	36.9
52	Wyoming	453,588	469,557	-15,969	-3.4
53	Guam	133,152	• 107,000	• 26,000	• 24.2
54	Virgin Islands	101,809	• 98,000	• 4,000	• 4.1
55	American Samoa	46,773	• 32,000	• 15,000	• 47.9
56	North. Mariana Islands	43,345	• 17,000	• 26,000	• 152.9

• Estimated 1980 census populations

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overflow discharges), and the quantity and quality of the base flow (dry weather flow) of the stream. Appendix B further discusses the potential impacts from storm water discharges to different classes of receiving waters.

3.2.1 Major Pollutant Sources

Pollutants in discharges from municipal separate storm sewer systems originate from a variety of diffuse sources. This subsection discusses both runoff-related and non-storm water sources of pollutants.

3.2.1.1 Runoff-Related Pollutant Sources

The urban environment has many sources that can contribute pollutants to storm water. Table 3-14 provides selected examples of the major common sources of pollutants in the urban environment. Many of these sources, such as those related to vehicles, building materials, and road maintenance, are ubiquitous in the urban environment. The complex interactions of the various pollutant sources in the urban environment have limited efforts to quantify the contribution of pollutants from specific sources. Rather, most studies of the quality of urban runoff have characterized pollutant concentrations in runoff from general land use categories (e.g., residential, commercial, open land). However, several recent studies have begun to look at smaller segments of the urban environment that may generate runoff with elevated levels of pollutants.[10] At least one recent study has attempted to evaluate the contribution of pollutants from different formulations of a commercial product (brake pads) to urban runoff.[11] Another recent study addressing deposition of air pollutants to waters identified fossil fuel combustion in industrial, commercial, and residential units;

[10] For example, see Bannerman, R., et al., 1993 *Sources of Pollutants in Wisconsin Stormwater*, Water Science & Technology (28): 3-5, pp. 241, which indicates that streets and roads may be the most significant source of pollutants associated with residential, commercial and industrial land use. Pitt, R., et al. *The Treatability of Urban Stormwater Toxicants*, International Congress on Integrated Stormwater Management, 1991, which reported that runoff from vehicle service areas and parking lots generally had higher concentrations of polynuclear aromatic hydrocarbons and metal than runoff from street surfaces. In addition, a higher frequency of runoff from vehicle service areas and parking lots exhibited toxicity.

[11] See Public Review Draft of *Contribution of Heavy Metals to Storm Water from Automotive Disc Brake Pad Wear*, Santa Clara Valley Nonpoint Source Pollution Control Program, 1994.

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Table 3-14. Common Pollutants and Non-Industrial Pollutant Sources Associated With Urban Runoff

Pollutant	Source (Category: Components)
Lead	Vehicles: exhaust, tire wear (filler material), lubricating oil and grease Structures and roads: paint
Zinc	Vehicles: tire wear (filler material), oil and grease (stabilizing additive), brake pads, metal corrosion Paved surfaces: deicing salts Structures: paint, metal corrosion, wood preservatives
Copper	Vehicles: parts wear (brakes, metal plating, bearings and bushings), diesel fuel Structures: paint, metal corrosion, wood preservative Other: pesticides
Cadmium	Vehicles: tire wear (filler material) Other: pesticides
Chromium	Vehicles: parts wear (brakes, metal plating, engine parts)
Nickel	Vehicles: diesel fuel, lubricating oil, parts wear (brakes, metal plating, and bushings) Paved surfaces: asphalt
Manganese	Vehicles: parts wear (engine parts)
Bromide	Vehicles: exhaust
Mercury	Other: coal combustion Vehicles: fuel combustion Structures: paint
Iron	Vehicles: body rust, engine wear Structures: rust
Cyanide	Paved surfaces: deicing salts Structures: wood preservatives
PAHs	Vehicles: exhaust Other: incomplete combustion
Chloride	Paved surfaces: deicing salts
Sulphates	Other: combustion product Vehicles: exhaust Paved surfaces: road beds, deicing salts
Nitrogen, Phosphorus	Vehicles: exhaust Other: combustion product Landscape maintenance: fertilizers Soil erosion: land disturbance, exposed soils Sewage: leaking sanitary systems, septic systems

Sources: EPA, 1992, 1990, 1983; Kobriger et al., 1984.

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Table 3-14. Common Pollutants and Non-Industrial Pollutant Sources Associated With Urban Runoff (continued)

Pollutant	Source (Category: Components)
Sediments, Particulates	Soil erosion: land disturbance, exposed soils Streambank erosion: high flows Vehicles: body rust, tire wear, other wear
Pesticides	General outdoor application Structures: wood preservatives, paint
Floatables	Litter: residential, commercial, industrial, recreation Waste disposal: residential, commercial, industrial recreation Vegetation: leaves, branches, trunks
Bacteria	Sewage: leaking sanitary systems, septic systems Other: animal droppings Soil erosion: exposed soils
Oil and grease	Vehicles: drippings, leaks Paved surfaces: asphalt Equipment maintenance: exposed surfaces Other: wood preservatives, wood/coal combustion
PCBs	Vehicles: catalyst in synthetic tires Other: electrical, insulation
Benzene	Vehicles: fuel Other: solvent use
Toluene	Vehicles: fuel and asphalt Other: solvent use
Chloroform	Vehicles: form by mixing salt, gasoline and asphalt
Oxygen Demand	Vegetation: leaves Litter: various sources Soil erosion: land disturbance, exposed soils
Phthalate, bis(2-eth.)	Structures: plasticizer Other: plasticizer

Sources: EPA, 1992, 1990, 1983; Kobriger et al., 1984.

municipal waste combustion and hazardous waste and sewage sludge incineration; and various manufacturing processes, such as cement production as major local sources of metals. The report also identified fossil fuel and biomass combustion in petroleum refineries, motor vehicles, and industrial commercial and residential units as major local sources of polycyclic organic matter.

A number of the sources provided in Table 3-14 are related to materials exposed to precipitation. Examples of these sources include zinc from galvanized gutters and roofs and lead from certain exterior paints. Other sources are generally released to the environment, such as metals and polynuclear aromatic hydrocarbons (PAHs) in automobile emissions, zinc in tire wear, and emissions from industrial sites. Pollutants from these sources can be carried away from their original point of generation and accumulate on other impervious surfaces where they are eventually washed off. In addition, erosion of land and streambanks can contribute sediments and other pollutants.

Pollutant concentrations in runoff from different land uses are discussed below.

3.2.1.2 Non-Storm Water Sources

Although separate storm sewers are primarily designed to remove runoff from storm events, materials other than storm water end up in and are ultimately discharged from separate storm sewers. For example, in Sacramento, California, it is estimated that less than half of the water discharged from the storm water drainage system is directly attributed to precipitation.[12] Non-storm water discharges to storm sewers come from a variety of sources,[13] including:

- Illicit connections and cross connections from industrial, commercial, and sanitary sewage sources
- Leaking sanitary sewage systems
- Malfunctioning onsite disposal systems (septic systems)
- Improper disposal of wastes such as used oil, wastewaters, and litter

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[12] *Urban Runoff Discharge from Sacramento, CA*, Montoya, B., CA Regional Water Control Board, Central Valley Region, 1987, Report Number 87-1SPSS.

[13] A more complete description of non-storm water discharges to storm sewers is given in *Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems: A User's Guide*, EPA, January 1993, EPA/600/R-92/238.

- Spills
- Infiltration of ground water contaminated by a variety of sources, including leaking underground storage tanks
- Wash waters, lawn irrigation, and other drainage sources.

Appendix C provides a more complete description of these sources of non-storm water. Table 3-15 summarizes numerous studies involving problems with non-storm water discharges. These case studies illustrate the wide range of pollutants (e.g., pathogens, metals, nutrients, oil and grease, phenols, and solvents) that can be contributed to storm sewers from non-storm water discharges. Removal of these non-storm water sources of pollutants often provides opportunities for dramatically improving the quality of discharges from separate storm sewers and is required by Section 402(p)(3)(B)(ii).

Table 3-15. Summary of Non-Storm Water Discharge Problems

Study Site	Comments
Jones Falls Watershed Baltimore City and County, MD	During the NURP study of the Jones Falls Watershed, 15 illicit connections were discovered in portions of the watershed. The illicit connections were grouped into four types: direct discharges from residences, leakage from cracked or broken sewer lines, decades-old overflows from the sanitary sewer, and sanitary sewage pumping station malfunctions. Elevated levels of pathogens, TSS, ammonia, TKN, total nitrogen, COD, and TOC were identified.
Tulsa, Oklahoma	A physical inspection was conducted on 120,000 feet of storm sewer 48 inches and larger serving a drainage area of approximately 12 square miles. 35 potential non-storm water discharges were observed. 23 of these were observed and/or suspected sanitary sewer connections, 4 were potable water discharges, and 8 were of an unknown source. In addition, 12,900 feet of sanitary sewer were laid within the storm sewer where the storm sewer served as a conduit. Most illicit connections were associated with development that occurred before 1970. Other documented observations were structural defects (900 feet of pipe showed signs of structural defects), pipe cross through (176 total), and debris buildup.

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Table 3-15. Summary of Non-Storm Water Discharge Problems (continued)

Study Site	Comments
Washtenaw County, MI	Of the 1,067 businesses, homes, and other buildings inspected, 154 of the buildings inspected (14%) had illicit connections, including connections in restaurants, dormitories, car washes, and auto repair facilities. About 60% of the automobile-related businesses inspected had illicit discharges. A majority of the illicit connections discovered had been approved connections when installed. Pollutants that were detected include heavy metals, nutrients, TSS, oil and grease, radiator fluids, and solvents.
Fort Worth, TX	24 outfalls in a 10-mile radius were targeted for end-of-pipe observations. The success of the program was judged by a decline in the number of undesirable features at the target outfalls, from an average of 44 undesirable observations per month in 1986 (522 total) to an average of 21 undesirable observations per month in 1988. The Fort Worth investigation indicated problems associated with allowing septic systems, self-management of liquid waste by industry, and construction of municipal overflow bypasses from the sanitary sewer to the storm drains. These problems were attributed to the inability of the POTW to expand as rapidly as urban growth occurred. During a 30-month period, problems detected include 133 hazardous spills, 125 incidents related to industrial activity, 265 sanitary sewer line breaks, and 21 bypass connections of the sanitary sewer to the storm sewer. Highlighted cases include a 20 gallon-per-minute flow from a cracked sanitary sewer from a bean processing plant to a storm drain and an illicit connection of a sanitary sewer line from a 12-story office building to a storm sewer. Most industrial pollution enters the storm sewer system from illegal dumping, storm runoff, accidental spills, and direct discharges. Metals were not detected in dry-weather discharges but were found in significant levels in receiving water sediment. City officials state that the high metal concentrations in sediment are consistent with otherwise unexplained serious reported fish kills.
Seattle, WA	The city of Seattle has detected improper disposal and illicit connections from industrial sites by investigating sediment in storm sewers. One storm drain outfall that represented a major source of lead to the Duwamish River was traced back to a former smelter that crushed batteries to recover lead. Lead concentrations in the sediment were high enough to allow the city to send it to an operating smelter to be refined. Another storm drain contained high levels of creosote, pentachlorophenol, copper, arsenic, and PCBs, which (except for the PCBs) were traced back to a wood treatment facility. Thirty cubic yards of contaminated sediments removed from the storm drain contained 145 pounds of contaminants. Sediments removed from storm drains in another industrial area contained very high levels of PCBs (about 1 pound of PCBs in 70 cubic yards of sediment).
Upper Mystic Lake, NY	The NURP study for the Upper Mystic Lake Watershed project identified contamination of storm water runoff and, subsequently, surface water contamination of surface waters by sanitary discharges as a major problem in the watershed that contributed large quantities of phosphorus, certain metals, and bacteria. Interactions at 19 manholes serving both sanitary and storm sewer lines were identified as the major contributor of pollutants.

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Table 3-15. Summary of Non-Storm Water Discharge Problems (continued)

Study Site	Comments
Bellevue, WA	The NURP report for Bellevue, WA, recorded 50 voluntary citizen reports of illegal dumping and other non-storm water discharges during a 27-month period. The incidents reported were varied and resulted in at least two significant fish kills. 25 percent of the citizen reports involved improper disposal of used oil to the storm sewer. Other reports involved spills, illicit connections of floor drains, septic system pipes, and a car wash, as well as chemical dumping and concrete trucks rinsing out into catchbasins or streams.
Ann Arbor, MI	Studies in 19[illegible], 1978, and 1979 found that discharges from the Allen Creek storm drain contained significant quantities of fecal coliform, fecal streptococci, solids, nitrates, and metals. Of the 160 businesses dye-tested, 61 (38%) were found to have improper storm drain connections. Chemical pollutants, including detergents, oil, grease, radiator wastes, and solvents, were causing water quality problems. Monitoring of the storm drainage system during storm events indicated a decrease in the concentration of 32 of 37 chemicals monitored after the improper connections were removed.
Medford, OR	Fecal coliform tests at storm drain outfalls in city parks were used to detect 4 leaking sanitary sewer lines that were either located above the storm lines or saturated the ground with effluent, which entered the nearby storm drains; an agricultural equipment wash rack; and a house with sanitary lines plumbed to the storm drain. In addition, in one of the oldest sections of town, a large storm drain bored in the early 1900s also contained the sanitary sewer line. Under manholes, the sanitary line was only a trough. Even minor clogs or breaks resulted in a spillover of effluent into the storm drain below.
Toronto, Ontario*	Dry weather samples of discharges were taken from 625 storm drains in the Humber River watershed. About 10 percent of the outfalls were considered significant sources of nutrients, phenols, and/or metals, while 30 of the outfalls had fecal coliform levels of greater than 10,000 per 100 ml. Investigations identified 93 industrial and sanitary sewage illicit connections. Problems included residential connections of sanitary sewage to the storm sewers and yard runoff from a meat packing plant to a storm drain.
Grays Harbor, WA	Dry weather sampling of 29 outfalls of separate storm drains indicated that discharges from 6 of the outfalls had abnormally high pollutant levels with suspected illicit connections. The area under consideration had originally been served by combined sewers. Earlier efforts to separate the system had been incomplete, with some residences discharging sanitary sewage to the storm drain.
Seward, NY	Sewage from septic systems with clogged drainfields in clay soils flowed into open storm sewers. The open storm sewers posed health risks to neighborhood children and lowered property values.

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Table 3-15. Summary of Non-Storm Water Discharge Problems (continued)

Study Site	Comments
Norfolk Naval Station, VA	The Norfolk Naval Shipyard was originally built in 1767 and has had numerous additions since. It has an extensive network of underground pipes, including both separate storm sewers and sanitary/industrial sewers. In response to a lawsuit, officials at the Shipyard conducted dye-testing of sanitary facilities throughout the shipyard, which led to the identification and elimination of 25 cross-connections of sanitary and industrial waste to the separate storm sewer system.
Sacramento, CA	The city of Sacramento is currently undertaking a project to identify pollutant discharges and illegal connections to the storm water drainage systems. Recent studies identified acute toxicity in storm water and determined that less than half of the water discharged from the drainage system was not directly attributable to precipitation. Mass loading estimates of copper, lead, and zinc discharged by the drainage system were several times higher than the estimated pollutant loads of these metals from the Sacramento Regional Treatment Plant secondary effluent.
Hazardous Waste Case Studies	These case studies determined that onsite waste disposal where pollutants were added to runoff, eventually ending up in drainage systems, and other situations where a generator dumped wastes directly down a drain were common. Of the 36 cases of illegal dumping investigated in a GAO report, 14 cases investigated involved disposal of hazardous wastes directly to, or with drainage to, a storm sewer, flood control structure, or the side of a road. An additional 10 sites involved disposal to the ground, to landfills (other than those receiving hazardous wastes), or to trash bins, which can ultimately result in additional pollutants to subsequent storm water discharges.

* Information from cities outside of the United States included for informational purposes only.

3.2.2 Imperviousness

The level of watershed imperviousness can be linked to impacts to streams and other surface water resources (Schueler et al.). Urbanization and development increase the imperviousness of land, which alters the natural vegetation and infiltration characteristics of watersheds. These increases in imperviousness can dramatically alter natural flow patterns of streams, wetlands, and other surface water resources. Increased levels of imperviousness replace natural vegetation and decrease the natural infiltration characteristics of a watershed, increasing the amount of runoff during wet weather events. Schueler estimates that in undeveloped watersheds, 5 to 15 percent of the annual stream flow is delivered during storm events. As a general rule, the amount of runoff occurring during storm events is directly proportional to the amount of watershed imperviousness. For example, runoff from storm events will typically comprise half the annual stream flow in a watershed that is 50 percent impervious (Schueler, 1987). Figure 3-6 illustrates how storm water peak flows increase as population (and, consequently, imperviousness) increases based on data from the United States Geological Survey (USGS) and the Bellevue Planning Department (1977). In addition to causing increased flooding, changes in the hydrology of a stream can result in accelerated stream bank or stream bed erosion. Such erosion can cause or contribute to a number of generally detrimental effects on stream hydrology and morphology. For example, erosion can widen or deepen the stream channel, eliminate pools and other structures in the stream, and shift gravel or sand bars (Schueler, 1992).

Increased levels of imperviousness also cause less infiltration of rainfall to recharge ground water supplies, thereby lowering the water table. One result of lowered water tables is that baseline stream flows can be significantly decreased during dry weather. Reduced flows between storms may significantly affect the aquatic habitat and the ability of a stream to dilute toxic spills or other dry weather pollutants within the stream system (Bellevue NURP project). In some cases, the installation of storm sewers in a watershed results in previously perennial streams running dry several times a year (Long Island NURP project).

The level of watershed imperviousness is probably the most significant factor affecting pollutant loadings in runoff from many land uses, including residential and commercial areas (NURP, EPA 1984). Increasing imperviousness increases runoff volumes, which, in turn, increase pollutant loads. Increased imperviousness can also increase stream temperatures, resulting in adverse effects on cold water habitats. Moreover, increased imperviousness can result in decreases in fish diversity (Schueler and Galli, 1992).[14]

[14] For more information on the relationship of watershed imperviousness and biological quality see Jones and Clark, 1987; Klein, 1979; Limburg and Schmidt, 1990; Pedersen and Perkins, 1986; and Booth and Jackson, 1994.

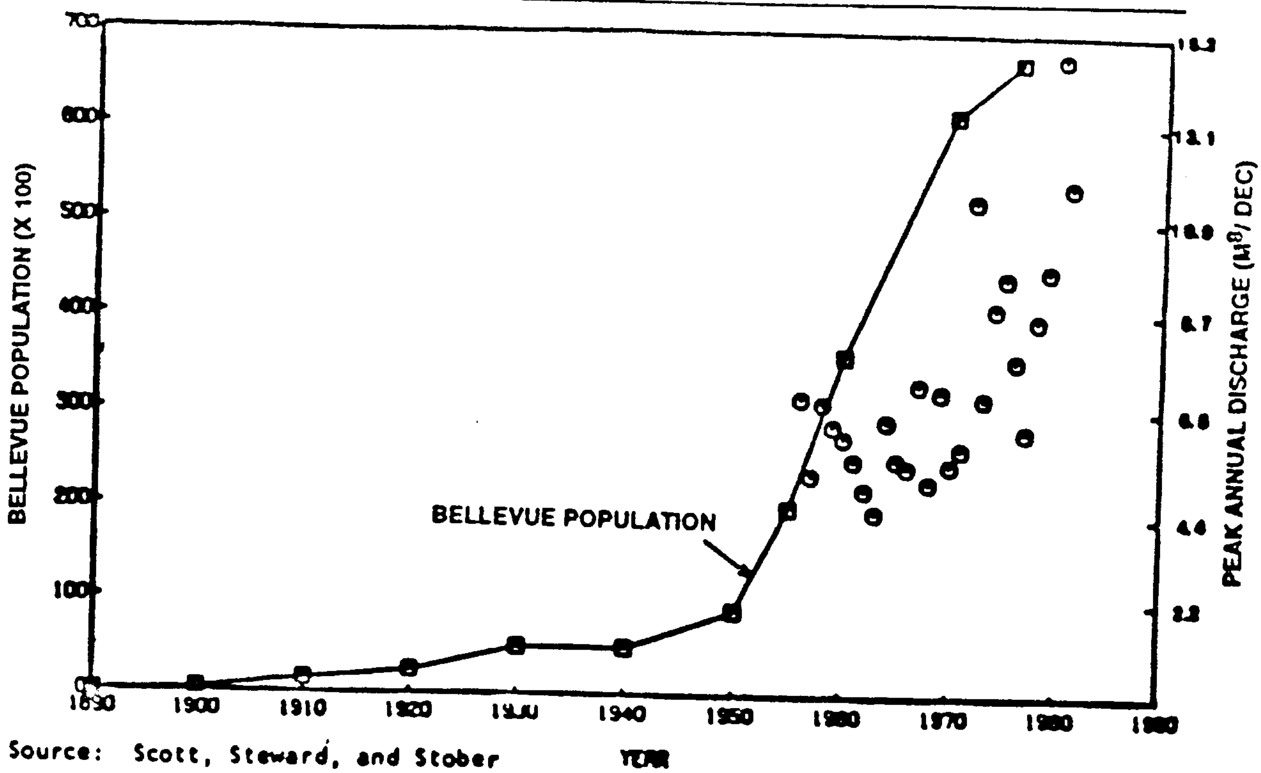

Figure 3-6. Population of Bellevue and Peak Annual Discharge in Kelsey Creek. Data From USGS and Bellevue Planning Dept., 1977

3.2.3 Modification of Natural Stream Channels and Riparian Vegetation

During the process of development, the natural drainage system (e.g., streams, wetlands, and other receiving waters) and surrounding vegetation is often modified. Streams can be diverted through underground culverts or channelized. Wetlands can be drained or filled, reducing the natural capacity of the drainage systems to dampen peak flows associated with storm events. After development has occurred, the natural drainage system is often unable to handle the higher volume of flows. The higher volume of flows can result in high stream bank and stream bed erosion rates or flooding. Drainage systems that have undergone these changes often need additional engineered modifications downstream, such as channelization or lining projects or direction of streams through underground culverts.

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Removal of riparian vegetation, coupled with increased watershed imperviousness, can result in significant increases in water temperatures. Such changes can reduce or eliminate sensitive stream insects and fish species. Modification of riparian vegetation can also have significant impacts on stream habitat value.[15]

3.2.4 Design Objectives of Drainage System

The manner in which a storm sewer system is installed, and its design objectives, affect the quality and quantity of the storm water discharge, as well as the potential presence of non-storm water discharges. The historical development of storm sewers can be characterized in terms of four overlapping time periods. A description of storm water management during these periods shows how some of the water quality problems associated with storm sewer discharges have come about.[16]

1800-1850	The first storm sewers were installed primarily to reduce flooding and ponding. Sanitary sewage connections resulted when adequate sanitary sewers were not provided.
1850-1950	In some municipalities, combined sewers designed to carry both storm water and sanitary sewage were installed.
1900-Present	In other municipalities, separate systems were installed for sanitary and storm sewers. Storm sewers were designed to provide for the rapid removal of storm water runoff from a site.
1970-Present	Some communities begin to address storm water as a resource to be used to recharge ground water and to supply fresh water to surface waters. In addition, properly managed storm water avoids problems with erosion, flooding and adversely impacting natural drainage features such as streams, wetlands and lakes. The multiple goals of water quality and water quantity are addressed when managing storm water.

[15] For a more detailed discussion of the relationship between streams and the hyporheic zone, the area that is biologically and hydrologically connected to the surface water of a system, see *Entering the Watershed, A New Approach to Save America's River Ecosystem*, Doppet, B. et al., 1993.

[16] NURP - Ann Arbor, MI Report, 1984, and *Water and the City: The Next Century*, Rosen and Keating, American Public Works Association, 1991.

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3.2.4.1 Early Sewers (1800-1850)

The oldest urban storm sewers in the United States date back to the early 1800s. Ponding of surface waters, coupled with poor sanitary conditions in urban areas, led to the installation of these early storm sewers to provide drainage. Little is known of the early storm sewers, as they were constructed by individuals or small districts at their own expense with little or no engineering or public supervision. Early storm sewers preceded the development of sanitary sewers. Once these early storm sewers were in place, they received wastes from other sources, some from direct connections of ditches and pipes to the storm sewers and others from materials dumped into the streets or storm sewers. Wastes which ended up in storm sewers included house wastes (most buildings lacked indoor plumbing), cesspool overflows, garbage, and excrement from horses and livestock. These practices created health and aesthetic problems, as storm sewers were often oversized on a flat grade, resulting in accumulation of sewage in storm sewers during dry weather. Wastes which accumulated during dry weather were then discharged into receiving streams during rain events. Many cities prohibited the discharge of domestic sewage to storm sewers but failed to provide public sanitary sewers, resulting in secret connections built without public supervision. Other illegal connections to the storm sewer were often overlooked by municipal officials because of the lack of proper sanitary sewers (NURP, 1984) (APWA, 1991).

3.2.4.2 Combined Sewers (1850-1950)

By the second half of the 19th century, combined sewer systems, designed to carry both sanitary sewage and storm runoff, were being installed to limit the costs associated with separate systems. At the time, these systems were chosen over separate systems because of their lower costs, even though it was known that separate systems were preferred on the basis of sanitary conditions. By 1875, although 67 cities in the United States with populations of greater than 100,000 had combined sewer systems, none treated waste before discharging it to the nearest receiving water body. In many cities, streams were covered to minimize the resulting nuisance. Pollution and health problems forced the expensive installation of interceptors to collect dry weather flows from hundreds of combined sewer outlets for conveyance or pumping to treatment plants prior to discharge.

As cities expanded, storm runoff and sewage flows increased. Combined interceptors which had been installed prior to expansion could not handle increases in flow to the point that even modest rain events could cause flooding of streets and basements. Combined sewer overflows (CSOs) that discharged storm water and sewage directly to surface waters were installed to minimize flooding problems, including sewage backing up into the basements of commercial and residential buildings. These systems bypassed treatment and the general sanitary quality of receiving waters again deteriorated (NURP, 1984) (APWA, 1991).

3.2.4.3 Separate Sewers for Water Removal (1900-Present)

The first large scale sewer system to provide separate collection of storm runoff and sanitary sewage was built in 1880 in Memphis, TN, although the construction of combined systems was continued and extended in most major cities. As early as 1900, many State regulatory agencies would not permit further construction of combined sewers. Where water quality impacts from CSOs were extreme, some cities implemented programs to separate portions of the older combined system.

Problems arose with separate storm water and sewage systems. As city populations increased, the demand for sewer service increased. However, sewer mains, interceptors, pumping stations and treatment plants were slow to grow. The post-World War II boom for sewer service into fast growing suburban areas was often associated with high infiltration rates and many illegal rain water connections which overloaded the system during rain events. To limit raw sewage backups in basements, hundreds of connections were made to bleed sewage from the sanitary sewers to the storm drains to limit flows in the sanitary sewers. Improper connections of grey waters such as automobile repair shop floor drains were either encouraged or implicitly allowed to discharge to storm drains.

Other problems arise with separate storm sewers, as storm water management often focuses on the rapid removal of storm water runoff from a site. The assumption is that problems will disappear after storm water leaves the site. Under this approach, which usually involves concrete channels and underground piping networks, storm drains are constructed without regard for the control and slow release of storm water or for possible downstream effects. This approach to storm water management has been characterized by simplistic goals, rigid design standards (such as requiring piping for drainage instead of relying on natural drainage features), low engineering review costs, and high construction and maintenance costs. In some cases, flood problems are only shifted to downstream sites (NURP, 1984) (APWA, 1991).

3.2.4.4 Storm Water Management for Water Quantity and Water Quality Purposes (1970-Present)

A few communities have developed programs where storm water is managed for multiple purposes including controlling water quantity (to avoid flooding and stream scour and to maintain stream flows during dry weather by recharging ground water during storms) and improving water quality. A range of alternative storm water control measures and facilities can be implemented to serve multiple purposes effectively. The natural cycles and processes which occur prior to the development of the land are used as a guide for managing storm water after development has occurred. Natural flow patterns and rates of discharge are retained through special storm water control facilities and measures. Natural processes are incorporated into the design of many "soft" engineered systems, including vegetated buffers, greenways, revegetation of storm water systems, wetland creation or retention for storm water management, and onsite retention, detention or infiltration systems. Policies emerging from these programs include:

- Reducing peak flows and improving storm water quality by onsite retention
- Reducing the volume of storm water leaving the site by natural infiltration

- Releasing storm water from onsite facilities at a rate similar to the pre-development runoff rate
- Managing for smaller storm events as well as those larger storm events that can cause major floods
- Protecting wetlands and floodplains as natural storm water storage areas
- Making storm water facilities amenities of the development (such as retaining natural drainage channels or providing attractive landscaping for storm water management ponds) and encouraging open space and recreational uses
- Developing programs that relate erosion and sediment controls during construction with storm water management after construction is completed.

The implementation of this approach typically involves somewhat higher costs for development plan review by local governments, but lower costs for storm water facility construction, and results in reduced social costs (NURP, 1984) (APWA, 1991).

3.3 THE EXTENT OF DISCHARGES FROM MUNICIPAL SYSTEMS

3.3.1 Pollutant Concentrations of Runoff From Residential and Commercial Areas

Many studies have examined the nature of pollutants in municipal storm water discharges on a local level, but few have attempted to do so on a national level. The two most extensive assessments of pollutants in urban runoff are the Nationwide Urban Runoff Program (NURP) and information compiled in the USGS data base. These two data bases primarily reflect pollutant concentrations associated with runoff from residential and commercial areas.

From 1978 to 1983, EPA provided funding and guidance to NURP to provide a better understanding of the nature of urban runoff from residential and commercial areas. NURP included 28 projects that were conducted separately at the local level but were centrally reviewed, coordinated, and guided by EPA. Project locations across the country were selected by EPA to provide a range of types of receiving waters and beneficial uses, hydrologic characteristics, and urban characteristics.

The major focus of NURP was to characterize the water quality of runoff from residential, commercial, and industrial park sites. The NURP program evaluated data from 81 sites in 22 cities covering more than 2,300 separate storm events. Of the 81 sites selected, 39 were completely or primarily residential, 10 were commercial, 20 were mixed commercial and residential, 4 were industrial parks, and 8 were open spaces in urban areas. Because the industrial park category did not represent heavy industrial activity, the data from industrial parks were merged with commercial land use data. Each project was separate and distinct but shared common field monitoring protocols.

The NURP study provides insight on what can be considered background levels of pollutants for runoff from residential and commercial land uses. Sites evaluated in NURP were carefully selected so that they were not influenced by pollutant contributions from construction sites, industrial activities, or illicit connections. Several sites were eliminated from the study because of elevated pollutant loads associated with these or other sources.

NURP showed that the concentrations of pollutants in runoff from residential and commercial areas vary considerably from site to site. NURP postulated that the best general characterization of runoff from commercial and residential areas for planning purposes, where local information is lacking, can be obtained by pooling data from many sites.

The majority of samples collected under NURP were analyzed for seven conventional pollutants (biochemical oxygen demand, chemical oxygen demand, total suspended solids, total Kjeldahl nitrogen, nitrate plus nitrite, total phosphorus, and soluble phosphorus) and three metals (total lead, total copper, total zinc). Table 3-16 presents average discharge concentrations for these pollutants in runoff from the residential and commercial sites studied in NURP.[17]

[17] Recently, concerns have been raised regarding the validity and use of historical data for metals. As discussed in Chapter 2, EPA believes that historical data on storm water runoff from NURP and USGS are suitable for the purposes of this report.

Table 3-16. Summary of Event Mean Concentrations From NURP for Selected Pollutants

Constituent	Mean	Median Site	90th Percentile Site	Coefficient of Variability for Events
TSS (mg/l)	239	100	300	1-2
BOD (mg/l)	12	9	15	0.5-1
COD (mg/l)	94	65	140	0.5-1
Total P (mg/l)	0.50	0.33	0.70	0.5-1
soluble P (mg/l)	0.15	0.12	0.21	0.5-1
TKN (mg/l)	2.3	1.5	3.3	0.5-1
Nitrate plus nitrite (mg/l)	0.86	0.68	1.75	0.5-1
Total Cu (mg/l)	0.05	0.03	0.09	0.5-1
Total Pb (mg/l)	0.24	0.14	0.04	0.5-1
Total Zinc (mg/l)	0.35	0.16	0.50	0.5-1

In addition, the Section 307(a) priority pollutants were measured at 20 of the sites. Of the 119 pollutants analyzed, 77 were detected. All 13 metals on the priority pollutant list were detected, and all but 3 of the metals were detected at frequencies greater than 10 percent of the samples. Copper, lead, and zinc, found in at least 91 percent of the samples, were the most frequently detected metals. Of the 106 organic pollutants measured, 63 were detected. A plasticizer (bis (2-ethylhexyl) phthalate) and a pesticide (alpha-hexachlorocyclohexane (alpha-BHC)) were found in at least 20 percent of the samples analyzed. An additional 11 organic pollutants were reported at frequencies between 10 and 20 percent, including 4 pesticides, 3 phenols, 4 polycyclic aromatics, and a single halogenated aliphatic compound. NURP data also showed that during warm weather conditions, fecal coliform counts in urban runoff are typically in the tens to hundreds of thousands per 100 milliliters of runoff. Table 3-17 lists pollutants that were detected in 10 percent or more of the NURP samples.

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Table 3-17. Priority Pollutants Detected in at Least 10 Percent of the NURP Samples

Pollutant	Detection Frequency (%)
Metals and inorganics	
Antimony	13
Arsenic	52
Beryllium	12
Cadmium	48
Chromium	58
Copper	91
Cyanides	23
Lead	94
Nickel	43
Selenium	11
Zinc	94
Pesticides	
Alpha-hexachlorocyclohexane	20
Alpha-endosulfan	19
Chlordane	17
Lindane	15
Halogenated aliphatics	
Methane, dichloro-	11
Phenols and cresols	
Phenol	14
Phenol, pentacholoro-	19
Phenol, 4-nitro	10
Phthalate esters	
Phthalate, bis(2-ethylhexyl)	22
Polycyclic aromatic hydrocarbons	
Chrysene	10
Fluoranthene	16
Phenanthrene	12
Pyrene	15

Source: EPA, 1983

The USGS has also collected urban rainfall, runoff, and water quality data nationally for several decades. In the mid-1980s, a data base containing information on 717 storms at 99 stations in 22 metropolitan areas throughout the United States (Driver et al., 1985) was compiled. The USGS examined a set of constituents similar to those compiled for NURP; the USGS also reported its data in terms of flow-weighted samples so that concentrations and loading values could be compared directly to NURP results. As described in Section 2.1.2.1 of this report, EPA compared information from the USGS data base to the findings from NURP.

In general, the findings between the two studies were very similar. Both data bases identified sediments and metals as the most significant pollutants measured. This determination is consistent with the findings of Driver and Lystrom (1986), who also compared the two data sets.

Two major trends related to automobiles that have occurred since the bulk of NURP data were collected are expected to affect urban runoff quality. The first trend involves the dramatic reductions in the levels of lead in gasoline. NURP data were generally collected during the time period when leaded gasoline was being phased out, and current concentrations of lead in runoff are expected to be generally lower than indicated by the NURP data.[18] Storm water monitoring data collected since that time tend to show a significant decrease in lead, but much less of a reduction then the percentage reductions of

[18] Tetraethyl lead has been extensively used as an inexpensive anti-knock, octane boosting gasoline additive since 1923. Aside from the Surgeon General temporarily suspending the production and sale of lead in gasoline in 1925, the use of lead in gasoline was largely unregulated until 1978. Decreases since that time are the result of two regulatory programs under the Clean Air Act (CAA): regulation of the amount of lead in leaded gasoline; and automobile emission standards resulting in new technology, catalytic converters, requiring the use of unleaded gasoline. Beginning in 1975, many automobile manufacturers began installing catalytic converters, which were poisoned by lead in gasoline, to meet emission standards. In 1978, EPA began to lower the level of lead in leaded gasoline under sections 211(c)(1) and (2) of the CAA to protect the public health and welfare and to safeguard the performance of emission control devices in general use. Most recently, EPA lowered the low-lead standard to 0.10 gplg, effective January 1, 1986, (March 7, 1985 (50 *FR* 9386)).

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lead in gasoline. Other remaining sources of lead include industrial sources, paint, background levels in soil, and soil contaminated after 65 years of using lead in gasoline.[19]

The second trend pertains to the prohibition of the use of asbestos in brake pads and clutch linings. This is expected to result in a decrease in asbestos in runoff, which was not monitored in NURP, and an increase in copper and zinc, which are a substitute for asbestos in some brake pads.

3.3.1.1 Comparison of Pollutant Concentrations in Runoff from Residential/Commercial Areas to Discharges From Publicly Owned Treatment Works

The concentration of pollutants in runoff from residential and commercial areas (based on NURP and USGS data bases) can be compared to the typical concentration of pollutants found in the discharges from publicly owned treatment works (POTWs) that provide secondary treatment[20] (see Table 3-18). The concentration of total suspended solids (TSS) in runoff from residential and commercial areas is about an order of magnitude greater than the concentrations from POTWs receiving secondary treatment. The concentrations of COD, total lead, and total copper were somewhat higher in runoff from residential and commercial areas. The concentration of phosphorus and nitrogen were about an order of magnitude greater in discharges from POTWs.

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[19] This is consistent with the finding of *Deposition of Air Pollutants to the Great Waters, 1994 Report to Congress*, EPA, 1994, which indicates that the environment may act as an important reservoir or source of persistent contaminants that have been released previously.

[20] EPA estimates that 76 million people, or 42 percent of the population served by sanitary sewage treatment works, are served by systems that either provide greater than secondary treatment or have no discharge. *1992 Needs Survey Report to Congress*, EPA, 1993.

Table 3-18. Comparison of Mean Pollutant Concentrations in Runoff From Residential and Commercial Areas to Sewage Treatment Plant Receiving Secondary Treatment

Constituent	Runoff from Residential and Commercial Sites (NURP)	Sewage Plant With Secondary Treatment
TSS (mg/l)	239	20
BOD (mg/l)	12	20
COD (mg/l)	94	33
Total P (mg/l)	0.5	6
Soluble P (mg/l)	0.15	5
TKN (mg/l)	2.3	20
Nitrate plus nitrite (mg/l)	0.86	NA
Total Cu (mg/l)	0.05	0.05
Total Pb (mg/l)	0.24	0.03
Total Zn (mg/l)	0.35	0.14

Source: POTW discharge concentrations for lead, zinc, copper, BOD, COD, TSS, and oil and grease were based on data reported in *Fate of Priority Pollutants in Publicly Owned Treatment Works* (EPA, 1981). This report summarizes monitoring data from POTWs receiving secondary treatment in 50 cities. Pollutant concentrations for total phosphorus, soluble phosphorus, and total Kjeldahl nitrogen were based on personal communication with Dolloff Bishop or the EPA Wastewater Engineering Laboratory in Cincinnati, Ohio. Recently, concerns have been raised regarding the validity and use of historical data for metals. As discussed in Chapter 2, EPA believes that historical data on storm water runoff from NURP and USGS are suitable for the purposes of this report.

3.3.1.2 Comparison of Pollutant Concentrations in Runoff from Residential/Commercial Areas to Water Quality Criteria

NURP determined that toxic metals were the most prevalent priority pollutants in runoff from commercial and residential areas. All 14 inorganic priority pollutants (13 metals, plus cyanides, excluding asbestos) were detected in urban storm water. As shown in Table 3-19, a number of these constituents were detected at levels exceeding EPA water quality criteria. The table also identifies organic pollutants found that exceeded certain EPA water quality criteria. These exceedances were observed less frequently than exceedances for the inorganic constituents. Levels of coliform bacteria were also found to exceed EPA water quality criteria during and immediately after storm events in many surface waters (EPA, 1983).

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Table 3-19. Summary of Water Quality Criteria Exceedances for Pollutants Detected in at Least 10 Percent of NURP Samples—Percentage of Samples in Which Pollutant Concentrations Exceed Criteria[1]

Pollutant	Frequency of Detection(%)	Detection Samples[2]	Criteria Exceedances: None	FA	FC	OL	HH	HC[4]	DW
I. Pesticides									
α-Hexachlorocyclohexane	20	21/106						8,18,20	
γ-Hexachlorocyclohexane (Lindane)	15	15/100			8			0,10,15	
Chlordane	17	7/42		2	17			17,17,17	
α-Endosulfan	19	9/49			10				
II. Metals and Inorganics[5]									
Antimony	13	14/106	X					52,52,52	1
Arsenic	52	45/87						12,12,12	
Beryllium	12	11/94			6*				1
Cadmium[6]	48	44/91		8	48		1		1
Chromium[6,7]	58	47/81			1*				
Copper[6]	91	79/87		47	82				
Cyanides	23	16/71		3	22		4		
Lead[6]	94	75/80		23	94		73		73
Nickel[6]	43	39/91			5		21		
Selenium	11	10/88			5		10		10
Zinc[6]	94	88/94		14	77				
IV. Halogenated Aliphatics									
Methane, dichloro-	11	3/28						0,0,11	
VII. Phenols and Cresols									
Phenol	14	13/91	X						
Phenol, pentachloro	19	21/111		1*	11*	1			
Phenol, 4-nitro-	10	11/107	X						
VIII. Phthalate Esters									
Phthalate, bis(2-ethylhexyl)	22	15/69			22*				
IX. Polycyclic Aromatic Hydrocarbons									
Chrysene	10	11/109						10,10,10	
Fluoranthene	16	17/109	X						
Phenanthrene	12	13/110						12,12,12	
Pyrene	15	16/110						15,15,15	

*Indicates FTA or FTC value substituted where FA or FC criterion not available (see below).

[1] Based on 121 sample results received as of September 30, 1983, adjusted for quality control review. Where a value is reported for criteria exceedances, this value is a percentage of the number of samples where the pollutant was detected and blanks indicate no exceedances by any of the samples for which the pollutant was detected.

[2] Number of times detected/number of acceptable samples.

[3] FA = Freshwater ambient 24-hour instantaneous maximum criterion ("acute" criterion).
FC = Freshwater ambient 24-hour average criterion ("chronic" criterion).
FTA = Lowest reported freshwater acute toxic concentration. (Used only when FA is not available.)
FTC = Lowest reported freshwater chronic toxic concentration. (Used only when FC is not available.)
OL = Taste and odor (organoleptic) criterion.
HH = Non-carcinogenic human health criterion for ingestion of contaminated water and organisms.
HC = Protection of human health from carcinogenic effects for ingestion of contaminated water and organisms.
DW = Primary drinking water criterion.

[4] Entries in this column indicate exceedances of the human carcinogen value at the 10^{-5}, 10^{-6}, and 10^{-7} risk level, respectively. The numbers are cumulative (i.e., all 10^{-5} exceedances are included in 10^{-6} exceedances, and all 10^{-6} exceedances are included in 10^{-7} exceedances).

[5] Concerns have been raised regarding the validity and use of historical data for metals. As discussed in Chapter 2, EPA believes that historical data on storm water runoff from NURP and USGS are suitable for the purposes of this report.

[6] Where hardness dependent, hardness of 100 mg/l $CaCO_3$ equivalent assumed.

[7] Different criteria are written for the trivalent and hexavalent forms of chromium. For purposes of this analysis, all chromium is assumed to be in the less toxic trivalent form.

3.3.2 Pollutant Concentrations from Other Urban Land Uses

The NURP data base is limited to runoff from residential, commercial and industrial park land uses. These land uses typically comprise between 55 to 85 percent of the area of urban areas (EPA, 1990). Other major urban land uses which have the potential to contribute runoff with higher levels of pollutants include central business districts, industrial areas (typically 10 to 20 percent of the area of urban areas), and construction activities.

3.3.2.1 Central Business Districts

NURP noted that data describing runoff from central business districts are limited. However, NURP suggested that some central business districts may produce pollutant concentrations in runoff that are significantly higher than those from other sites in a given urban area. Pollutant loads from central business districts are thought to be significant because of the high pollutant concentrations coupled with the high degrees of imperviousness.

3.3.2.2 Industrial Land Uses

No truly industrial sites were included in any of the NURP projects. However, NURP suggested that runoff from industrial sites may have significantly higher contaminant levels than runoff from other urban land use sites. Several studies tend to support this suggestions, such as the Fresno, CA, NURP project which showed that industrial areas had the poorest storm water runoff quality of the four land-uses evaluated. Of the 62 non-pesticide constituents monitored, 52 were statistically highest in industrial site runoff. A study conducted in Spokane, WA, showed that industrial and commercial sites clearly contributed greater quantities of total dissolved solids, COD, total Kjeldahl nitrogen, lead and zinc (Oregon, 1986—Spokane Water Quality Management Program).

Given the range of different industrial activities in different urban areas, it would be difficult to characterize industrial runoff on a national basis. However, recent data collection efforts describing runoff from different types of industrial activities can be used to evaluate

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the potential for pollutants in runoff from specific industrial areas. Chapter 4 summarizes some of these efforts.

3.3.2.3 Construction Activities

The amount of sediment in storm water discharges from construction sites can vary considerably, depending on whether effective management practices are implemented at the construction site. Uncontrolled or inadequately controlled construction site sediment loads have been reported to be on the order of 35 to 45 tons/acre/year (Novotny and Chesters, 1981). Sediment runoff rates from construction sites are typically 10 to 20 times that of agricultural lands, with runoff rates as high as 100 times that of agricultural lands; the rates are typically 1,000 to 2,000 times those of forest lands. Over a short period of time, construction sites can contribute more sediment to streams than was previously deposited over several decades.[21]

3.3.3 Pollutant Loading Estimates

EPA has developed loading estimates for selected pollutants in discharges from municipal separate storm sewer systems associated with urbanized areas.[22] Chapter 2 describes the methods used for estimating pollutant loads.

Table 3-20 summarizes pollutant load estimates for different classes of municipalities currently addressed by Phase I of the NPDES storm water program and potentially addressed under Phase II. EPA estimates that in 1990, about 40 percent of the pollutant loads associated with runoff from urbanized areas came from Phase I municipalities. About one-quarter of the pollutant loads in runoff from urbanized areas came from potential Phase II

[21] Under current regulations, construction activities resulting in the disturbance of 5 or more acres are covered by the NPDES storm water program.

[22] The model used to estimate pollutant loads assumed constant concentrations for each of the seven pollutants. This assumption results in the ratio of loadings of different pollutants remaining constant for different classes of municipalities. Thus, where the percentage of pollutant loadings is presented, the percentage is the same for all seven pollutants.

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Table 3-20. Estimated Pollutant Loadings in Runoff From Urbanized Areas

Classification	Population Category	Number of Urbanized Areas*	Population* (millions)	Total Area** (sq. mi.)	Number of Incorporated Places*	Number of Minor Civil Divisions*	Number of Counties*	Percentage of Urbanized Area Loading
NATIONAL		405	252.2	3,540,166	19,289	17,796	3,141	NA
ALL URBANIZED AREAS	50,000 - 99,999	176	12.2	7,674.0	457	285	251	12
	100,000 -249,999	125	19.5	10,243.0	485	350	154	16
	Over 250,000	104	128.7	43,603.0	2,649	939	296	72
	TOTAL	405	160.4	61,520.0	3,591	1,574	703	100
URBANIZED AREAS AFFILIATED WITH PHASE I MS4s								
- Phase I MS4s within Phase I affiliated Urbanized Areas	50,000 - 99,999	8	0.4	210.7	9	0	6	0
	100,000 - 249,999	47	6.3	3,066.4	51	0	13	5
	Over 250,000	81	75.0	21,741.9	504	0	53	35
	SUBTOTAL	136	81.7	25,019.0	564	0	72	40
- Phase II Portions of Phase I affiliated Urbanized Areas	50,000 - 99,999	8	0.2	102.5	10	1	4	1
	100,000 - 249,999	47	1.9	1,174.4	69	58	62	2
	Over 250,000	81	33.7	14,944.8	1,508	575	239	25
	SUBTOTAL	136	35.8	16,221.7	1,587	634	305	28
	TOTAL	136	117.5	41,240.7	2,151	634	377	68
URBANIZED AREAS NOT AFFILIATED WITH A PHASE I MS4								
- Urbanized Areas Not Affiliated with Phase I MS4s	50,000 - 99,999	168	11.6	7,232.7	443	284	242	11
	100,000 -249,999	78	11.3	5,823.0	371	297	91	9
	Over 250,000	23	20.0	6,176.7	656	385	47	12
	TOTAL	269	42.9	19,606.0	1,470	966	380	32
- Urbanized Areas Containing a City with a CSO Exemption**	50,000 - 99,999	0	0	0	0	0	0	0
	100,000 -249,999	7	1.5	661.2	40	70	17	1
	Over 250,000	14	16.0	5,242.5	524	358	43	9
	TOTAL	21	17.5	5,903.7	564	428	60	10
PHASE I MS4s OUTSIDE URBANIZED AREAS		NA	4.3	86,097	57	0	5	NA

* Totals are based upon 1990 Census, and include Puerto Rico, Guam, Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands.
** Some municipalities identified in the November 1990 application regulations (55 *FR* 47990) as Phase I based on 1980 census data received combined sewer exclusions from Phase I where the total population served by separate storm sewers was less than 100,000 after subtracting the population served by combined sewers. (The 21 urbanized areas [with a population of 17.5 million] containing these municipalities are also contained in the above totals and are not in addition to those totals.)

portions of urbanized areas with a Phase I municipality. An additional one-third of the pollutant loadings associated with urbanized areas came from urbanized areas that do not have a Phase I municipality.

Table 3-21 compares annual pollutant loadings for three metals, zinc, lead, and copper, from urban runoff from the Metropolitan Washington urbanized area, with a sewage treatment plant that provides advanced treatment and that serves about 2 million people (the Blue Plains sewage treatment plant), and major industrial process wastewater discharges located in Maryland and Virginia. In general, the data in Table 3-21 indicates that the annual loadings of metals, nutrients, and oxygen demanding pollutants in urban runoff from the Washington, DC, area are higher than the loadings from the predominant sewage treatment plant for the area (the Blue Plains Sewage Treatment Plant provides advanced treatment and serves approximately two million people). The data also indicate that the annual loadings of zinc and lead in urban runoff from the Washington, DC, area are higher than the loadings from all industrial point source discharges from facilities in Maryland and Virginia that reported pollutant release information in 1987 to the Toxic Release Inventory established under the Emergency Planning and Community Right-to-Know Act.

Table 3-21. Annual Pollutant Loadings in Pounds for Selected Pollutant Sources

Pollutant	Urban Storm Water from Metropolitan Washington	Blue Plains Sewage Treatment Plant[1]	All MD and VA Direct Industrial Discharges in 1987 Toxic Release Inventory
Zinc	480,000	137,000	132,000
Lead	132,600	5,500	31,300
Copper	113,000	21,000	127,000
Nitrogen	30,000,000	12,000,000	not available
Phosphorus	1,200,000	113,000	not available
BOD5	9,500,000	1,400,000	not available

[1] Portions of collection system for Blue Plains are combined sewers carrying both runoff and sewage. The POTW loadings do not account for discharges from combined sewer overflows. The loadings estimate does account for urban storm water that is conveyed to Blue Plains, treated, and discharged. Recently, concerns have been raised regarding the validity and use of historical data for metals. As discussed in Chapter 2, EPA believes that historical data on storm water runoff are suitable for the purposes of this report.

A number of factors are expected to result in future changes to total loadings and the distribution of loadings between Phase I and Phase II municipalities. Factors that would generally increase loadings include increases in population and the area of urbanized areas. If recent development trends continue, most increases in loadings are expected to occur in urbanized areas with a Phase I municipality. The majority of the increase in loadings in these areas is expected to occur in suburban areas surrounding core cities.

The increased implementation of storm water management measures is expected to generally decrease pollutant loadings. Given the existing Federal mandate for storm water controls, such decreases are expected to occur in Phase I municipalities sooner than in potential Phase II municipalities.

Widespread product substitutions associated with activities that generate pollutants ultimately discharged in storm water may either increase or decrease pollutant loads, depending on the nature of such substitutions.

When analyzing annual loadings associated with urban runoff, it is important to recognize that discharges of urban runoff are highly intermittent and that the short-term loadings associated with individual events will be high and may have shockloading effects on receiving water.

3.3.4 Floatables/Litter/Plastics

Litter is common in urbanized areas. During storm events, litter can be washed into separate storm sewers or carried through other storm water conveyances to receiving waters. Litter is also commonly disposed of directly to storm sewer catchbasins. Discharges from separate storm sewers were identified as major sources of plastics to the surface waters in *Methods to Manage and Control Plastics Wastes—Report to Congress*, (EPA, 1989). Another study concluded that the majority of floating litter that washes up on New Jersey's beaches originates from discharges from separate storm sewers (New Jersey DEP, 1988).

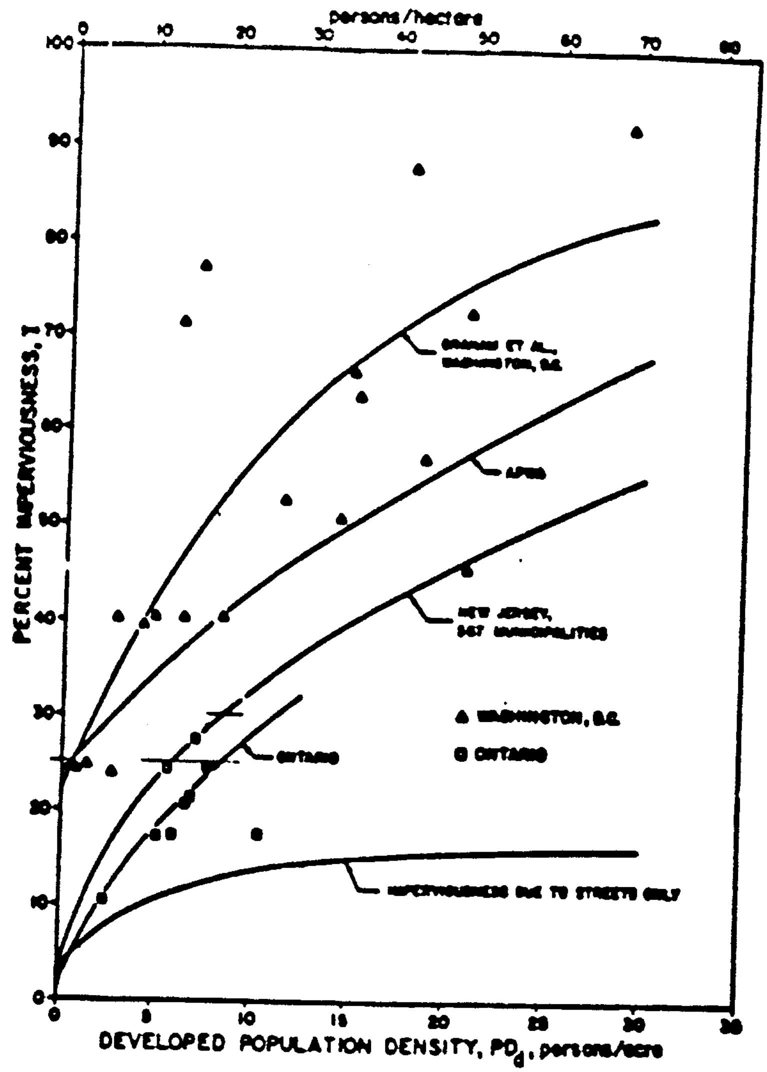
Litter can cause significant aesthetics problems and impact the operating effectiveness of drainage systems and related management practices such as detention ponds.

3.3.5 Population Densities and Imperviousness

As discussed previously, the amount of imperviousness in urban watersheds can be linked to impacts to streams and other surface water resources. The population density of a municipality can be used as an indicator of the level of imperviousness. Figure 3-7 summarizes several studies that attempted to link population densities to percent imperviousness (Kobriger, 1984). However, using population density as an indicator of imperviousness does not account for high levels of day-time use associated with many commercial or industrial areas with high levels of imperviousness.

Population density is related to the total urban population in an area. Table 3-1, presented previously, indicates that as the total population of an urbanized area increases, so does the average population density. The average population density of urbanized areas with a total population of 1,000,000 or more (3,413 persons per square mile) is more than double the average population density of urbanized areas with a population of 50,000 to 100,000 (about 1,600 persons per square mile).

The population density varies within urbanized areas. Core cities generally have a higher population density than outlying suburban areas. However, other smaller cities that are part of larger urbanized areas can have high population densities. In 1990, the Bureau of the Census reported more than 600 incorporated places with populations under 100,000 but with a population density of at least 5,000 persons per square mile. Approximately 550 of the more than 600 incorporated places meeting this criterion were in an urbanized area. Approximately 415 of these incorporated places are in an urbanized area where at least one Phase I municipality is located.



Source: Kobriger, 1984.

Figure 3-7. Relationship Between Population Density and Percent Imperviousness

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3.4 SUMMARY

Bureau of the Census estimates that the population of the United States and associated territories was more than 252.2 million in 1990[23] and that there are 19,289 incorporated places and 17,796 minor civil divisions in the continental United States, Alaska and Hawaii. These incorporated places and minor civil divisions are located in 3,141 counties or county equivalents.

The concept of Bureau of the Census-designated urbanized areas served as an important tool for analyzing potential approaches to a Phase II program that addresses municipal separate storm sewer systems. More than 160 million people (63 percent of the total United States population) reside in the 405 urbanized areas with a population of 50,000 or more that have been designated by the Bureau of the Census. These areas occupy less than 2 percent of the Nation's total land area. These areas represent the largest, most widespread areas of dense urban development in the country.

The majority of new urban development also occurs in Census-designated urbanized areas. Construction activity related to new development is recognized as a significant source of pollution and impairment of waterbodies, providing some of the best opportunities for implementing storm water management controls in a highly cost-effective fashion. Between 1980 and 1990, the population of Census-designated urbanized areas increased by 21.2 million.[24] During the same time period, the rural population of the United States increased by 2.2 million, and the urban population that lived outside of urbanized areas increased by 0.9 million. Between 1980 and 1990, the population of urbanized areas with one or more municipal systems addressed by Phase I of the NPDES storm water program increased by 16.4 million (or 75 percent of the total National growth). This represents a 25 percent

[23] Population estimates based on the 50 States, the District of Columbia, Guam, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, and the Commonwealth of the Northern Mariana Islands.

[24] About 7 percent of this increase, (1.5 million people) are associated with the net addition of 30 new urbanized areas between 1980 and 1990. Another part of this increase which has not been estimated here is associated with the increase in land area of pre-existing urbanized areas.

increase in the population of these areas. The population of urbanized areas without a Phase I municipal system increased by 2.6 million. This represents 12 percent of the total national growth and a 7 percent increase in the population of these areas.

The population and number of municipalities in urbanized areas, and estimated percentage of pollutant loads in runoff from urbanized areas are summarized in Table 3-20 and discussed below.

Phase I of the NPDES program for storm water discharges addresses 621 incorporated places (cities) and portions of 77 counties.[25] These municipalities had a combined population of 86 million people in 1990. Cities with a population of 100,000 or more whose municipal systems are already addressed by Phase I of the NPDES storm water program increased in population by about 4.9 million between 1980 and 1990.[26] The majority of the population of Phase I municipalities, 81.7 million people live in 136 of the 405 Census-designated urbanized ares. EPA estimates that about 40 percent of the pollutant loads in storm water discharged from urbanized areas come from Phase I municipalities.

The Phase II portions of the 136 urbanized areas with one or more Phase I municipal separate storm sewer system had a combined population of 35.8 million people. The population of those portions of these urbanized areas increased by 2.6 million between 1980 and 1990. EPA estimates that 1,587 incorporated places, 634 minor civil divisions, and parts of 305 counties are located in the Phase II portions of these urbanized areas. EPA estimates that 28 percent of the pollutant loads in storm water discharged from urbanized areas come from Phase II portions of the 136 urbanized areas with a Phase I municipality.

[25] Of these municipalities, 140 cities and 45 counties are specifically identified in the NPDES regulations that were published in November of 1990. EPA and authorized NPDES States have designated an additional 481 cities and 32 counties as Phase I municipalities. In addition, approximately 30 municipalities (located in 21 urbanized areas) have received combined sewer exclusions where the total population served by separate storm sewers is less than 100,000 after subtracting the population served by combined sewers. The methodology used to classify municipalities as Phase I vs. Phase II for the purposes of this report is explained in Chapter 2.

[26] The 4.9 million increase does not include increases associated with unincorporated, urbanized portions of Phase I counties and designated municipalities.

A total of 269 of the Census-designated urbanized areas do not have a municipality with separate storm sewers subject to Phase I of the storm water program. The 269 urbanized areas without a Phase I municipal separate storm system have a combined population of 42.9 million people. EPA estimates that 1,470 incorporated places, 966 minor civil divisions, and parts of 380 counties are located in these urbanized areas. EPA estimates that about one-third of the pollutant loads in storm water discharged from urbanized areas come from the 269 urbanized areas without a Phase I municipality. Of the 269 urbanized areas without a Phase I municipal system, 101, or over a third, have a population of more than 100,000, and 23 have a population of more than 250,000.

In addition to populations within urbanized areas discussed above, the Bureau of the Census has identified an additional urban population of 29 million people that live outside of urbanized areas, as well as 62.8 million people classified as rural. Of this total, 25.1 million people live in 3,689 incorporated places. The remaining 4 million people live in either minor civil divisions or unincorporated portion of counties. Although discharges from municipal separate storm sewer systems serving these populations are potential Phase II sources, they are not addressed in this report.

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CHAPTER 4. INDIVIDUAL PHASE II DISCHARGES

This chapter identifies the discharges of storm water other than those from municipal separate storm sewer systems for which permits are not currently required and assesses, to the extent practicable, the nature and extent of pollutants in those discharges. To provide a context for this analysis, this chapter begins with an overview of the industrial categories that are addressed under Phase I of the storm water regulatory program. Using an approach described in Chapter 2 of this report, other categories of industrial, commercial, and retail facilities that may be sources of polluted storm water discharges are identified. For these potential Phase II sources, the type of their discharges and statistics on their geographic distribution are described. The nature of industrial storm water discharges is characterized using a summary of the sampling data reported by Phase I group permit applicants and comparing groups of Phase II sources to these Phase I industries. In an analysis patterned after that in Chapter 3, this chapter also explores the relationship between individual Phase II industrial, commercial, and retail facilities and urbanized areas of different configurations. The final section of this chapter summarizes the results of the analyses and offers some perspectives on individual Phase II storm water discharges. The results of these analyses are meant to be guideposts and are not intended to be an identification of specific industrial categories that must be regulated under Phase II.

4.1 OVERVIEW OF INDIVIDUAL PHASE II SOURCES

There are more than 7.7 million industrial, commercial, retail, and government facilities in the United States.[1] The Office of Management and Budget classifies businesses into categories based on similarity of economic activity. Some aspects of this discussion are

[1] This estimate is based on data from the FACTS data base, which is leased by EPA from Dun & Bradstreet Information Services, which created, maintains, and annually updates information based on a variety of sources. This estimate does not include inactive and abandoned mines which may constitute hundreds of thousands of additional sources.

based on this Standard Industrial Classification (SIC) code system.[2] Table 4-1 presents a breakdown of the major categories of industry and commerce. The current storm water regulatory program potentially applies to some types of individual facilities within the mining, construction, manufacturing, and transportation divisions. There are more than 850,000 enterprises in these divisions; however, only a portion of these are within the 11 categories of activities "associated with industrial activity" as defined by the November 1990 storm water permit application regulations.[3] As a result, from these 850,000 enterprises, EPA has estimated that approximately 150,000 facilities are currently subject to Phase I requirements.

Table 4-1. Summary of Major SIC Divisions of U.S. Commerce

Description	Total Facilities	SIC Codes Covered
Agriculture, Forestry, and Fishing	310,086	01 - 09
Mining	39,936	10 - 14
Construction	805,100	15 - 17
Manufacturing	511,831	20 - 39
Transportation and Public Utilities	306,894	40 - 49
Wholesale Trade	582,681	50 - 51
Retail Trade	1,850,121	52 - 59
Finance, Insurance, and Real Estate	672,693	60 - 67
Services	2,585,750	70 - 89
Public Administration	71,379	90 - 97
Total	7,736,471	

The remaining universe of facilities fall into two main groups, those that have a statutory or regulatory exemption, including agricultural and most silvicultural activities, and those that are considered to be potential Phase II activities. Many of these potential Phase II

[2] The Standard Industrial Classification (SIC) code system organizes industries into categories and subcategories. Major groups are designated by a two-digit code number between 01 and 99. Within major groups, facilities are further categorized at the industry group (3-digit) level and industry (4-digit) level.

[3] This figure excludes about 800,000 building, construction, and specialty contractors, which are regulated to the extent that they engage in construction activities disturbing 5 acres or more.

sources, however, are not expected to become subject to Phase II regulation. Sources that are not in Phase I and are not expected to become subject to NPDES storm water regulation in Phase II consist of sources that lack the potential to contribute significant levels of pollutants to storm water, including financial institutions, some governmental activities and many types of service organizations.

The remaining categories of light industrial, commercial, retail, governmental establishments, and residential activities represent the universe of facilities under consideration for potential inclusion in Phase II. These facilities fall into several general categories with respect to Phase II:

- Facilities with activities essentially identical or closely related to those "associated with industrial activity," that are not covered for a variety of statutory and regulatory reasons.
- Facilities with activities similar to those "associated with industrial activity," such as transportation activities, energy producers and distributors, and utilities.
- Commercial activities with industrial components, such as assembly and repair operations.
- Agriculture-related operations that include currently unregulated feedlots.[4]
- Non-agricultural operations with potential for use of pesticides and fertilizers.
- Facilities and households with failing septic systems.
- Other facilities with potential to use or produce toxic substances, including laboratories and some governmental facilities.

In general, the geographic distribution of industrial, commercial, and retail activity—in short, economic activity—tends to be closely associated with population and population

[4] To be subject to the NPDES program, sources must have point source discharges of pollutants to waters of the United States. EPA has defined concentrated animal feeding operations (CAFOs) as point sources currently subject to permitting under NPDES. This study looks at feedlots which do not meet the regulatory definition of CAFO to study their impacts on water quality and to identify them as potential sources to be covered under Phase II.

density. Through this relationship between population and economic activity, this industrial analysis can be compared with the municipal analysis undertaken in the previous chapter. The Phase I municipal approach is taken as the starting point for a locational analysis of industrial Phase I and potential Phase II sources in this chapter. The municipal component of Phase I of the storm water regulatory program focuses on the largest cities and counties, which contain about one-third of all the facilities in both regulated and nonregulated categories. There are a few notable exceptions to this relationship between economic activity and population, including agricultural and mining activity. These are discussed in more detail later in this chapter.

4.1.1 The Phase I Permitting Framework for Industrial Discharges

Section 402(p) of the CWA provides that EPA or NPDES-approved States cannot require a permit for storm water discharges from individual sources before October 1, 1994, except for discharges "associated with industrial activity" or those that had a permit prior to February 4, 1987, unless they are significant contributors of pollutants to waters of the United States or contribute to the violation of a water quality standard. The Act also clarifies that permits for discharges associated with industrial activity must meet all of the applicable provisions of CWA Sections 402 and 301, including both applicable technology-based requirements and water quality-based standards. All other storm water discharges that are potential candidates for coverage fall under Phase II of the program. The basic permitting framework for Phase I of the NPDES storm water program is established in 40 *CFR* 122, primarily Section 122.26.

The November 16, 1990, storm water regulations described 11 categories of industrial facilities that defined the term "discharges associated with industrial activity." The categories were derived from a combination of narrative descriptions and specific SIC code designations to define and identify Phase I sources (40 *CFR* 122.26(b)(14)). The types of industrial facilities covered by the definition are illustrated in Table 4-2.

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Table 4-2. Industrial Facilities That Must Submit Applications for Storm Water Permits (Phase I)

40 *CFR* 122.26(b)(14) Subpart	Description
(i)	Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutants effluent standards under 40 *CFR*, Subchapter N [except facilities which are exempt under category (xii)]
(ii)	Facilities classified as: SIC 24 (except 2434) ...... Lumber and Wood Products SIC 26 (except 265 and 267) . Paper and Allied Products SIC 28 (except 283 and 285) . Chemicals and Allied Products SIC 29 .... Petroleum and Coal Products SIC 311 .... Leather Tanning and Finishing SIC 32 (except 323) ...... Stone, Clay and Glass Products SIC 33 .... Primary Metal Industries SIC 3441 .... Fabricated Structural Metal SIC 373 .... Ship and Boat Building and Repairing
(iii)	Facilities classified as SIC 10 through 14, including active or inactive mining operations and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts, or waste products located on the site of such operations. SIC 10 .... Metal Mining SIC 11 .... Anthracite Mining SIC 12 .... Coal Mining SIC 13 .... Oil and Gas Extraction SIC 14 .... Nonmetallic Minerals, except Fuels
(iv)	Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA).
(v)	Landfills, land application sites, and open dumps that receive or have received any industrial wastes including those that are subject to regulation under subtitle D or RCRA.
(vi)	Facilities involved in the recycling of material, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but not limited to those classified as: SIC 5015 .... Motor Vehicle Parts, Used SIC 5093 .... Scrap and Waste Materials
(vii)	Steam electric power generating facilities, including coal handling sites.
(viii)	Transportation facilities which have vehicle maintenance shops, equipment cleaning operations, or airport de-icing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category, are included. SIC 40 .... Railroad Transportation SIC 41 .... Local and Suburban Transit SIC 42 (except 4221-25) .... Motor Freight and Warehousing SIC 43 .... U.S. Postal Service SIC 44 .... Water Transportation SIC 45 .... Transportation by Air SIC 5171 .... Petroleum Bulk Stations and Terminals

Table 4-2. Industrial Facilities That Must Submit Applications for Storm Water Permits (Phase I) (continued)

40 *CFR* 122.26(b)(14) Subpart	Description
(ix)	Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including lands dedicated to the disposal of the sewage sludge that are located within the confines of the facility, with a design flow of 1.0 million gallons per day or more, or required to have an approved pretreatment program under 40 *CFR* Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA.
(x)	Construction activity including clearing, grading, and excavation activities except operations that result in the disturbance of less than 5 acres of total land area and those that are not part of a larger common plan of development or sale.
(xi)	Facilities under the following SICs [which are not otherwise included in categories (ii)-(x)], including only storm water discharges where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to storm water. SIC 20 .... Food and Kindred Products SIC 21 .... Tobacco Products SIC 22 .... Textile Mill Products SIC 23 .... Apparel and Other Textile Products SIC 2434 .... Wood Kitchen Cabinets SIC 25 .... Furniture and Fixtures SIC 265 .... Paperboard Containers and Boxes SIC 267 .... Converted Paper and Paper Board Products (except containers and boxes) SIC 27 .... Printing and Publishing SIC 283 .... Drugs SIC 285 .... Paints, Varnishes, Lacquer, Enamels SIC 30 .... Rubber and Misc. Plastics Products SIC 31 (except 311) .... Leather and Leather Products SIC 323 .... Products of Purchased Glass SIC 34 (except 3441) .... Fabricated Metal Products SIC 35 .... Industrial Machinery and Equipment, except Electrical SIC 36 .... Electronic and Other Electric Equipment SIC 37 (except 373) .... Transportation Equipment SIC 38 .... Instruments and Related Products SIC 39 .... Miscellaneous Manufacturing Industries SIC 4221 .... Farm Products Warehousing and Storage SIC 4222 .... Refrigerated Warehousing and Storage SIC 4225 .... General Warehousing and Storage

Source: *Federal Register*, Vol. 55, No. 222, p. 48065, November 16, 1990.

Note: On June 4, 1992, the U.S. Court of Appeals for the Ninth Circuit remanded the exemption for construction sites of less than five acres and for manufacturing facilities in category (xi) which do not have materials or activities exposed to storm water to the EPA for further rulemaking. *NRDC* v. *EPA*, 966 F.2d 1292 (9th Cir. 1992). In response to the remands, the Agency intends to conduct further rulemakings on both the light manufacturing and the construction activities. In the December 18, 1992, *Federal Register*, EPA stated that it is not requiring permit applications from construction activity under five acres or light industry without exposure until this further rulemaking is completed.

For a more complete discussion of the interpretation of this definition, refer to the *NPDES Storm Water Program Question and Answer Document*, Parts I and II (EPA, 1992, 1993), which appear in Appendix D.

The original permitting framework of Phase I provided operators of industrial facilities with three options for applying for NPDES permit coverage. They could (1) submit individual applications, (2) participate in a group application, or (3) submit a notice of intent to be covered by a general permit.[5] For the first phase of the storm water program, EPA issued general permits to facilitate permitting the large number of facilities covered by the program on September 9, 1992 (57 *FR* 41176), September 25, 1992 (57 *FR* 44412), and April 14, 1993 (58 *FR* 19427). This Phase I framework is the result of a lengthy rulemaking process that included opportunities for, and response to, public comment. In addition, authorized NPDES States have issued numerous other general permits for facilities within their States.

Section 402(p)(2)(E) of the CWA allows EPA or States to require permits for any other discharges determined to be a contributor to a violation of a water quality standard or a significant contributor of pollutants to waters of the United States. Thus, the Phase I approach provides the foundation for extending regulation to additional sources and classes of discharges, as appropriate.

4.1.2 Industrial, Commercial, and Retail Sources *Not* Subject to Phase I Permit Requirements

This section responds to Congress' first mandate in CWA Section 402(p)(5): to identify the sources of storm water discharges for which permits are not currently required under Phase I. This chapter addresses individual Phase II sources; municipal separate storm sewer systems were discussed in Chapter 3. Based on a review of those facilities not subject to Phase I permitting requirements and a screening procedure based on information drawn from the literature review, activities were identified that may present opportunities for pollutant releases to storm water. The purpose of the source identification is to present the

[5] The group application permitting option is no longer available to permit applicants because the application deadlines have passed. EPA proposed an industry-specific multi-sector model general permit based on the information received through the group application process on November 19, 1993. EPA will be finalizing the multi-sector general permit in the near future.

full range of potential Phase II sources and to characterize them to the extent possible to facilitate decision making on the appropriate scope and approach of Phase II. The screening process was used to narrow consideration to a subset of facilities that may be appropriate for coverage under Phase II. Both the regulatory analysis and screening procedure are described below.

4.1.2.1 Phase I Regulatory Review

In defining "storm water discharges associated with industrial activity," the Phase I regulations identify 11 categories of facilities considered to be engaging in "industrial activity" (see Table 4-2). Only those facilities described in the 11 categories of the definition that have point source discharges of storm water are required to apply for storm water permit coverage under Phase I of the program. As shown in Table 4-2, regulated activities under Phase I were identified by SIC category, narrative descriptions of activities, or, in some cases, both. For example, Category viii regulated activities are defined as "only those portions of the facility that are either involved in vehicle maintenance . . ., equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category . . . ." Seven separate SIC codes are then listed, including six two-digit codes and one four-digit code; several four-digit codes were specifically omitted from coverage.

There are a number of sources closely related to Phase I activities that are currently unregulated. One general class includes construction activities that disturb less than 5 acres (Category x) and light industrial activities that have no exposure of materials to storm water (Category xi). On June 4, 1992, the Court of Appeals for the Ninth Circuit remanded the exemption of both of these categories from the original storm water regulations.[6] The court found that EPA had not adequately established that light industrial facilities without exposure of materials or operations to storm water and construction sites disturbing less than 5 acres were non-industrial in nature.

[6] *Natural Resources Defense Council v. EPA*, 966 F.2d 1292 (9th Cir. 1992).

In response to the Ninth Circuit Court ruling, EPA issued a *Federal Register* notice on December 18, 1992, to explain the outcome of the ruling and to request comment and specific factual information to assist in the development of a new proposal to address light industry and small construction site categories. EPA noted that it did not believe that the court's decision has the effect of automatically subjecting small construction sites and light industries to the existing application requirements and deadlines. The Agency also indicated that it believed that additional notice and comment were necessary to clarify the status of these facilities. To the extent that some or all of these facilities may not be addressed by Phase I, they would be potential Phase II sources.

Additional categories of potential Phase II facilities have been identified based on the screening procedure described below.

4.1.2.2 Screening Procedure

Potential Phase II sources, categories, and activities were identified using previous information and additional screening based on the major sectors of the economy identified by SIC codes. Identifying potential Phase II sources based on SIC codes facilitates quantitative analysis of the numbers of facilities potentially subject to Phase II and provides a basis for a geographical location analysis that parallels the municipal analysis in Chapter 3. The geographical analysis (discussed in Section 4.2.2) was developed to show the distribution and "concentration" of non-domestic enterprises across the country and their association with various sizes and types of population centers. This geographical approach could later be related to a water quality or environmental assessment at a finer level of detail at the regional, state or local level.

As discussed in Chapter 2, major sectors of the economy are defined on the basis of the two-digit SIC code. This two-digit code is a relatively general categorization of the Nation's economic activity: all industrial, commercial, and retail activities are organized into 83 two-digit SIC codes. The four-digit SIC code provides a more detailed breakdown of these enterprises and is much more specific to the activities conducted at the establishment. Although all unregulated activities are potential Phase II sources, in practical terms, only a subset of four-digit SIC industry groups has real potential to use, process, or store pollutant-bearing materials or to engage in activities that could lead to contamination of storm water.

SIC codes are assigned by economic activity, not pollution potential. However, economic activities often correspond to physical activities or use of specific materials that can be assessed relative to the potential to generate storm water pollution. Thus, SIC codes can serve as an indicator of the underlying activities or materials of concern, even if they cannot be used to directly assess environmental effects.

The screening process described below focuses on two broad classes of facilities. The first (designated Group A) consists of facilities that fall within the same general range of SIC codes as Phase I industrial activities but that are not covered under Phase I. The second major group (designated Group B) consists of a specific subset of four-digit SIC codes of concern (outside SIC codes 10-45) where discharges of pollutants are suspected based on case studies, expert opinion, literature review, other EPA programs and concerns, and experience with Phase I of the storm water program.

This screening process does not establish negative environmental effects from storm water discharges. It does serve as a tool for focusing attention on those categories potentially contributing to storm water pollution. The geographical analysis reported in Section 4.2.2 allows EPA to determine how these specific categories of potential Phase II facilities are distributed nationally in geographic areas of concern (e.g., urbanized areas).

The following criteria were used to identify four-digit SIC codes of primary environmental concern. First, facilities highly similar to Phase I facilities are identified (Group A). Next, an additional 12 categories of potential Phase II sources are identified based on their similarity to Phase I activities or based on case studies and expert opinion

(Group B). These 12 Group B categories are then related to specific SIC code groupings for subsequent analysis in Section 4.2. The categories identified through this process represent the types of establishments or activities that may warrant further investigation and control under Phase II. This preliminary identification does not establish that water quality impacts are occurring.

As noted earlier, the SIC code system is a useful framework for identifying the numbers and locations of facilities. The SIC approach allows EPA to access information from many sources with a very precise level of detail, because of the efforts of many organizations (e.g., Commerce Department) to record and track economic activity by industrial category. Still, focusing on SIC codes for the purposes of this study does not imply that a regulatory strategy must proceed on this basis. The types of activities conducted at these facilities could be regulated through narrative descriptions, as was done for some categories in Phase I. Experience with the Phase I definition of "discharges associated with industrial activity" suggests that SIC designations alone may not be completely satisfactory because activities of concern may be conducted at a wide variety of facilities that do not happen to have the same primary SIC code. In addition, other potential Phase II sources that are not reflected by the SIC code system, including parking lots, large retail complexes, and facilities or residences with septic systems for septic wastewater disposal, can similarly be studied for impacts on water quality or regulated based on narrative description. Even within an SIC-based regulatory framework, additional factors, such as size, location, pollutant usage, or activity cutoffs or restrictions, can be used to identify specific facilities for regulation based on a potential correlation between facilities and water quality impacts.

The SIC system does not capture some types of facilities or activities that generate storm water discharges. SIC codes are designated based on the primary activity in which an establishment is engaged. A business that is involved in a number of different activities will be classified according to a single industrial code, which may not reflect activities associated with storm water discharges. In addition, some facilities carry out activities off-site, such as material storage and vehicle maintenance, that will not have independent business identities and, thus, no separate SIC designations. Similarly, the SIC system may not identify all facilities that are owned or operated from a remote central business location. The SIC system also does not individually identify industrial activities associated with municipalities. Although some municipal services (e.g., public ambulance services) are identified, other types of activities (e.g., municipal power generating facilities) are not captured within the SIC system. Even with these limitations, EPA analysis of potential Phase II sources in terms of SIC code assignments provides an extremely valuable analytical tool to assess the location and concentration of these activities at the national level.

Group A Sources

Although Phase I industrial activities generally fall within SIC codes 10-45, there are many omissions and exceptions within this range. While some of these omissions were intentional, others are the result of the specificity of the 1990 application regulations. Other facilities have been excluded from Phase I based on specific legislative changes. These classes of facilities are deserving of special attention due to their extreme similarity to Phase I industrial activities. For the purposes of discussion and analysis in this report, these facilities have been classified as Group A.

To clearly identify Phase II facilities that fall within the SIC range 10-45, a list of unregulated activities related to Phase I sources in each of the 11 industrial categories was developed. This list appears in Table 4-3. The similarity of many of the facilities on this list to Phase I facilities makes them difficult to distinguish from Phase I facilities for the purposes of the analyses in this report. In order to help characterize these sources, they have been categorized below according to three main criteria. The three groups identified together make up Group A. Although these groups do not encompass every one of the possible exceptions presented in Table 4-3, they represent the majority of facilities in SIC codes 10-45 that were not addressed under Phase I.

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Table 4-3. Categories of Activities *Not* Regulated Under Phase I

Category	Activities and Facilities
i	• Facilities that were not considered for inclusion in the effluent guideline formulations
ii	• Offsite warehouses (unless auxiliary to a regulated facility) • Offsite salt storage piles • Chemical distributors that conduct incidental mixing and blending of products • Distributors of farm products and equipment with mixing and blending of fertilizers (not SIC 2875)
iii	• Pipelines • Petroleum product distribution, including SIC 49
iv	• Hazardous waste generation/storage sites subject to certain RCRA Subtitle C requirements but not permitting
v	• Landfills that have not received or do not receive industrial waste (Municipal Solid Waste Landfills (MSWLFs)) • Solid waste transfer stations with no vehicle maintenance or that are owned or operated by the entity that owns the final disposal site • Land application of sewage treatment plant effluent (exempted from RCRA requirements) • Incinerators (BIFs and municipal incinerators) (hazardous waste incinerators are permitted under RCRA Subtitle C and therefore are regulated under Phase I) • Temporary offsite waste storage sites
vi	• Interim recycling facilities (collection sites, satellite storage sites)
vi	• Facilities that generate electricity, but do not use steam electric generation
viii	• General equipment and vehicle storage/maintenance yards (municipal fire trucks, police cars, park maintenance; construction equipment yards) • Vehicle maintenance of garbage collection trucks owned by landfill operator • SIC 40-45 facilities without vehicle maintenance • Material handling/storage areas at SIC 40-45 facilities • School bus maintenance facilities owned or operated by school districts • Mining related equipment maintenance • Warehouses under SIC 4226 that do not have vehicle maintenance • Petroleum product wholesalers (SIC 5172) and bulk stations (SIC 5171) without vehicle maintenance
ix	• Treatment works with design flows less that 1 MGD (Transportation Act of 1991 exempted POTWs owned or operated by municipalities with population of less than 100,000) • Off-site non-domestic sewage treatment plants and sludge drying beds • Portable sanitary and septage service facilities • Water treatment plants
x	• Construction operations that result in the disturbance of less that five acres of total land area are under review due to the court opinion in *Natural Resources Defense Council* v. *EPA*, 966 F.2d 1292 (9th Cir. 1992)
xi	• Facilities where there is no exposure of material are under review due to the court opinion on *Natural Resources Defense Council* v. *EPA*, 966 F. 2d 1292 (9th Cir. 1992)

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- **Auxiliary Facilities or Secondary Activities**—SIC codes are assigned on the basis of the primary activity from a financial standpoint that is taking place at a particular facility. Facilities with industrial activities that are in support of, or auxiliary to, a non-regulated activity would not be covered under Phase I. Examples include maintenance of construction equipment and vehicles and local trucking for an unregulated facility (grocery stores etc.).

- **Facilities Intentionally Omitted from Phase I**—Another class of facilities which are not addressed under Phase I are those that are related to, but were intentionally omitted from, one of the 11 industrial categories. For example, category ix does not cover treatment works with a design flow of less than 1 MGD, and category v does not address landfills that have not received industrial waste. While these activities may be slightly different from Phase I activities in size, scope, or specific materials present, there are many similarities which may make these facilities a potential concern in Phase II.

- **Facilities Exempted by the Transportation Act**—The Intermodal Surface Transportation Efficiency Act of 1991 (Transportation Act) exempted most industrial activities owned or operated by municipalities of less than 100,000 people from permit coverage under Phase I.[7] This exemption applies to approximately 19,000 incorporated places and 17,000 minor civil divisions in over 3000 counties. It is important to note that these activities are identical to Phase I facilities and are not located in municipalities which are covered under Phase I.

The overlap in SIC code assignments between Group A facilities and Phase I regulated activities make accurate estimation of the number of facilities in Group A very difficult. The estimates used are based on a process of elimination. Beginning with the total number of facilities in SIC codes 10-45 and subtracting the number of facilities accounted for under Phase I gives approximately 100,000 to 200,000 facilities. This is roughly equivalent to the size of Phase I. The difficulty in distinguishing these facilities from their closely related Phase I analogues also makes the geographic analysis conducted in section 4.2 difficult. Although the analysis has been conducted on a general basis for the entire group, this will only yield an overall approximation. Sub-classes of facilities within this group may be

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[7] The Transportation Act exempted industrial activities owned or operated by municipalities of less than 100,000 population from Phase I permitting requirements with the exception of powerplants, airports, and uncontrolled sanitary landfills.

distributed quite differently. For information on the distribution of specific two-digit SIC codes within group A, see Appendix G.

Group B Sources

Based on the regulatory review and analysis of the types of industrial sources not covered under Phase I (discussed previously), several categories of facilities that are inherently similar or related to Phase I sources, but that fall into SIC code categories outside of SIC codes 10-45, were identified. A number of criteria were used to develop a comprehensive list of facilities which should be considered for inclusion in Phase II. This list constitutes Group B.

The first criteria used to identify Group B facilities were activities with industrial components or closely related activities. The main categories identified include:

- **Transportation Activities and Services**—SIC series 478x, which are similar to those identified in Category viii of the Phase I definition (see Table 4-2)
- **Energy Producers and Distributors**—Similar to Categories iii and vii, including pipelines (SIC 461x) and petroleum producers (SIC 4925)
- **Other Utilities**—Water supply, irrigation, and sanitation services that may often be municipally operated (SICs 494x, 495x, and 497x), which are related to Category ix
- **Municipal or Governmental Activities or Services**—In the 922x series that may have industrial components (Category ii) or activities related to transportation or vehicle maintenance (Category viii) (e.g., police stations, jails, and fire stations).

The next criterion used was commercial facilities with industrial components or similar operations. Commercial facilities were specifically excluded from Phase I by congressional intent. However, officials engaged in controlling urban runoff and nonpoint source pollution at the local, State, and national level believe that many commercial sources represent an important environmental concern. These concerns are documented in State and local nonpoint source programs, urban runoff programs, and estuary programs identified through the literature review. The Rensselaerville Study (1992) reflected potential areas of concern by identifying "gas, auto, service stations, transportation related activities, highway systems, land development, agricultural sources and related activities, commercial activities with industrial components, and large retail complexes."[8] Taking a broad view of these descriptions, facilities were identified in two main categories. The first category comprises commercial or retail establishments with industrial components or activities:

- Many types of establishments that provide automotive or transportation services, including car dealers and gas/service stations (SICs in the 55xx series) and other automobile-related services and maintenance with SIC codes from 751x to 754x, such as truck and car renters, various types of repair and body shops, parking structures, and car washes

- Commercial enterprises involved in fuel wholesaling and distribution, such as gas and petroleum storage and distribution (SICs 493x and 517x) and fuel oil and coal dealers (SIC 598x)

- Commercial or wholesale enterprises with manufacturing or assembly activities, mainly in the 50xx and 52xx series

- Commercial or wholesale facilities that include food processors or wholesalers that may have organic wastes (SIC 514x), photographic studios (SIC 7221) and photo finishing labs (SIC 7384), small repair shops that may have metal wastes (SIC 769x), including repair of communications devices, refrigeration units, other electrical or electronic devices, and welding; research and testing laboratories (SIC 873x) and laundries (SIC 721x)

- National security entities (SIC 9711); although industrial activities at military facilities are regulated in Phase I, potential Phase II activities may be located on these sites as well and would not show up individually in the analysis that follows.

The second category consists of commercial or retail facilities and other sources that are similar or related to agricultural activities or sources and includes:

[8] No SIC codes specifically identify all large retail complexes. However, these are partially addressed through the loading analysis of storm water from urban/urbanized areas in the municipal section (Chapter 3). If such items were to be addressed in a regulatory framework, it would likely be on the basis of a narrative description rather than a SIC designation.

- Agriculture-related operations in the SIC groups 021x and 025x because they may represent confined animal facilities or feedlots.[9] Wholesale livestock facilities (SIC 5154) were also included under this criterion as were animal husbandry operations aside from general farms, such as zoos (SIC 8422), racetracks and stables (SIC 7948), which may have operations that are similar to feedlots.

- Because of potential for use of pesticides and fertilizers, the following were included: nurseries and lawn and garden facilities (SIC 078x) and other facilities that may store, mix, or use agricultural chemicals or other pesticides, such as farm products and raw materials sellers (SIC 5159), wholesalers of chemicals and allied products (SIC 5169), farm suppliers (SIC 5191), lawn and garden suppliers (SIC 5261), and exterminators (SIC 7342).

- Other facilities that may use pesticides or fertilizers in substantial quantities, such as golf courses and other recreational establishments with large lawns (SIC 799x) and colleges and schools (SIC 822x), which may have lawns, gardens, nurseries, or experimental agricultural areas. (These may also operate power plants or treatment works or engage in other activities similar to regulated industrial categories.)

From the 12 categories of Group B Phase II sources identified above, the universe of facilities was screened to identify a specific subset for further analysis. Through this selection process, potential Phase II facilities were identified, including those associated with products or waste materials that contain pollutants, such as metals, pesticides, and nutrients, and those associated with processes, practices, or events that can lead to the discharge of those pollutants into storm water. The SIC manual identifies 83 major groups of SIC codes in 10 major divisions (identified in Table 4-1). These major groups are divided into 1,047 four-digit categories. Of these, 604 fall into Phase I regulated activities or closely related facilities which make up Group A (SIC 10-45). Of the 443 that remain in agricultural, commercial, and retail divisions, 168 fall into the excluded service sectors. Of the remaining 275 categories, the screening process and the 12 categories identified above correspond to 90 individual categories of facilities and activities for further study as potential Phase II sources.

[9] See footnote 4 regarding feedlots currently regulated under the NPDES program.

This subset of 90 four-digit SIC codes is listed in Table 4-4. More than a million facilities were identified for these SIC categories by searching EPA's Facility and Company Tracking System (FACTS) data base.[10]

To facilitate analysis, some additional grouping is necessary. These 90 individual categories could be grouped together based on the 12 criteria used to identify them. However, some of the criteria group together dissimilar activities. For example, "commercial wholesalers" include four dissimilar categories: wood, ore, metal, and machinery wholesalers. Based on these distinctions, the 12 groups were further subdivided, forming 18 potential Phase II sectors. The 18 sectors are listed in Table 4-5. The affiliation of each specific SIC code with a sector is shown in Table 4-4, along with the numbers of facilities in that SIC code. This grouping into sectors facilitates discussion of similarities and differences among categories later in the chapter.

The data on numbers of facilities in Table 4-4 reveal some interesting facts about individual categories. Of the 18 Group B sectors, the automobile service sector (comprised of gas/service stations (SIC 5541), general automobile repair (SIC 7538), top, body repair (SIC 7532), repair shops and services (SIC 7699), car dealers, new & used (SIC 5511), car dealers, used only (SIC 5521), car washes (SIC 7542), passenger car rental (SIC 7514), truck rental (SIC 7513), parking structures (SIC 7521), and miscellaneous auto services (SIC 7549)) make up more than one-third of the total number of facilities identified in all 18 sectors.

Table 4-5 also shows facility counts for the 18 Group B sectors, illustrating even more clearly the dominant categories. Facilities engaged in automotive service and vehicle maintenance are far more numerous than other groups of potential Phase II sources. Machinery and electrical repair facilities are the second largest group, and intensive users of agricultural chemicals, including lawn and garden establishments and nurseries, are the third largest group.

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[10] As discussed in Chapter 2, the FACTS data base is leased by EPA from Dun & Bradstreet Information Services, which created, maintains, and annually updates information based on a variety of sources.

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Table 4-4. SIC Codes Selected for Study Based on Screening Procedure

SIC Code	Description Selected (90) 4-Digit Code	Number of Facilities	Phase II* Sector
5541	Gas/Service Stations	91,924	Automotive Service
7538	General Auto Repair	87,994	Automotive Service
7699	Repair Shops & Related Svcs., NEC	70,095	Machinery & Electrical Repair
7532	Top, Body Repair	48,800	Automotive Service
5084	Industrial Mach. & Equipment	38,880	Wholesale, Machinery
5511	Car Dealers, New & Used	37,387	Automotive Service
0782	Lawn & Garden Services	36,369	Intensive Ag. Chemical Use
5211	Lumber & Bldg. Materials	34,757	Wholesale, Wood Products
5521	Car Dealers, Used Only	32,145	Automotive Service
7539	Specialized Repair	26,381	Automotive Service
7216	Dry Cleaning	22,042	Laundries
7622	Radio and Television Repair	20,527	Machinery & Electrical Repair
5191	Farm Supplies	20,189	Intensive Ag. Chemical Use
7221	Photographic Studios	20,010	Photographic Activities
9629	Electrical Repair Shops, NEC	19,448	Machinery & Electrical Repair
5261	Lawn & Garden Supply	19,443	Intensive Ag. Chemical Use
5085	Industrial Supplies	17,869	Wholesale, Machinery
0212	Beef Cattle, not Feedlots	14,684	Livestock, Feedlots
7692	Welding Repair	14,305	Machinery & Electrical Repair
5031	Lumber, Millwork	13,836	Wholesale, Wood Products
5083	Farm Mach. & Equip.	13,670	Wholesale, Machinery
7217	Carpet Cleaners	13,636	Laundries
7549	Misc. Automotive Services	13,571	Automotive Service
7542	Car Washes	12,842	Automotive Service
7342	Disinfect/Exterminating	12,359	Intensive Ag. Chemical Use
4731	Arrangement Freight Trans.	12,303	Transport, Rail and Other
0241	Dairy Farms	12,298	Livestock, Feedlots
5172	Petroleum Products/Dist.	11,128	Petrol. Pipelines & Distributors
0181	Ornamental Nurseries	11,019	Intensive Ag. Chemical Use
4953	Refuse Systems	10,797	Various Utilities
7384	Photo Finishing Labs	10,674	Photographic Activities
5169	Chem & Allied Prod, NEC	10,355	Intensive Ag. Chemical Use
5051	Metal Service Centers	10,267	Wholesale, Metal Products
7623	Refrig. & Air Condition. Repair	8,504	Machinery & Electrical Repair
5171	Petroleum, Bulk	8,086	Petrol. Pipelines & Distributors
7514	Passenger Car Rental	7,939	Automotive Service
7513	Truck Rental	7,799	Automotive Service
7212	Garment Cleaners	7,280	Laundries
0783	Shrub & Tree Services	7,260	Intensive Ag. Chemical Use
5983	Fuel Oil Dealers	7,233	Petrol. Pipelines & Distributors
5082	Constr. & Min. Mach.	7,143	Wholesale, Machinery
8221	Colleges and Universities	6,829	Extensive Ag. Chemical Use
8731	Comm. Research Labs	6,382	Laboratories
5984	Fuel and Coal Dealers	6,226	Petrol. Pipelines & Distributors
5147	Meat & Products	5,298	Wholesale, Food
4941	Water Supply	4,904	Various Utilities

Table 4-4. SIC Codes Selected for Study Based on Screening Procedure (continued)

SIC Code	Description Selected (90) 4-Digit Code	Number of Facilities	Phase II* Sector
8249	Vocational Schools	4,647	Extensive Ag. Chemical Use
5146	Fish & Seafoods	4,579	Wholesale, Food
7219	Laundry Services	4,575	Laundries
5154	Livestock	4,351	Livestock, Feedlots
0213	Hogs	4,328	Livestock, Feedlots
8734	Testing Laboratories	4,301	Laboratories
7992	Golf Courses, Public	4,295	Extensive Ag. Chemical Use
5039	Construct Materials	4,036	Wholesale, Metal Products
9511	Air, H_2O & Solid Waste Mgmt.	3,688	Various Utilities
7521	Parking Structures	3,088	Automotive Service
0211	Beef Cattle Feedlots	2,972	Intensive Ag. Chemical Use
7211	Laundries	2,940	Laundries
7694	Armature Rewinding Shops	2,865	Machinery & Electrical Repair
9221	Police Protection	2,508	Munic. Services, Vehicle Maint.
9711	National Security	2,414	National Security
7948	Race Tracks/Stables	2,271	Livestock, Feedlots
5159	Farm Prods. Raw Mats	1,895	Intensive Ag. Chemical Use
4959	Sanitary Svcs., NEC	1,894	Various Utilities
8222	Junior Colleges	1,850	Extensive Ag. Chemical Use
9223	Jails	1,714	Munic. Services, Vehicle Maint.
5144	Poultry & Products	1,495	Wholesale, Food
5052	Coal/Minerals & Ores Wholesale	1,384	Wholesale, Coal & Ores
7996	Amusement Parks	1,371	Extensive Ag. Chemical Use
0252	Chicken Eggs	1,171	Livestock, Feedlots
0219	General Livestock, not Dairy	1,160	Livestock, Feedlots
4783	Packing and Crating	1,099	Transport, Rail and Other
5989	Fuel Oil Dealers, NEC	1,075	Petrol. Pipelines & Distributors
0251	Broiler, Fryer, Roaster Chicken	941	Livestock, Feedlots
7218	Ind. Launderers	903	Laundries
4789	Transport Services, NEC	899	Transport, Rail and Other
0254	Poultry Hatcheries	719	Livestock, Feedlots
4971	Irrigation System	662	Various Utilities
0214	Sheep and Goats	618	Livestock, Feedlots
4925	Gas Producers, Distributors	604	Petrol. Pipelines & Distributors
0273	Animal Aquaculture	595	Livestock, Feedlots
4612	Crude Petroleum Pipelines	390	Petrol. Pipelines & Distributors
9229	Fire Protection	389	Munic. Services, Vehicle Maint.
4613	Refined Petroleum Pipelines	347	Petrol. Pipelines & Distributors
4785	Weighing: Vehicle Trans.	332	Transport, Rail and Other
4939	Utilities, NEC	297	Various Utilities
8422	Botanical Gardens & Zoos	285	Livestock, Feedlots
4932	Gas & Service	212	Petrol. Pipelines & Distributors
4741	Rental of Railroad Cars	175	Transport, Rail & Other
4619	Pipelines, NEC	18	Petrol. Pipelines & Distributors
	TOTAL	1,015,239	

*Phase II sector is a grouping devised to facilitate discussion of similar facilities. The sectors are further described in the text and summarized in Table 4-5.

Table 4-5. Summary of Group B Phase II Sectors

Description of Phase II Sectors	No. of Facilities
Automotive Service	369,870
Machinery & Electrical Repair	135,744
Intensive Ag. Chemical Use (a)	121,861
Wholesale, Machinery	77,562
Laundries	51,376
Wholesale, Wood Products	48,593
Livestock, Feedlots	43,421
Petroleum Pipelines & Distributors	35,319
Photographic Activities	30,684
Various Utilities	22,242
Extensive Ag. Chemical Use (b)	18,992
Transport, Rail and other	14,808
Wholesale, Metal Products	14,303
Wholesale, Food	11,372
Laboratories	10,683
National Security	4,611
Municipal Services, Vehicle Maint.	2,414
Wholesale, Coal & Ores	1,384
Total	1,015,239

(a) e.g., nurseries, farm chemical suppliers & distributors
(b) e.g., large lawns, golf courses

Remaining Phase II Activities

The identification of all Phase I facilities together with facilities in Groups A and B only account for approximately 1.5 million of the estimated 7.7 million total facilities. This leaves over 6 million facilities "unaccounted for" in this analysis. These remaining facilities include a wide range of activities which fall into a number of general classifications.

General Sources—Widespread sources of potential storm water contamination which are not necessarily associated with any one particular activity are a large category of sources not addressed in this analysis. These include parking lots, trash dumpsters, leaking and failing septic systems, and activities related to individual residences such as fertilizer and pesticide application. The tremendous number of these sources would make individual permitting virtually impossible. Although the identification and analysis of individual Phase II sources does not focus on these sources, the municipal analysis does account for pollutant loadings from these types of sources which are related to the general process of urbanization.

Service Sectors—Major SIC groups in the service sectors, such as banking, finance, insurance firms, and all types of food services were not considered to be potential Phase II sources. The activities of these enterprises are generally conducted indoors and do not inherently use or produce contaminants that may enter storm water. However, these facilities may also have some of the general sources of storm water contamination discussed above, such as parking lots or trash dumpsters. All of the major SIC groups excluded on this basis are listed in Table 4-6. Although the analysis of this report does not focus on service sector facilities in detail at the four-digit SIC level, the geographic and distributional analysis was conducted for these facilities at the major group (two-digit SIC) level. These results are presented in Appendix G.

4.2 NATURE AND EXTENT OF POLLUTANTS ASSOCIATED WITH INDIVIDUAL PHASE II SOURCES

This section responds to the second congressional mandate in CWA Section 402(p)(5): to determine the nature and extent of pollutants in storm water discharges to the maximum extent practicable. EPA developed quantitative and qualitative information on the types of activities or materials associated with potential Phase II sources and their locations relative to various geographic jurisdictions.[11]

The nature of storm water discharges from industrial and commercial sources was addressed in two ways. First, sampling data on quality of runoff from Phase I industrial sources were analyzed and summarized to provide a basis of comparison for potential Phase II sources. The data submitted with group permit applications are among the most comprehensive sources of data on pollutant concentrations in industrial runoff. Second, descriptive information on the potential for storm water discharges from industrial and commercial activities was identified and summarized. This was based on the literature review, inference from descriptions of the activities associated with industrial and

[11] As discussed in Chapter 2, EPA was not able to identify adequate data to support the calculation of pollutant loadings on a national scale.

Table 4-6. SICs Not Considered as Potential Phase II Sectors

Transportation and Public Utilities Sector:	
SIC 48	Communication Facilities
Retail Trade Sector:	
SIC 53	General Merchandise Stores
54	Food Stores
56	Apparel and Accessory Stores
57	Home Furniture, Furnishings and Equipment Stores
58	Eating and Drinking Places
Finance, Insurance, and Real Estate Sector all facilities:	
SIC 60	Banking
61	Credit Agencies
62	Security Brokers
63	Insurance Carriers
64	Insurance agents
65	Real Estate
67	Investment Offices
Services Sector:	
SIC 70	Hotels and Lodging Places
78	Motion Pictures
Health Services Sector:	
SIC 80	Doctors' Offices and Medical Clinics
81	Legal Services
83	Social Services
86	Membership Organizations
88	Private Households with Employees
Public Administration Sector:	
SIC 91	General Government, Except Finance
93	Public Finance and Taxation
94	Administration of Human Resource Programs
96	Administration of Economic Programs

Source: OMB, 1987

commercial facilities, the documented experiences of municipalities operating storm water management programs, and EPA's experience in assisting the regulated community in meeting group application requirements under Phase I of the regulatory program.

Determining the extent of pollutants was addressed by identifying the geographic distribution of the sources that may contribute pollutants to storm water. Through a locational analysis, categories of facilities were analyzed to determine to what extent they are located in various sizes of cities, urban areas, and other political jurisdictions. This quantitative assessment of location is informative and useful for certain policy discussions but does not establish the presence of pollutants in storm water for any potential Phase II sources.

4.2.1 Nature of Pollutants Associated With Individual Phase II Sources

This section presents information on pollutants and activities associated with industrial, commercial, and retail categories that may contribute to storm water contamination.

4.2.1.1 Phase I Industrial Group Applicant (Part II) Data

Phase I Industrial Group Applicant (Part II) Data provides a basis for identifying the areas and activities that may be of concern when associated with nonregulated categories of facilities. This section presents analyses of storm water runoff quality data from Phase I (industrial) permit applicants. As part of the permitting process, 44,000 Phase I group applicants in 700 groups were organized into 29 sectors based on general similarity for purposes of writing a multisector general permit.[12] Part II of the permit application required approximately 10 percent of the members of each group to submit sampling results for pollutants in storm water discharges, including conventional, nutrients, and other toxic pollutants that might be present. Table 4-7 summarizes these results by reporting the composite sample mean concentration for each sector for nine of the basic pollutants studied in NURP plus oil and grease. Although the sources and methods of data collection differ, this industrial sector concentration data can be compared with summary data from NURP or USGS to provide some insight into storm water runoff quality. Comparisons can also be made among sectors to determine which are more likely to discharge higher concentrations of certain classes of pollutants. Appendix E provides a comprehensive summary of the industry sectors and sampling data from the group application process.

[12] The sectors were designed to group similar facilities together. Facilities were separated into 31 sectors for analysis of the Part II Group Application data for this report. Only 29 sector permits were developed in the multi-sector general permit. After some groups were combined, and others withdrew, only 700 groups representing 44,000 facilities remained from approximately 60,000 which began the group application process.

Table 4-7. Summary of Sampling Data from Phase I Group Permit Applications (with comparison to NURP and USGS studies[1])

		Pollutant Composite Mean (mg/l)									
		Conventionals				Nutrients			Metals		
Sector	Description	BOD5	COD	TSS	O&G	NO2+3	TKN	P	Copper	Lead	Zinc
NURP	Median Urban Site *	12	82	180	NR	0.86	1.90	0.42	0.04	0.18	0.20
USGS	Commercial Site *	16	NR	248	NR	0.38	NR	0.31	0.03	0.22	0.31
01	Lumber & Wood Products	45.37	242.50	575	2.54	0.75	2.32	6.29	0.05		0.36
02	Paper & Allied Prod.	24.25	133.90	44		0.76	3.17	0.36	0.03	0.03	0.78
03	Chemicals & Allied Products	11.74	77.24	94	0.19	4.29	17.75	9.51	0.12	0.02	1.74
04	Petrol Refining & Related Ind.	10.87	86.93	165	0.00	0.82	1.63	0.28			
05	Stone, Clay, Glass Products	7.32	77.53	386	1.55	1.40	2.37	0.87	0.16	0.25	0.39
06	Primary Metal Ind.	34.08	109.84	162	2.97	1.38	3.00	0.52	2.25	0.19	6.55
07	Metal Mining	10.63	195.07	623		0.90	3.39	1.06	0.59	6.07	3.87
08	Coal & Lignite Mining	6.55	26.86	690		1.00	2.65	0.12	0.00		0.06
09	Oil & Gas Extraction	10.59	115.94	413	2.14	0.60	1.69	3.41			
10	Nonmetallic Mineral Mining	6.89	66.20	1576	0.00	1.27	2.41	1.13	0.01		0.29
11	Hazardous Waste TSDFs	9.44	51.93	83		0.39	1.07	0.11			
12	Industrial Landfills & Dumps	9.04	102.02	1850		1.38	3.03	0.95		20.64	
13	Used Motor Vehicle Parts	11.77	66.23	839		1.62	2.27	2.23		0.88	
14	Scrap & Waste Materials	24.00	203.71	376	1.06	5.88	3.38	0.77	0.63	0.02	3.35
15	Steam Electric Power Plants	5.69	69.47	212	2.90	0.75	1.95	0.63	0.03		0.37
16	Railroad Transport	9.27	189.46	249		1.41	2.48	0.92		0.01	0.28
17	Transport: Trucks, Freight, etc.	11.07	85.64	454	5.28	1.99	2.04	0.73	0.02	0.05	1.34
18	Water Transport	6.00	75.79	224		0.66	9.41	0.15		0.09	0.42
19	Ship & Boat Building, Repair	6.27	69.96	45		0.82	2.20	0.86	0.08		0.33
20	Air Transport	21.34	75.63	80	6.36	1.29	16.00	0.29	0.01	0.01	0.35
22	Wastewater Treatment	46.11	187.09	114	2.96	20.50	4.74	0.68	0.05	0.01	0.12
23	Food, Tobacco Manufact.	42.54	141.65	200	5.03	0.98	4.07	1.32	0.05	0.04	0.79
24	Textile & Apparel Manufact.	9.82	48.05	80		1.14	1.92	0.31	0.07	0.01	0.30
25	Furniture & Fixtures	8.80	76.33	143		1.51	4.40	0.26	0.00		0.59
26	Printing & Publish.	6.95	42.37	31		1.35	1.57	0.35	0.02	0.01	0.47
27	Rubber & Plastic Prods.	11.21	72.08	119	1.56	1.26	1.63	0.34	0.03	0.02	0.80
28	Leather/Products	22.32	91.94	115	0.00	1.88	6.22	0.83		0.06	
29	Fabricated Metal Prod., Jewelry	10.04	86.17	125	6.83	1.27	1.78	0.84	0.46	0.22	2.17
30	Ind. & Comm & Transport Equip.	7.32	46.09	97	0.00	1.28	1.76	0.39	0.08	0.01	0.42
31	Electronic Equip & Instruments	7.48	36.32	67	3.40	0.66	1.34	1.02	0.01	0.14	0.15
33	Military Indust. Activities	16.51	54.50	126	3.68	0.88	1.28	7.12	0.17		0.68

*Recently, concerns have been raised regarding the validity and use of historical data for metals. As discussed in chapter 2, EPA believes that historical data on storm water runoff from NURP and USGS are suitable for the purposes of this report.

Although it focuses on Phase I sources rather than Phase II, this analysis is an important contribution to the literature and this report because it may be the most comprehensive data available on sector-specific industrial discharges. This information can assist EPA and States in evaluating and targeting Phase II sources, at least those that may be similar to Phase I sources. The information can also be used to compare with other sources of information and to give some perspective on which Phase II sectors are of most concern (to the extent they are similar to Phase I activities). This exercise also demonstrates the usefulness of the data collection effort involved in the group application process. These summary data can also provide a baseline from which to measure future improvements in runoff quality and a basis for developing measurable indicators for performance evaluation of State, local, or industrial programs in the future.

An understanding of the group application sampling data is necessary. EPA approved facilities chosen for sampling within a group (ranging from 50 percent of small groups to 10 percent of large groups but no more than 100 facilities per group) only if they were representative, based on industrial activity, significant materials exposed, and geographic distribution. All data received from samplers were checked and double key punched and verified during entry.[13] At the same time, it is important to understand that the facilities submitting sampling data were not randomly selected but rather were identified by the group applicants. These facilities also chose the sampling locations at their sites and conducted monitoring in accordance with EPA guidance on the selection of suitable locations, storm events, and methodology.

In addition to the Phase I permit application data, historical data from past studies can provide some perspective on the nature of storm water from regulated and unregulated sources. Historical data on storm water quality from various types of sites from NURP and USGS were presented in Chapter 2. These data were collected from general urban, commercial, or industrial areas, not from specific industrial facilities. However, these data do provide useful historical reference points. In particular, the mean and median for the NURP urban site and USGS commercial sites were chosen for comparison with the new industry-specific data from permit applications. These levels provide a reference point based on past studies of the nature of storm water discharges. The pollutant concentrations observed in the NURP study should not be considered to be "acceptable" or normal levels of storm water contamination.

[13] Only those applications received before January 1993 are included in the data base used in this analysis.

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Permit application data were analyzed for 11 pollutants, including 9 pollutants studied in NURP—biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), nitrate plus nitrite nitrogen, total Kjeldahl nitrogen (TKN), total phosphorus, copper, lead, and zinc—plus oil and grease and pH. As discussed, Table 4-7 reports summary results for the composite mean from the permit application data for 31 Phase I sectors. Appendix F gives more detailed results for each pollutant and each industrial sector, including the mean, median, and 95th percentile, as well as the number of samples taken. To provide a basis for comparing across industrial categories, the mean of the composite sample results was chosen as an indicator of average storm water quality. Composite samples are preferable to grab samples for comparing average runoff conditions because grab sample results (also reported in the tables) may represent pollutant spikes, rather than more long term average storm conditions. The following paragraphs review these results.

Conventionals

Among the conventional pollutants, total suspended solids appears to be the pollutant with highest concentration. Half of the Phase I industrial sectors had concentrations higher than NURP and average results in the hundreds of parts per million are common. Composite mean concentrations were over 1,500 mg/l for mineral mining and for landfills. These data confirm the result in NURP and other literature that sediment is an important component of storm water runoff. It should be noted that sediments can also carry additional pollutants, such as metals and organics. As reported on Table 4-7, COD results for the composite mean are higher than NURP in about half of the sectors (14 sectors out of 31). The highest reported composite mean value for COD was 242 mg/l and five sectors had concentrations greater than 150 mg/l, including lumber and wood products, scrap and waste materials, metal mining, railroad transport, and wastewater treatment. All sectors had concentrations higher than the average of commercial sites found in USGS studies. Results for BOD indicate that average runoff quality is not appreciably higher than the secondary treatment standard for POTWs of 30 mg/l. Although 10 sectors have higher levels of BOD than reported in NURP and USGS, the highest composite mean value for BOD was 46 mg/l. Most results for pH (reported in Appendix F) are in the range of 6.8 to 8.5, indicating that acidity or alkalinity is not the greatest concern associated with runoff from these industrial sites. For oil and grease, composite results are highly variable, and neither NURP nor USGS provides a baseline for comparison. The highest concentrations, over 5 mg/l, are engaged in industrial sectors associated with transportation and vehicle and machinery maintenance, as might be expected.

Nutrients

Overall, storm water discharges from industrial sites do not appear to be contributing high concentrations of nutrients. Results reported in Table 4-7 indicate that concentrations for TKN exceed NURP results in 22 cases, including wastewater treatment plants, chemical manufacturers, scrap yards, mining sectors, transportation sectors, and leather manufacturers. However, most of the results were in the range of 2 to 5 mg/l. Concentrations (for the composite mean) over 16 mg/l were reported for the chemical and allied products sector and the air transport sector. Concentrations of nitrogen in the form of nitrates and nitrites for the industrial sites represented in the permit application data are generally in the range of 0.8 to 2.0 mg/l, but there are some important exceptions. The highest concentrations for the composite mean occurred in the wastewater treatment sector (20.5 mg/l) and the scrap and waste materials sector (5.9 mg/l). Phosphorus results also do not show generally high concentrations; only nine sectors had composite mean results over 1 mg/l. The highest concentrations occurred for chemical and allied products manufacturers (9.5 mg/l), military facilities (7.1 mg/l), lumber and wood products manufacturers (6.3 mg/l), and oil extractors (3.4 mg/l). In summary, nutrient concentrations exhibit a mixed pattern across industrial groups, with some very low and very high results. Results for the two forms of nitrogen and for phosphorus indicate that storm water discharges of nutrients tend to be site- and pollutant-specific. That is, discharge of one form of nutrient does not in general indicate that other forms are present or suspect, although the chemical and allied products sector is associated with all three.

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<u>Metals</u>

Because sampling for metals proceeded on the basis of whether individual facilities had reason to believe they were present in their discharge, not all sectors reported results for metals. Again, referring to Table 4-7, results for copper show that 13 sectors had composite mean concentrations higher than NURP. The highest of these included the primary metals sector (2.25 mg/l) and scrap and waste materials (0.63 mg/l). Eight sectors reported no sampling results for copper. For lead, the table shows that the majority of sectors (15 out of 23) had concentrations below the mean value reported in NURP (0.18 mg/l). However, two of those with higher concentrations had extremely high values: the highest concentrations of lead found in industrial runoff were associated with industrial landfills and dumps (20.6 mg/l) and metal mining (6.1 mg/l). The next highest values came from the scrap and waste materials sector (.88 mg/l) and the stone, clay, and glass products sector (.25 mg/l). Results for zinc show that most of the sectors (22 of 25) had composite mean concentrations higher than the 0.20 mg/l value reported in NURP for general urban runoff. Nineteen sectors had concentrations higher than the 0.31 mg/l value reported in USGS studies for commercial sites. The highest concentrations found were associated with the primary metals (6.6 mg/l), metal mining (3.9 mg/l), and scrap and waste materials (3.6 mg/l) sectors. Six sectors did not report results for zinc. In summary, higher concentrations of metals tended to be associated with the primary metals sector, metal mining, industrial landfills, scrapyards, and metal fabricators.

4.2.1.2 Qualitative Assessment of Potential Phase II Categories

The sampling data presented previously were used to assist in understanding the nature of storm water discharges in Phase II sectors. To facilitate comparison of potential Phase II sources with the sampling results reported above, where possible, categories of Phase II sources were compared to similar Phase I sectors. These comparisons were made qualitatively and are not meant to suggest that the sectors conduct exactly the same activities or operations. Similarities were identified for 12 of the 18 Phase II sectors, as summarized in Table 4-8. The remaining categories of potential Phase II sources were generally not

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classifiable based on similarities to Phase I sources. Using this correspondence to Phase I and information from the literature review, a summary table was developed showing the potential pollutants associated with each of the potential Phase II sectors. For some sectors, permit application data were used as the basis for determining which pollutants could be present. For other sectors, literature review information and other documents were used. This information is summarized in Table 4-8, which can be used as a guide to the possible presence of pollutants at Phase II facilities. This does not indicate that the pollutants will be found in substantial quantities or that water quality will be impaired. In particular, pollutants are associated with categories similar to Phase I facilities based on the fact that the Phase I sector had among the highest (top ten) concentrations of that pollutant. Thus, it is based on a relative ranking: an industrial category may be among the highest, even when overall concentrations are not very high.

Based on the literature review, assessments of SIC descriptions, the selection criteria outlined above, and the pollutant data summarized in Table 4-8, information about the 18 potential Phase II categories can be summarized into several major groups. The first major group includes facilities with activities similar to those regulated under Phase I, even though they may be small commercial or retail establishments, rather than industrial ones. This class includes about 80 percent of the potential Phase II sources. One of the chief activities of concern in this group is vehicle maintenance and related transport, storage, and machine repair activities. Other activities conducted at these facilities that are substantially similar to those already regulated include loading and unloading operations, which include pumping of gases or liquids, pneumatic transfer of dry materials, or transfer of containers to or from vehicles; outdoor storage, including storage of fuels, raw materials, byproducts, intermediates, final products, and process residuals or wastes; and other outdoor activities and land disturbing operations, such as small construction and landscape maintenance. The types of products or waste materials at facilities in this class could include a wide variety of materials that potentially contribute pollutants to storm water runoff. Although discharges could include the whole range of pollutants, these sources may be more likely to contribute

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Table 4-8. Correspondence Between Potential Phase II Sectors and Phase I Sectors and Potential Pollutants of Concern

Description	Rank by # of Facilities	Corresp. to Phase I	Potential Pollutants of Concern						Pesticides & Toxics
			Conventionals			Nutrients		Metals	
Phase II "Sectors"		Sectors	B COD	TSS	O&G	N	P		
Automotive Service	369,870	17, 13		X	X	•	•	X	S
Machinery & Electrical Repair	135,744	31			X		•		
Intensive Ag. Chemical Use	121,861	NA	S	S		S	S		S
Wholesale, Machinery	77,562	30			S			X	
Laundries	51,376	NA	S			S	S		
Wholesale, Wood Products	48,493	1	X	X			•		
Livestock, Feedlots	43,421	NA	S	S		S	S		
Petrol. Pipelines & Distributors	35,319	9, Other				•	•	X	S
Photographic Activities	30,684	NA	S					S	S
Various Utilities	22,242	11, 12, 22	X	X	X	•		X	
Extensive Ag Chem Use	18,992	NA	S	S		S	S		S
Transport, Rail and Other	14,808	16	X	S	S	•		S	S
Wholesale, Metal Products	14,303	14	X		S	•		X	
Wholesale, Food	11,372	23	X	S	X	•	•	X	
Laboratories	10,683	NA	S						S
National Security	4,611	17, 29, 33		X	X	•		X	S
Munic. Services, Vehicle Maint.	2,414	17, 29	X	S	X		•	X	S
Wholesale, Coal & Ores	1,384	8		X			•		

X - Indicates similar Phase I sector ranked in top ten of all sectors for this pollutant class
S - Indicates pollutant is suspected, based on literature review and expert opinion
NA - Not applicable: No clear correspondence with Phase I Sectors
• - Overall, nutrient levels were not high in Phase I application data. This indicates that the pollutant was found in the top ten, but actual concentration levels were not high.
Blanks indicate that such pollutants are not pollutants of concern for the Phase II sectors.

toxics, in addition to conventionals and nutrients. Pollutants of concern include organic and inorganic chemicals; fuels, such as coal and oil; paints; metals; solvents; and oil and grease. Although not specifically addressed in this analysis, off-site storage and maintenance activities, which may be owned and operated by Phase I facilities but are not currently regulated, could also fall into this class.

The second major classification of facilities includes categories of industrial, commercial, or retail activities and businesses with discharges that may be similar to those from agricultural sources (which are exempt from NPDES regulation under the CWA). For example, smaller feedlots that are not currently regulated and large users of pesticides and fertilizers may be similar to agricultural discharges but are not specifically exempted by statute. This class of facilities includes more than 180,000 facilities or about 20 percent of

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those selected for study. This group includes lawn and garden services (SIC 0782), farm supplies (SIC 5191), and lawn and garden supply (SIC 5283), which are among the largest SIC groups selected for study (see Table 4-4). Fertilizers and pesticides from these facilities have the potential to contaminate storm water from activities such as land application, spills and leaks, rinsing of containers and trucks, and improper disposal. Thus, the pollutants of concern include conventionals, pesticides, and nutrients that are associated with uses of open space that superficially resemble agricultural uses, such as lawn and landscape care or commercial/retail production, transport, or storage of nursery products.

The third major class of potential Phase II sources includes categories of facilities with the potential to use or produce toxic substances but about which there is little information. Research and development laboratories and some kinds of governmental activity (such as justice and public order facilities, SIC 92xx) fall into this category. Some of these facilities may be administrative centers with little potential to discharge pollutants. Others, such as police and fire protection services, however, may include vehicle maintenance activities with potential for discharges similar to those described above. This group includes about 20,000 facilities, representing only about 2 percent of those chosen for study.

This section described the categories of facilities and evaluated the nature of potential pollutant discharges qualitatively based on similarity to Phase I sources and information from storm water literature. However, from a national perspective, little quantitative information exists on discharge quality from these potential Phase II sources.

The majority of Group A facilities are so similar to Phase I activities that data collected from Phase I permit application data may be used to evaluate their pollution potential. There are also a very few classes of unregulated facilities for which some data is already available. One category of facilities for which substantial information is currently available is feedlots. Although feedlots which meet the definition of Concentrated Animal Feeding Operation (CAFO) are currently subject to NPDES permitting requirements, many smaller feedlots do

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not meet the current regulatory definition of CAFO and hence are not subject to current NPDES regulations.[14]

The United States Department of Agriculture (USDA) has estimated that there are approximately 6,000 animal feeding operations with 1,000 or more animal units.[15] EPA's Permit Compliance System (PCS) data base indicates that, as of October of 1994, EPA and authorized States have individual permits covering 928 CAFOs and general permits covering at least another 2,130 facilities. The total number of NPDES permits for feedlots is significantly less than the approximately 6,000 facilities that have more than 1,000 animal units. The discrepancy between the number of facilities authorized to discharge by NPDES permits and the total number of feedlots over 1,000 animal units is believed to be due to a number of factors, including: (1) due to limited State and Federal resources, some feedlots that should have a permit have not been brought into the NPDES program; (2) some regulatory authorities misinterpret the Federal regulations for CAFOs and mistakenly exempt facilities that should have permits; and (3) permits are only required for facilities that discharge at times other than the event of a 25-year/24-hour storm. USDA estimates that there are approximately 378,000 animal feeding operations with less than 1,000 animal units but more than 20 animal units.

Animal feedlots contribute to a significant degree of water quality impairment. States report the scope and sources of water quality impairments under Sections 305(b) and 319 of the CWA. Information from these sources indicates that, nationally, feedlots cause 7 percent

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[14] As discussed in Chapter 1, CAFOs are defined as animal feeding operations that discharge to waters of the United States at times other than during events greater than a 25-year, 24-hour storm and that: (1) have more than 1,000 animal units; (2) have more than 300 animal units and pollutants are discharged into navigable waters through a man-made flushing system or other man-made device, or pollutants are discharged directly into waters of the United States which originate outside of and pass over, across or through the facility or otherwise come into direct contact with the animals confined in the operation; or (3) are designated by EPA or an authorized NPDES State upon determining that it is a significant contributor of pollution to the waters of the United States.

[15] U.S. Department of Agriculture, Office of Budget and Policy Analysis, Draft Report, 1992. *Progress and Status of Livestock and Poultry Waste Management to Protect the Nation's Waters.*

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of impairment in lakes and 13 percent of impairments in rivers.[16] Feedlot impact is less significant, on average, in estuaries and ocean coasts, although there are estuaries, such as the Chesapeake Bay and Puget Sound, where animal waste is a significant water quality problem. In addition, the U.S. Fish and Wildlife Service estimated in 1984 that feedlots impair fisheries in nearly 60,000 miles of streams nationally. EPA is unable to identify the relative contributions to impairment of facilities currently subject to NPDES permits and those that are not; however, waterbodies have been identified in case studies where impairment is due to smaller feedlots not subject to permits, e.g., the Chesapeake Bay.

Feedlots produce an estimated 400 million tons of animal waste per year, twice as much waste as humans produce. These wastes contain ammonia, phosphorus, nitrogen, oxygen demanding materials, and high levels of pathogenic bacteria. When used properly, animal wastes are a valuable resource, but when such wastes are discharged into surface or ground water, they often cause impairment.

High pollutant concentrations can be associated with feedlot runoff. Nutrients, oxygen demanding materials, and bacteria in runoff from feedlots are often present in concentrations that are 10 to 100 times those of untreated sanitary sewage[17] or combined sewer overflows.[18] Fish kills may result from runoff, wastewater, or manure entering surface waters, due to ammonia and dissolved oxygen depletion. The decomposition of organic materials can deplete dissolved oxygen supplies in water, resulting in anoxic or anaerobic conditions. Methane, amines, and sulfide are produced in anaerobic waters causing the water to acquire an unpleasant odor, taste, and appearance. Such waters can be unsuitable for drinking, fishing, and other recreational uses. Solids deposited in water bodies can

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[16] *Water Pollution from Feedlot Waste: An Analysis of its Magnitude and Geographic Distribution*, EPA Feedlot Workgroup, December 1992.

[17] *Report of the EPA/State Feedlot Workgroup*, EPA Feedlot Workgroup, September 1993.

[18] *Water Pollution from Feedlot Waste: An Analysis of its Magnitude and Geographic Distribution*, EPA Feedlot Workgroup, December 1992.

accelerate eutrophication through the release of nutrients over extended periods of time. Animal diseases can be transmitted to humans through contact with animal feces. Animal waste has been responsible for shellfish contamination in some coastal waters.[19] Animal wastes discharged to waterways perform the same nutritional function for aquatic plants as they do for field crops, with high levels of nitrogen and phosphorus promoting algae growth in receiving waters. Pathogens, nitrates, and salts in manure can impair ground water, with problems being reported in at least 17 States.

4.2.2 Geographic Extent of Facilities

This section addresses the extent of potential Phase II facilities through a geographic analysis of their location with respect to urbanized areas, regulated Phase I municipalities, and other population centers. The procedures used to generate this information were discussed in Chapter 2. This analysis does not provide any information on the quantity or quality of storm water discharged by these facilities. This is locational data only. Some facilities may have completely enclosed operations. Some may be connected to sanitary or combined sewers, rather than to separate storm sewer systems. Finally, some may have few pollutants of concern in use or in their discharges.

Even so, determining location and geographic distribution lends some valuable insights. The location of facilities is important for both environmental and for policy reasons. From an environmental perspective, facilities located in populous, urban, or dense areas may be larger and more heavily used, with the potential for larger amounts or concentrations of pollutants to be discharged. At the same time, however, runoff from these urban facilities may be more likely to discharge to storm or sanitary sewers, where it will mix with other storm water flows before ultimate discharge to receiving waters. Facilities located in more rural areas may be no different in terms of pollutant content but may have a greater potential for discharging directly into the Nation's waters.

[19] *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, EPA, January 1993.

From a policy perspective, urban and rural storm water discharges could also be treated differently. Industrial, commercial, and retail facilities in urban areas will more often fall within the boundaries of a municipal storm water control program. Thus, any control, detention, or sampling efforts by municipalities may help to locate and mitigate the impact of the storm water discharges within their jurisdictions, whether these discharges are federally regulated or not. The rural discharger, on the other hand, is more likely to be a direct discharger or to be located in a smaller municipality with no storm water program and, thus, may be relatively uncontrolled unless located in a high priority watershed that receives special State attention.

As discussed in Chapter 2, Phase II of the storm water program could cover additional commercial sources directly through permitting requirements for individual facilities or indirectly by requiring local governments to address commercial sources. With respect to the second approach, there are many ways of expanding control strategies to additional geographic areas and political jurisdictions, beyond those covered in Phase I. For example, EPA could expand regulatory or control requirements to:

- The urbanized fringe around existing Phase I cities
- All urbanized areas not covered in Phase I
- Additional cities (incorporated areas) based on size
- Growing areas, where both development pressures and opportunities for preventive measures are greatest
- Coastal areas, where storm water quality impacts have been identified.

Of course, a combination of options can also be considered, such as urbanized areas in coastal areas or cities of a certain size in fast growing counties. To evaluate alternatives, consideration must be given to how industrial, commercial, and retail establishments are distributed in different jurisdictions, such as cities or urbanized areas of a certain size. The analysis on the following pages demonstrates how these various options would affect

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industrial and commercial facilities (i.e., what portion of facilities in a given sector would be covered by a particular geographic approach). This analysis of location was completed for each of these perspectives. This section presents and discusses results for urbanized areas, primarily. Other relevant results are discussed in the text, but full numerical details are reported in Appendix G.

As discussed in Chapter 2, this presentation is based on the premise that individual commercial and retail activities are distributed similarly to the population at the county level. That is, if 40 percent of the people in a county live in urbanized areas, this analysis assumes that 40 percent of the industrial, commercial, and retail sources are located in urbanized areas. This premise may not hold true for activities that are usually located in rural areas, such as agricultural or silvicultural operations. However, because rural counties have a lower proportion of urbanized population, facilities that are commonly located in rural counties would be allocated to the non-urbanized portion of the county under this procedure. Thus, on average on a national scale,[30] the premise provides a useful estimation tool even for typically rural enterprises. This procedure is explained in more detail in Chapter 2.

The results of the distributional analysis of facilities and SIC-code activities are presented graphically in this section. Figure 4-1 shows the geographic distribution of facilities (by county) in the 90 selected four-digit SIC codes (potential Phase II) chosen for analysis. Counties are shaded in the map based on the number of facilities located in each. Counties with more than 1,000 facilities are shown in black, those with 500 to 999 facilities are shown in cross-hatch shading, and those with 250 to 499 facilities are shown in light shading. Counties with facility counts lower than 250 are shown in white but are not outlined.

Figure 4-2 shows similar information, except that counties are shaded on the basis of density of facilities (facilities per square mile) rather than straight facility counts. The

[30] The analysis does not address individual commercial and retail activities that are located in Territories other than the District of Columbus.

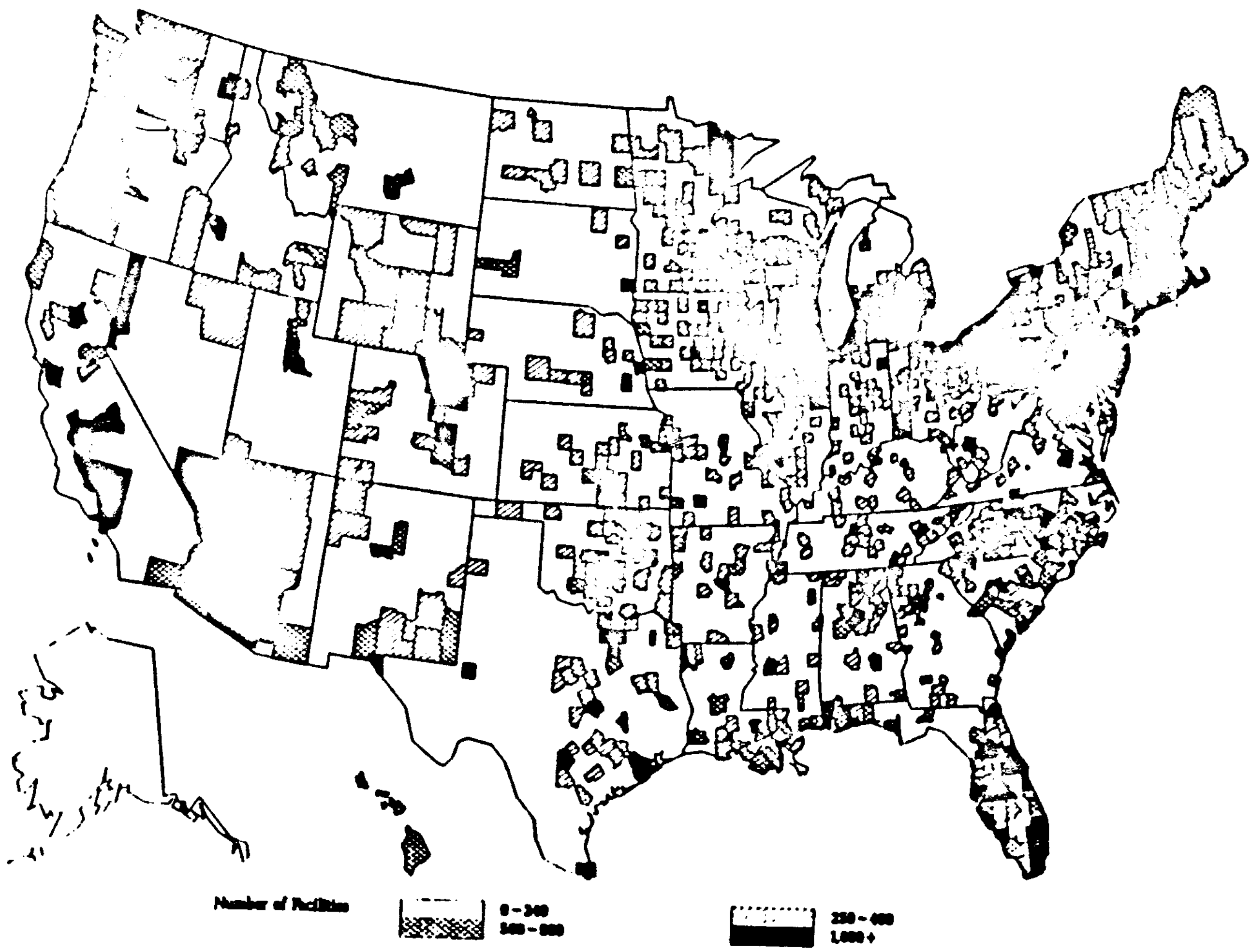

Figure 4-1. Geographic Distribution of Facilities With Selected 4-Digit SIC Codes (counties with less than 250 facilities are not shown)

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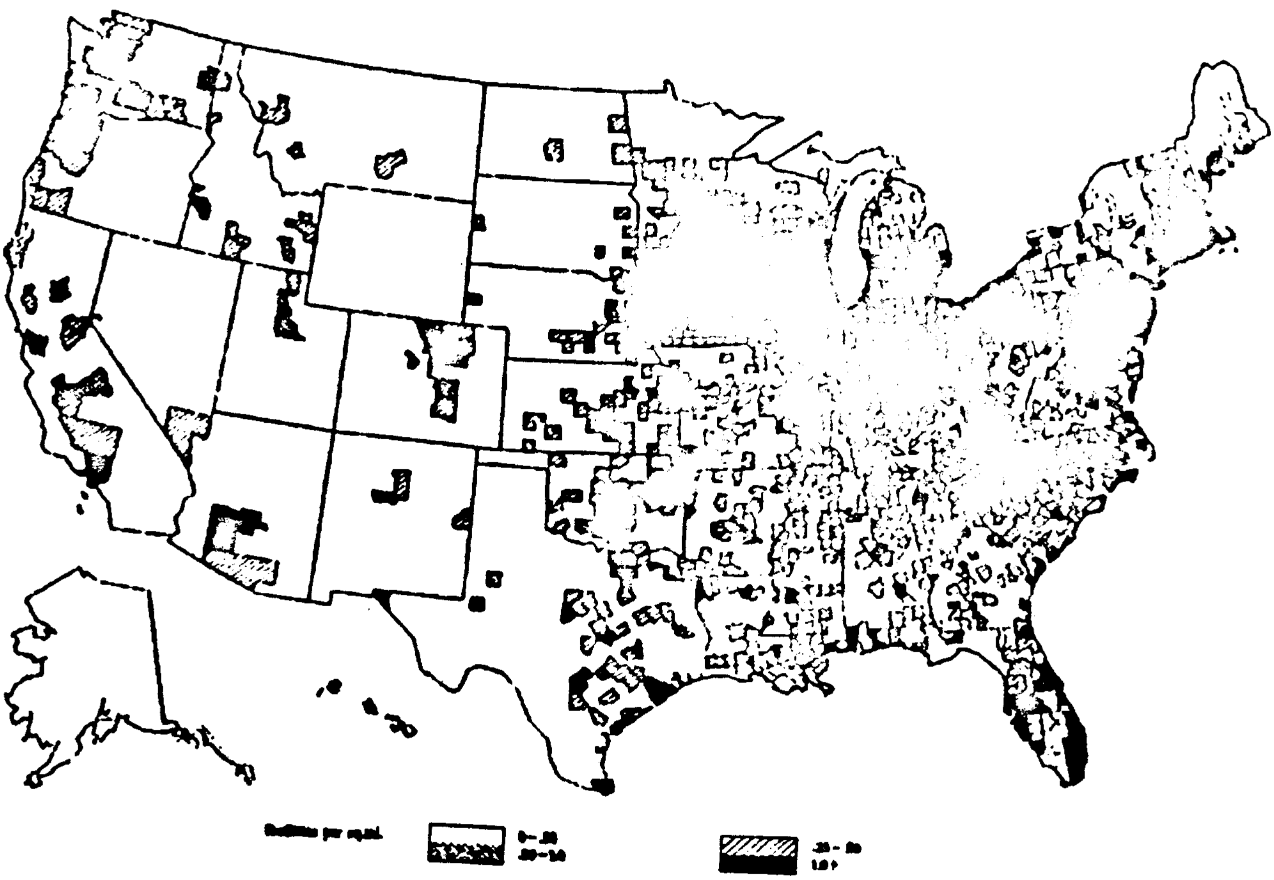

Figure 4-2. Geographic Distribution of Facilities With Selected 4-Digit SIC Codes by Density (counties with less than .25 facilities per square mile are not shown)

counties with the densest concentrations of facilities are shown in black, counties in the next density class are shown in cross-hatch shading, and the third density class is shown in light shading. Counties in the lowest density class are shown in white, but are not outlined.

As illustrated, the largest numbers and concentrations of facilities occur along the Eastern Seaboard; the industrialized southern Great Lakes Region; southern Florida; the Gulf Coast; and major cities of the southwest, California, and the Pacific Northwest. Although results for density show more focus around population centers, especially in the East and Midwest, both maps illustrate that potential Phase II facilities, which represent economic activity in industries, businesses, offices, and government services, are highly associated with population centers, in general. The same generalizations apply whether based on numbers of facilities or density of facilities, indicating that the most populous places tend also to have the greatest concentrations of potential Phase II facilities.

This geographic information on facility location is also presented quantitatively to lend additional insights. As described in the approach in Chapter 2, facility-specific information, including SIC code and county location, was combined with information from the 1990 census, which includes county population and area. These two sources of data were used to analyze the geographic distribution of all facilities in all two-digit SIC codes and of the 90 four-digit SIC codes selected as Group B Phase II categories. The results of this analysis are reported in detail in Appendix G. This section reviews some of the data and highlights important findings for the Group B sectors.

Table 4-9 presents information about the geographic distribution of industrial and commercial facilities in urbanized areas, based on the location with respect to Phase I cities. The columns of the table illustrate the locational relationships among jurisdictions when taking the perspective of expanding from current core (Phase I) cities out to the urbanized areas surrounding them, then on to remaining urbanized areas. Note that some urbanized areas encompass Phase I cities, while others are not contiguous with them.

Table 4-9. Geographic Distribution of Potential Phase II Facilities in Relation to Urbanized Areas

Potential Phase II Facilities Identified		Cumulative % of facilities located within:		
Description	Count	Phase I Areas	Phase I Areas + UAs	All UAs
Phase II - Group A	100,000[1]	32	45	61
Phase II - Group B	1,015,239	28	40	56
Group B Sectors				
Automotive Service	369,870	27	38	55
Machinery & Electrical Repair	135,744	29	40	56
Intensive Ag. Chemical Use	121,861	26	38	54
Wholesale, Machinery	77,562	32	47	65
Laundries	51,376	38	52	71
Wholesale, Wood Products	48,593	26	36	53
Livestock, Feedlots	43,421[2]	8	11	20
Petrol. Pipelines & Distributors	35,319	16	25	39
Photographic Activities	30,684	40	53	70
Various Utilities	22,242	24	36	53
Extensive Ag Chem Use	18,992	31	42	62
Transport, Rail and Other	14,808	47	64	81
Wholesale, Metal Products	14,303	36	54	75
Wholesale, Food	11,372	36	49	67
Laboratories	10,683	38	56	74
Munic. Services, Vehicle Maint	4,611	25	35	51
National Security	2,414	34	43	60
Wholesale, Coal & Ores	1,384	23	31	48

[1] This figure is an approximation based on the total number of facilities in SIC codes 10 through 45 after subtracting an estimate of the number of facilities covered under Phase I. Geographical distribution information is based on all facilities in SIC codes 10 through 45 and may not be representative of all classes of facilities in this group. For the geographic distribution of specific SIC codes, refer to Appendix G.

[2] This number is based on SIC codes and does not reflect all feedlots potentially subject to Phase II. The United States Department of Agriculture has estimated that there are approximately 378,000 animal feeding operations between 20 and 1,000 animal units. The facilities identified here should be representative of feedlots in general and allow estimation of the distribution of these facilities as a class.

The rows of the table show each potential Phase II sector and the proportion of industrial facilities located in each of the geographic jurisdictions. Other major groups of industries—all facilities nationally, agricultural and silvicultural categories, manufacturing categories, and all commercial and retail categories—are included in the table to show by comparison how the potential Phase II categories are distributed relative to other major

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industrial and commercial sectors. As shown in the table, about one-third of the potential Phase II industrial and commercial facilities within the United States are located within municipalities already covered under Phase I of the storm water program. As a point of reference, agricultural and silvicultural activities (SIC Codes 01xx to 09xx) are less often associated with cities or urban areas. Only about 14 percent of the facilities in these agricultural sectors are associated with Phase I cities. Only about half of them are associated with urban areas, as compared to three-quarters for other more industrial sectors. This distribution holds also for the Phase II sector containing livestock and feedlot activities.

The table also shows the cumulative effect of expanding control of individual sources outward from central cities to encompass larger urbanized areas. In general, 30 percent of facilities are located in regulated Phase I municipalities, an additional 15 percent are located in the urbanized areas associated with Phase I cities, and an additional 15 percent are found in the remaining urbanized areas. Thus, about twice as many industrial facilities are found in all urbanized areas as are found in Phase I cities alone. This result holds for most of the potential Phase II categories. However, there are some exceptions. Petroleum pipelines and distributors show a weaker association with urban areas. It also is not surprising that feedlots are less closely associated with highly urbanized areas.

In another series of analyses, the distribution of industrial facilities was examined according to other geographic areas of potential interest. The results of these analyses are reviewed briefly here; Appendix F contains complete results. Urbanized areas of various population size classes were analyzed. This analysis shows that most facilities (about 45 to 50 percent) are located in the largest urbanized areas (over 250,000 people). An additional 7 percent are found in medium UAs (from 100,000 to 250,000 people). An additional 5 percent are found in UAs containing 50,000 to 100,000 people. These results show that the majority of facilities are located in the largest UAs and only a small increment is gained by including smaller UAs in the regulatory scenario.

For additional perspective on potential Phase II areas of concern, an analysis was conducted on the relationship between facility distribution and fast growing geographic areas. This analysis focused on counties expected to grow by more than 15 percent in the 15 years between 1990 and 2005 (based on Census Bureau projections).[21] The results show that about a quarter of Phase II facilities are located in these fast-growing counties. Of these, almost three-quarters are located in urbanized areas.[22]

Because coastal areas are also a potential concern, as reflected in the CZARA program, another analysis addressed the geographic distribution of industrial and commercial facilities in coastal counties. The definition used by the National Oceanic and Atmospheric Administration and the Bureau of the Census of the Department of Commerce is used in determining coastal counties. Of the 3,141 counties in the United States, 672 are defined as coastal by NOAA and have at least 15 percent of their land area in a coastal watershed or in a coastal cataloging unit (note that this is quite different from the "coastal zone" definition used in CZARA). The results reveal that coastal areas represent an important component of the industrial and commercial base in the country. As many as 44 percent of the potential Phase II facilities are located in coastal areas. Of these, about one-third are in areas that are already regulated in Phase I and almost three-quarters are located in urbanized areas.

The results in this section covered the 18 Group B sectors. The detailed results of this analysis for all two-digit and selected four-digit SIC codes are reported in Appendix G. The four-digit analysis provides a more detailed look at certain subsets within the two-digit groups. Generally, the four-digit breakdowns follow the pattern of the major (two-digit) groups: for the most part, the additional detail about selected four-digit SICs does not reveal much beyond that provided by the major group distribution.

[21] Note that this designation of "growing counties" differs from that used in Chapter 3.

[22] While this result holds in general, petroleum pipelines, wholesale coal and ores, and livestock feedlots appear to be less closely associated with fast growing areas.

4.3 SUMMARY

This section summarizes the findings on individual sources in terms of the main elements identified by Congress for discussion in this report: identification, nature and extent of unregulated discharges. Due to very limited national data on which to base loadings estimates, the discussion of the extent of unregulated storm water discharges is limited to an analysis of the number and geographic distribution of potential Phase II facilities.

4.3.1 Identification of Phase II Sources

The effort to identify sources and categories of storm water discharges for which permits are not required in Phase I of the program resulted in the identification of two general classes of facilities. The first group includes sources that are very similar or identical to Phase I activities but that were omitted from Phase I for a variety of statutory and regulatory reasons (Group A). The second general class of facilities were identified on the basis of potential activities and pollutants that may contribute to storm water contamination (Group B). The report also discussed general sources of storm water contamination which are widespread and not necessarily associated with specific activities or facilities.

Although the difficulty in differentiating Group A facilities from existing Phase I regulated activities makes quantitative analysis difficult, EPA estimates that there are approximately 100,000 facilities in this group. Facilities in Group A, which may be of high priority for Phase II due to their similarity to Phase I industrial facilities, are described and categorized in this report but are not included in the subsequent geographical analysis in the same level of detail as Group B facilities. Activities identified in Group A can be classified into three distinct categories: auxiliary or secondary activities such as vehicle maintenance in support of an unregulated activity; facilities which are related to Phase I facilities but that were intentionally omitted such as POTWs with a capacity of less than 1 MGD; and facilities which were specifically exempted from Phase I by the Transportation Act which include industrial activities owned or operated by municipalities of less than 100,000 population.

Group B consists of over one million facilities in 90 SICs. These 90 SIC categories have been organized into 18 Phase II sectors for the purposes of this report. Of these 18 sectors, the automobile service sector (comprised of gas/service stations (SIC 5541), general automobile repair (SIC 7538), top, body repair (SIC 7532), repair shops and services (SIC 7699), car dealers, new & used (SIC 5511), car dealers, used only (SIC 5521), car washes (SIC 7542), passenger car rental (SIC 7514), truck rental (SIC 7513), parking structures (SIC 7521), and miscellaneous auto services (SIC 7549)), make up more than one-third of the total number of facilities identified in all 18 sectors.

Other general sources of storm water discharges discussed but not clearly identified in the report include parking lots, trash dumpsters, leaking and failing septic systems, and activities related to individual residences such as fertilizer and pesticide application. Facilities in the service sectors, such as banking, finance, insurance firms, and all types of food services, were also discussed but not included in much of the analysis.

4.3.2 Nature of Phase II Sources

There is little quantitative or comprehensive data from a national perspective on the concentrations and loadings of storm water discharges from the industrial, commercial, and retail facilities selected for study as potential Phase II sources. As a result, it is not currently possible to estimate national concentrations or loadings from these sources. It is clear, however, that a significant number of facilities remain in unregulated Phase II categories that conduct operations that have the potential to discharge contaminated storm water. It is possible to classify the unregulated categories into three major groups:

- All of the potential Phase II facilities in Group A may have discharges similar or identical to discharges associated with industrial activity regulated under Phase I.
- Of the facilities in Group B, 80 percent may have discharges similar or identical to discharges associated with industrial activity regulated under Phase I. Facilities in this class have activities analogous to Phase I activities but are covered by different SIC codes. These facilities are also likely to employ substances that could result in

pollutants, such as toxics, metals, solvents and oil and grease, entering storm water.[23] This class includes wholesale operations and vehicle repair and maintenance categories.

- Almost 20 percent of the facilities in Group B had activities that resemble exempted agricultural sources but do not fall under the statutory exclusion of agriculture. These include smaller, currently unregulated feedlots, nurseries, and retailers of farm supply chemicals. Facilities in this class are likely to have activities that result in contributions of pesticides or fertilizers and nutrients to storm water.

In general, industries with large areas of industrial activity and significant materials exposed to storm water exhibited the highest concentrations of pollutants in their storm water discharges. Suspended solids, which can also carry metals and organic pollutants, appear to be the pollutant with the highest concentrations overall. Chemical oxygen demand appears at relatively high concentration levels in some industrial sectors. Oil and grease results were highly variable but highest in industrial sectors associated with transportation and vehicle and machinery maintenance. Results for metals varied across industrial sectors, but those that handle, process, manufacture, or mine metals, as well as landfills, had higher concentrations than other categories. Biochemical oxygen demand, and nutrients (nitrogen and phosphorus) were generally not found at high concentration levels in Phase I data, although results were variable for nutrients.

4.3.3 Geographic Distribution

The geographical analysis shows that the majority of industrial and commercial facilities are located in or near population centers (cities and other urban places). To the extent that they are located in populous, urbanized areas, they are more likely to be served by municipal storm sewers (either separate or combined) than to be discharging directly to streams.

[23] About 2 percent of these facilities conduct other activities that may use toxic pollutants but are not substantially similar to the other facilities in this group. These include research laboratories and some kinds of municipal or governmental entities, which may engage in a wide variety of activities. There is very little information available about the pollution potential of facilities in this class.

In general, about 30 percent of potential Phase II facilities are found within the geographic jurisdiction of a Phase I municipality. An additional 20 to 30 percent of Phase II facilities fall into Census-designated urbanized areas. Thus, nearly twice as many industrial facilities are found in all urbanized areas as are found in Phase I municipalities alone.

Notable exceptions to these generalizations include lawn/garden establishments, feedlots, wholesale livestock, farm and garden machinery repair, bulk petroleum wholesale, farm supplies, lumber and building materials, and petroleum pipelines, which are (relatively) more frequently associated with smaller municipalities or rural areas. Because a larger portion of these facilities are outside the confines of regulated municipalities, a larger portion of storm water discharges from these facilities may be going directly to receiving waters rather than into municipal separate storm sewer systems.

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APPENDIX A

LIST OF PHASE I MUNICIPAL SEPARATE STORM SEWER SYSTEMS

List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places)

State	Place Name	Population	Area (sq.mi.)
Alaska	Anchorage city*	226,338	1697.65
Alabama	Adamsville city	4,161	3.07
	Alabaster city	14,732	18.85
	Bessemer city	33,497	38.70
	Birmingham city*	265,968	148.49
	Brighton city	4,518	1.40
	Brookside town	1,365	2.38
	Chickasaw city	6,649	3.58
	Creola city	1,896	14.60
	Daphne city	11,290	11.03
	Fairfield city	12,200	3.36
	Fairhope city	8,485	7.70
	Fultondale city	6,400	7.57
	Gardendale city	9,251	15.14
	Graysville city	2,241	2.79
	Helena city	3,918	13.73
	Homewood city	22,922	7.37
	Hoover city	39,788	23.85
	Hueytown city	15,280	8.65
	Huntsville city*	159,789	164.39
	Indian Springs	NA	NA
	Irondale city	9,454	8.83
	Leeds city	9,946	21.48
	Lipscomb city	2,892	1.15
	Madison city	14,904	20.01
	Maytown town	651	2.74
	Midfield city	5,559	2.45
	Mobile city*	196,278	118.03
	Montgomery city*	187,106	134.98
	Moody town	4,921	11.05
	Mountain Brook city	19,810	11.61
	Mulga town	261	0.19
	Pelham city	9,765	13.80
	Pleasant Grove city	8,458	6.17
	Prichard city	34,311	25.39
	Saraland city	11,751	11.40
	Satsuma city	5,194	5.97
	Tarrant city	8,046	6.36
	Trussville city	8,266	14.84
	Vestavia Hills city	19,749	8.83
Arkansas	Little Rock city*	175,795	102.86

NOTE: Unless indicated otherwise, municipalities have been designated.
* Identified in November 1990 rule.
† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
Arizona	Mesa city*	288,091	108.59
	Mesa city*	288,091	108.59
	Phoenix city*	983,403	419.91
	Tempe city*	141,865	39.52
	Tucson city*	405,390	156.29
California	Agoura Hills city	20,390	8.17
	Alameda city	76,459	10.75
	Albany city	16,327	1.70
	Alhambra city	82,106	7.62
	Anaheim city*	266,406	44.28
	Arcadia city	48,290	10.88
	Artesia city	15,464	1.62
	Atherton town	7,163	4.89
	Azusa city	41,333	9.00
	Bakersfield city*	174,820	91.84
	Baldwin Park city	69,330	6.60
	Bell city	42,355	2.51
	Bellflower city	34,365	2.56
	Bell Gardens city	61,815	6.08
	Belmont city	24,127	4.53
	Berkeley city*	102,724	10.46
	Beverly Hills city	31,971	5.68
	Big Bear Lake city	5,351	6.24
	Bradbury city	829	1.67
	Brisbane city	2,952	3.33
	Burbank city	93,643	17.35
	Burlingame city	26,801	4.35
	Camarillo city	52,303	18.44
	Campbell city	36,048	5.61
	Carlsbad city	63,126	37.67
	Carson city	83,995	18.84
	Cerritos city	53,240	8.61
	Chula Vista city†	135,163	28.99
	Claremont city	32,503	11.01
	Colma town	1,103	1.90
	Commerce city	12,135	6.53
	Compton city	90,454	10.17
	Concord city	111,348	29.47
	Contra Costa county (15 cities)	~553,831	~172.65
	Coronado city	26,540	7.71

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NOTE: Unless indicated otherwise, municipalities have been designated.
* Identified in November 1990 rule
† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
California (continued)	Covina city	43,207	6.90
	Cudahy city	22,817	1.10
	Culver City city	38,793	5.10
	Cupertino city	40,263	10.30
	Daly City city	92,311	7.51
	Del Mar city	4,860	1.77
	Diamond Bar city	53,672	15.09
	Downey city	91,444	12.44
	Duarte city	20,688	7.21
	Dublin city	23,229	8.56
	East Palo Alto city	23,451	2.55
	El Cajon city	88,693	14.41
	El Monte city†	106,209	9.50
	El Segundo city	15,223	5.55
	Emeryville city	5,740	1.22
	Encinitas city	55,386	17.95
	Escondido city†	108,635	35.64
	Fairfield city	77,211	35.85
	Fillmore city	11,992	2.64
	Folsom city	29,802	21.43
	Foster City city	28,176	3.76
	Fremont city*	173,339	77.03
	Fresno city*	354,202	99.14
	Fullerton city*	114,144	22.12
	Galt city	8,889	5.60
	Gardena city	143,050	17.94
	Garden Grove city*	49,847	5.28
	Gilroy city	31,487	10.26
	Glendale city*	180,038	30.61
	Glendora city	47,828	19.47
	Half Moon Bay city	8,886	6.47
	Hawaiian Gardens city	13,639	0.95
	Hawthorne city	71,349	5.93
	Hayward city†	111,498	43.45
	Hermosa Beach city	18,219	1.43
	Hidden Hills city	1,729	1.62
	Hillsborough town	10,667	6.22
	Huntington Beach city*	181,519	26.42
	Huntington Park city	56,065	3.05
	Imperial Beach city	26,512	4.25
	Industry city	631	11.56
	Inglewood city†	109,602	9.17
	Irvine city†	110,330	42.32

NOTE: Unless indicated otherwise, municipalities have been designated.
* Identified in November 1990 rule.
† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
California (continued)	Irwindale city	1,050	9.32
	La Canada Flintridge city	19,378	8.67
	Laguna Beach city	23,170	8.68
	La Habra Heights city	6,226	6.37
	Lakewood city	73,557	9.39
	La Mesa city	52,931	9.22
	La Mirada city	40,452	7.85
	La Palma city	15,932	1.82
	La Puente city	36,955	3.49
	La Verne city	30,897	7.79
	Lawndale city	27,331	1.98
	Lemon Grove city	23,984	3.79
	Livermore city	56,741	19.63
	Lomita city	19,382	1.89
	Long Beach city*	429,433	50.02
	Los Alamitos city	11,676	4.03
	Los Altos city	7,514	8.42
	Los Altos Hills town	26,303	6.37
	Los Angeles city*	3,485,398	469.34
	Los Gatos town	27,357	10.38
	Lynwood city	61,945	4.86
	Manhattan Beach city	32,063	3.93
	Maywood city	27,850	1.17
	Menlo Park city	28,040	10.06
	Millbrae city	20,412	3.21
	Milpitas city	50,686	13.76
	Modesto city*	164,730	30.18
	Monrovia city	35,761	13.37
	Montebello city	3,287	1.61
	Monterey Park city	59,564	8.26
	Monte Sereno city	60,738	7.64
	Moorpark city	25,494	12.26
	Moreno Valley city†	118,779	49.13
	Mountain View city	67,460	12.03
	National City city	54,249	7.57
	Newark city	37,861	13.96
	Norwalk city	94,279	9.76
	Oakland city*	372,242	56.06
	Oceanside city†	128,398	40.67
	Ojai city	7,613	4.43
	Ontario city†	133,179	36.75
	Orange city†	110,658	23.34
	Orange county (17 cities)	~841,825	~179.74

NOTE: Unless indicated otherwise, municipalities have been designated.
* Identified in November 1990 rule
† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
California (continued)	Oxnard city*	142,216	24.44
	Pacifica city	37,670	12.64
	Palo Alto city	55,900	23.68
	Palos Verdes Estates city	13,512	4.81
	Paramount city	47,669	4.70
	Pasadena city*	131,591	22.99
	Pico Rivera city	59,177	7.98
	Piedmont city	10,602	1.68
	Pleasanton city	50,553	16.21
	Pomona city†	131,723	22.83
	Port Hueneme city	20,319	4.43
	Poway city	43,516	39.28
	Rancho Cucamonga city†	101,409	37.81
	Rancho Palos Verdes city	41,659	13.66
	Redondo Beach city	60,167	6.28
	Redwood City city	66,072	19.04
	Riverside city*	226,505	77.68
	Riverside county (10 cities)	~161,120	~133.44
	Rolling Hills city	7,789	3.54
	Rolling Hills Estates city	1,871	3.05
	Rosemead city	51,638	5.12
	Sacramento city*	369,365	96.29
	Salinas city†	108,777	18.63
	San Bernardino city*	164,164	55.08
	San Bernardino county (13 cities)	~558,047	~231.35
	San Bruno city	38,961	6.43
	San Carlos city	26,167	5.63
	San Diego city*	1,110,549	324.00
	San Dimas city	32,397	15.52
	San Fernando city	22,580	2.39
	San Gabriel city	37,120	4.14
	San Jose city*	782,248	171.26
	San Leandro city	68,223	13.11
	San Marcos city	38,974	23.19
	San Marino city	12,959	3.77
	San Mateo city	85,486	12.21
	Santa Ana city*	293,742	27.09
	Santa Clara	93,613	18.30
	Santa Clarita city†	110,642	40.48
	Santa Fe Springs city	15,520	8.67
	Santa Monica city	86,905	8.27
	Santa Paula city	25,062	4.60

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NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
California (continued)	Santee city	52,902	15.87
	Saratoga city	28,061	11.97
	Seal Beach city	25,098	11.72
	Sierra Madre city	10,762	3.00
	Signal Hill city	8,371	2.22
	Simi Valley city†	100,217	33.03
	Solana Beach city	12,962	3.52
	South El Monte city	20,850	2.89
	South Gate city	86,284	7.35
	South Lake Tahoe city	21,585	10.06
	South Pasadena city	23,936	3.43
	South San Francisco city	54,312	8.96
	Stockton city*	210,943	52.57
	Suisun City city	22,686	3.56
	Sunnyvale city*	117,229	21.90
	Temple City city	31,100	4.01
	Thousand Oaks city†	104,352	49.56
	Torrance city*	133,107	20.52
	Union City city	53,762	18.76
	Vallejo city†	109,199	30.22
	Vernon city	152	4.93
	Vista city	71,872	17.94
	Walnut city	29,105	8.86
	West Covina city	96,086	16.20
	West Hollywood city	36,118	1.88
	Westlake Village city	7,455	5.21
	Whittier city	77,671	12.53
	Woodside town	5,035	11.74
Colorado	Aurora city*	222,103	132.53
	Colorado Springs city*	281,140	183.19
	Denver city*	467,610	153.28
	Lakewood city*	126,481	40.80
	Pueblo city	98,640	35.90
Connecticut	Stamford city*	108,056	37.72
District of Columbia	Washington city*	606,900	61.41
Delaware	Arden village	477	0.27
	Ardencroft village	282	0.11
	Ardentown village	325	0.17
	Bellefonte town	1,243	0.18
	Delaware City city	1,682	1.24
	Elsmere town	5,935	0.98
	Middletown town	3,834	3.41

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NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
Delaware (continued)	Newark city	25,098	8.62
	New Castle city	4,837	2.22
	Newport town	1,240	0.37
	Odessa town	303	0.44
	Townsend town	322	0.21
	Wilmington city	71,529	10.78
Florida	Atlantis city	1,653	1.35
	Auburndale city	8,858	4.10
	Bartow city	14,716	8.59
	Belle Glade city	60	0.06
	Boca Raton city	61,492	27.19
	Boynton Beach city	46,194	15.14
	Briny Breezes town	400	0.07
	Broward County (24 cities)	1,050,742	322.96
	Century town	1,989	3.28
	Clearwater city	98,784	24.88
	Cloud Lake town	121	0.06
	Dade County (19 cities)	886,235	118.42
	Davenport city	1,529	1.47
	Delray Beach city	47,181	14.84
	Dundee town	2,335	3.10
	Eagle Lake city	1,758	0.72
	Fort Lauderdale city*	149,377	31.36
	Fort Meade city	4,976	3.17
	Frostproof city	2,808	2.39
	Glen Ridge town	207	0.23
	Golf village	234	0.83
	Golfview town	153	0.16
	Greenacres City city	18,683	4.05
	Gulf Stream town	11,727	2.84
	Haines City city	11,683	8.01
	Haverhill town	1,058	0.52
	Hialeah city*	188,004	19.24
	Highland Beach town	3,209	0.49
	Highland Park village	155	0.45
	Hillcrest Heights town	221	0.16
	Hollywood city*	121,697	27.26
	Homestead city	26,866	11.61
	Hypoluxo town	830	0.60
	Jacksonville city*	635,230	758.67
	Juno Beach town	2,121	1.08
	Jupiter town	405	0.18
	Jupiter Inlet Colony town	24,986	13.11

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NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
Florida (continued)	Lake Alfred city	3,622	2.52
	Lake Clarke Shores town	3,364	0.98
	Lake Hamilton town	1,128	3.03
	Lakeland city	6,704	1.80
	Lake Park town	9,670	6.40
	Lake Wales city	28,564	5.62
	Lake Worth city	70,576	38.39
	Lantana town	8,392	2.28
	Longboat Key town	5,937	4.92
	Manalapan town	312	0.45
	Mangonia Park town	1,453	0.71
	Miami city*	358,548	35.57
	Miramar city	40,663	29.67
	Mulberry city	2,988	2.87
	North Palm Beach village	11,343	3.31
	North Port city	11,973	74.78
	Ocean Ridge town	1,570	0.86
	Orange County (8 cities)	239,522	103.68
	Orlando city*	164,693	67.27
	Pahokee city	6,822	5.34
	Palm Beach town	22,965	26.28
	Palm Beach Gardens city	1,040	0.25
	Palm Beach Shores town	9,814	3.93
	Palm Springs village	9,763	1.33
	Pembroke Pines city	65,452	31.94
	Pennsuee	NA	NA
	Pensacola city	58,165	22.64
	Pinellas County (21 cities)	586,612	NA
	Plant City city	66,692	21.75
	Polk City town	1,439	0.59
	Riviera Beach city	27,639	7.49
	Royal Palm Beach village	14,589	8.81
	St. Petersburg city*	238,629	59.19
	Sarasota city	50,961	14.62
	Seminole city	9,251	2.25
	South Bay city	3,558	1.93
	South Palm Beach town	1,480	0.13
	Tallahassee city†	124,773	63.27
	Tampa city*	280,015	108.67
	Temple Terrace city	16,444	4.94
	Tequesta village	4,499	1.71
	Venice city	16,922	7.42
	West Palm Beach city	67,643	49.33

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- NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
	Winter Haven city	24,725	12.19
Georgia	Acworth city	4,519	4.63
	Alpharetta city	13,002	19.02
	Atlanta city*	394,017	131.78
	Austell city	4,173	4.97
	Bloomingdale city	2,271	9.23
	Buford city	8,771	13.35
	Chamblee city	7,668	3.14
	Clarkston city	5,385	1.05
	College Park city	20,457	9.70
	Columbus city*	178,681	216.14
	Decatur city	17,336	4.16
	Doraville city	7,626	3.58
	Duluth city	9,029	7.39
	East Point city	34,402	13.76
	Fairburn city	4,013	4.46
	Forest Park city	16,925	8.59
	Garden City city	7,410	5.10
	Hapeville city	5,483	2.37
	Jonesboro city	3,635	2.40
	Kennesaw city	8,936	5.58
	Lawrenceville city	16,848	12.34
	Lilburn city	9,301	6.20
	Lithonia city	2,448	0.79
	Macon city*	106,612	47.88
	Marietta city	44,129	20.38
	Morrow city	5,168	2.83
	Norcross city	5,947	3.92
	Palmetto city	2,612	5.02
	Pooler city	4,453	11.07
	Powder Springs city	6,893	5.35
	Riverdale city	9,359	4.10
	Roswell city	47,923	32.57
	Savannah city*	137,560	62.59
	Smyrna city	30,981	11.37
	Snellville city	12,084	9.13
	Stone Mountain city	6,494	1.62
	Sugar Hill city	4,557	5.91
	Thunderbolt town	2,786	1.28
	Union City city	8,375	8.04
Iowa	Cedar Rapids city*	108,751	53.46
	Davenport city	95,333	61.36
	Des Moines city*	193,187	75.26
Idaho	Boise City city*	125,738	46.13
	Garden City city	6,369	3.33
Illinois	Rockford city*	139,426	44.98

NOTE: Unless indicated otherwise, municipalities have been designated.
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NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
Indiana	Fort Wayne city*	173,072	62.66
	Indianapolis city*	731,327	361.67
Kansas	Kansas City city*	149,767	107.79
	Topeka city*	119,883	55.16
	Wichita city*	304,011	115.14
Kentucky	Lexington-Fayette*	225,366	284.52
	Louisville city*	269,063	62.11
Louisiana	Baton Rouge city*	219,531	73.95
	Gretna city	17,208	3.2
	Harahan city	9,927	1.98
	Kenner city	72,033	15.13
	New Orleans city*	496,938	180.65
	Shreveport city*	198,525	98.61
	Westwego city	11,218	3.19
Massachusetts	Boston city*	574,283	48.42
	Lowell city	103,439	13.78
	Worcester city*	169,759	37.56
Maryland	Baltimore city*	736,014	80.81
	Aberdeen	13,087	5.29
	Annapolis	33,187	6.33
	Bowie	8,860	2.57
	Bel Air	37,589	12.86
	Havre de Grace	8,952	3.31
	Takoma Park city	16,700	2.01
Michigan	Ann Arbor city*	109,592	25.90
	Flint city*	140,761	33.83
	Grand Rapids city*	189,126	44.26
	Sterling Heights city*	117,810	36.64
	Warren city*	144,864	34.28
Minnesota	Minneapolis city*	368,383	54.93
	St. Paul city*	272,235	52.79
Missouri	Independence city*	112,301	78.19
	Kansas City city*	435,146	311.53
	Springfield city*	140,494	67.95
Mississippi	Jackson city*	196,637	109.01
Nebraska	Lincoln city*	191,972	63.29
	Omaha city*	335,795	100.65
New Mexico	Albuquerque city*	384,736	132.20
Nevada	Henderson city	64,942	71.54
	Las Vegas city*	258,295	83.29
	North Las Vegas city	47,707	60.97
	Reno city*	133,850	57.50
	Sparks city	53,367	14.25

NOTE: Unless indicated otherwise, municipalities have been designated.
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NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
New York	New York city• (Bronx Borough) (Brooklyn Borough) (Manhattan Borough) (Queens Borough) (Staten Island Borough)	7,322,564	308.95
North Carolina	Charlotte city•	395,934	174.26
	Durham city•	136,611	69.27
	Fayetteville city	75,695	40.60
	Greensboro city•	183,521	79.79
	Raleigh city•	207,951	88.13
	Winston-Salem city•	143,485	71.12
Ohio	Akron city•	223,019	62.19
	Cincinnati city•	364,040	77.22
	Cleveland city•	505,616	77.02
	Columbus city•	632,910	190.92
	Dayton city•	182,044	55.00
	Toledo city•	332,943	80.57
Oklahoma	Oklahoma City city•	444,719	608.16
	Tulsa city•	367,302	183.52
Oregon	Banks city	563	0.33
	Barlow city	118	0.06
	Beaverton city	53,310	13.82
	Cornelius city	6,148	1.79
	Durham city	748	0.43
	Eugene city•	112,669	38.04
	Fairview city	2,391	3.16
	Forest Grove city	13,559	40.22
	Gaston city	563	2.45
	Gladstone city	10,152	22.06
	Gresham city	68,235	2.30
	Happy Valley city	1,519	19.26
	Hillsboro city	37,520	0.06
	Johnson City city	586	0.41
	King City city	2,060	9.54
	Lake Oswego city	30,576	4.76
	Milwaukee city	18,692	1.63
	North Plains city	972	4.69
	Portland city•	437,319	0.18
	Rivergrove city	294	.13
	Sherwood city	3,093	3.21
	Tigard city	29,344	10.19
	Tualatin city	15,013	7.10
	West Linn city	16,367	6.63
	Wilsonville city	7,106	6.39
Pennsylvania	Allentown city•	105,090	17.71
	Philadelphia city•	1,585,577	135.13

NOTE: Unless indicated otherwise, municipalities have been designated.
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† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

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List of Phase I Municipal Separate Storm Sewer Systems (Incorporated Places) (continued)

State	Place Name	Population	Area (sq.mi.)
South Dakota	Sioux Falls city	100,814	45.05
Tennessee	Belle Meade city	2,839	3.14
	Berry Hill city	802	0.90
	Chattanooga city*	152,466	118.43
	Forest Hills city	4,231	9.28
	Goodlettsville city	11,219	13.65
	Knoxville city*	165,121	77.25
	Lakewood city	2,009	0.96
	Memphis city*	610,337	256.04
	Nashville-Davidson city*	488,374	473.33
	Oak Hill city*	4,301	7.88
	Ridgetop town	1,132	1.49
Texas	Abilene city†	106,654	103.09
	Amarillo city*	157,615	87.93
	Arlington city*	261,721	93.00
	Austin city*	465,622	217.78
	Beaumont city*	114,323	80.06
	Corpus Christi city*	257,453	134.97
	Dallas city*	1,006,877	342.41
	El Paso city*	515,342	245.36
	Fort Worth city*	447,619	281.08
	Garland city*	180,650	57.35
	Houston city*	1,630,553	539.88
	Irving city*	155,037	67.62
	Laredo city†	122,899	32.87
	Lubbock city*	186,206	104.11
	Mesquite city†	101,484	42.84
	Pasadena city*	119,363	43.77
	Plano city†	128,713	66.25
	San Antonio city*	935,933	333.03
	Waco city*	103,590	75.79
Utah	Salt Lake City city*	159,936	109.02
Virginia	Chesapeake city*	151,976	340.68
	Hampton city*	133,793	51.82
	Newport News city*	170,045	68.34
	Norfolk city*	261,229	53.76
	Portsmouth city*	103,907	33.14
	Roanoke city	96,397	42.90
	Virginia Beach city*	393,069	248.32
Washington	Seattle city*	516,259	83.89
	Tacoma city*	176,664	48.05
Wisconsin	Madison city*	191,262	57.76
	Milwaukee city*	628,088	96.08

NOTE: Unless indicated otherwise, municipalities have been designated.
* Identified in November 1990 rule
† 1990 Census population increased to over 100,000 and municipality has been designated.
NA Not available

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List of Phase I Municipal Separate Sewer Systems (Counties)

State	County	Unincorporated/ Urbanized Population	Total Population
Alabama	Baldwin county[1]	0	98,380
	Jefferson county[1]	78,608	651,525
	Mobile county[2]	45,418	378,643
	Shelby county[3]	16,148	99,358
	St. Clair county[4]	0	50,009
Arizona	Pima County*	162,202	666,880
California	Alameda County*	115,082	1,279,182
	Contra Costa County*	131,815	803,732
	Kern County*	128,504	543,447
	El Dorado County	0	125,995
	Fresno County	48,863	667,490
	Los Angeles County*	886,780	8,863,164
	Orange County*	223,081	2,410,556
	Placer County	10,564	172,796
	Riverside County*	166,509	1,170,413
	Sacramento County	594,889	1,041,219
	San Bernardino County*	162,202	1,418,380
	San Diego County*	250,414	2,498,016
	San Mateo County	50,250	649,623
	Santa Clara County	75,464	1,497,577
	Ventura County	41,020	669,016
Colorado	Arapahoe County†	103,248	391,511
Delaware	New Castle County*	296,996	441,946
Florida	Broward County*	142,329	1,255,488
	Dade County*	1,014,504	1,937,094
	Escambia County*	167,463	262,798
	Hillsborough County*	398,593	834,054
	Lee County†	102,337	335,113
	Manatee County†	123,828	211,707
	Orange County*	378,611	677,491
	Palm Beach County*	360,553	863,518
	Pasco County†	148,907	281,131
	Pinellas County*	255,772	851,659
	Polk County*	121,528	405,382
	Sarasota County*	172,600	277,776
	Seminole County†	127,873	287,529

[1] County was listed in regulation; however, population dropped below 100,000 in 1990 census.

[2] Unincorporated areas defined as: beginning at the mouth of the South Fork Deer River and extending west to SW corner Section 18, Township 6 South, Range 2 West, thence north to NW corner, Section 6, Township 2 South, Range 2 West, thence east to the Mobile County line, thence south along the county line to U.S. Highway 90 bridge.

[3] All unincorporated areas of Shelby County within the drainage basin of the Cahaba River upstream of the confluence of Shoal Creek and the Cahaba River.

[4] Unincorporated areas of St. Clair County within the drainage basin of the Cahaba River.

*Identified in November 1990 rule

†1990 Census unincorporated, urbanized population increased to more than 100,000 and municipality has been designated.

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List of Phase I Municipal Separate Sewer Systems (Counties) (continued)

State	County	Unincorporated Urbanized Population	Total Population
Georgia	Bibb County	19,340	149,976
	Chatham County	40,649	216,935
	Clayton County*	133,237	182,052
	Cobb County*	322,595	447,745
	DeKalb County*	448,686	545,837
	Fulton County†	127,776	648,951
	Gwinnett County†	237,305	352,910
	Muscogee County	0	179,278
	Richmond County*	126,476	189,719
Hawaii	Honolulu County*	114,506	836,231
Kentucky	Jefferson County*	239,430	664,937
Louisiana	East Baton Rouge Parish†	102,539	380,105
	Jefferson Parish*	331,307	448,306
Maryland	Anne Arundel County*	344,654	427,239
	Baltimore County*	627,593	692,134
	Carroll County	0	123,372
	Charles County	0	101,154
	Frederick County	14,100	150,208
	Harford County	82,302	182,132
	Howard County†	157,972	187,328
	Montgomery County*	599,028	757,027
	Prince George's County*	494,369	729,268
	Washington County	28,321	121,393
North Carolina	Cumberland County*	146,827	274,566
Nevada	Clark County*	327,618	741,459
	Washoe County	26,530	254,667
Oregon	Clackamas County	65,088	278,850
	Multnomah County	52,923	583,887
	Washington County*	116,687	311,554
South Carolina	Greenville County*	147,464	320,167
	Richland County*	130,589	285,720
Texas	Harris County*	729,206	2,818,199
Utah	Salt Lake County*	270,989	725,956
Virginia	Arlington County*	170,936	170,936
	Chesterfield County*	174,488	209,274
	Fairfax County*	760,730	818,584
	Henrico County*	201,367	217,881
	Prince William County†	157,131	215,686
Washington	King County*	520,468	1,507,319
	Pierce County*	258,530	586,203
	Snohomish County*	157,218	465,642

*Identified in November 1990 rule

†1990 Census unincorporated, urbanized population increased to more than 100,000 and municipality has been designated.

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List of Municipal Separate Storm Sewer Systems (Boundaries Not Defined by Census)

State	Municipal Separate Storm Sewer System
Alaska	DOT[1] University of Alaska Port of Anchorage
Alabama	Highway Department
Arizona	DOT
California	Alameda County Flood Control District Zone 7 of the Alameda County Flood Control District DOT Calabases Flood Control District Coachella Valley Area Contra Costa County Flood Control District Fresno Metro Flood Control District Malibu Flood Control District Orange County Flood Control District Riverside Flood Control District San Bernardino Flood Control District San Diego Unified Port District Santa Clara Valley Water District
Colorado	DOT Highway Department
Delaware	DOT
Florida	DOT Reedy Creek Improvement District
Hawaii	DOT
Idaho	DOT
Illinois	DOT
Indiana	DOT
Kansas	Kaw Valley Drainage District
Louisiana	DOT Louisiana State University Southern University
Maryland	State Highway Administration
Michigan	University of Michigan DOT
Minnesota	DOT Herrepin County Public Works Minneapolis Parks and Recreation University of Minnesota
North Carolina	DOT
Nevada	Clark County Flood Control District DOT
New Mexico	Albuquerque Metropolitan Flood Control Authority DOT
Ohio	DOT

[1] Department of Transportation

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List of Municipal Separate Storm Sewer Systems (Boundaries Not Defined by Census) (continued)

State	Municipal Separate Storm Sewer System
Oklahoma	DOT Turpike Authority
Oregon	DOT Port of Portland Multhomah County Drainage Districts (3)
Pennsylvania	DOT
South Carolina	Harbor of Charleston
Tennessee	DOT
Texas	Harris County Flood Control District DOT University of Texas-Arlington University of Texas-Austin
Utah	DOT
Washington	DOT
Wisconsin	DOT University of Wisconsin

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APPENDIX B

OVERVIEW OF IMPACTS FROM STORM WATER DISCHARGES

APPENDIX B - OVERVIEW OF IMPACTS FROM STORM WATER DISCHARGES

This appendix provides an overview of the types of impacts that storm water discharges have on receiving waters. Section B.1 describes the role of storm water discharges and the physical nature of storm water discharges. Section B.2 discusses the types of adverse impacts on receiving waters caused by storm water discharges. Section B.3 gives a general description of adverse impacts on various types of receiving waters that may be associated with storm water discharges.

B.1 THE PHYSICAL NATURE OF STORM WATER DISCHARGES

B.1.1 The Hydrologic Cycle

The hydrologic cycle is the continuous, unsteady circulation of water from the atmosphere to the Earth's surface and back to the atmosphere. Major features of the hydrologic cycle include precipitation, snow melt, surface runoff and drainage, infiltration, interflow, ground water recharge, and evapotranspiration. Each of these factors is discussed briefly below:

- **Precipitation**—Precipitation occurs as rain, sleet, hail, and snow. Precipitation is one of the key factors in analyzing storm water discharges because it is the initiating force in creating a discharge. Precipitation events are highly variable in nature and extent. As discussed in more detail below, the nature of precipitation patterns varies greatly in different parts of the country. Seasonal patterns also are usually important considerations.

- **Snow Melt**—When precipitation falls in the form of snow, surface runoff does not occur until the snow melts. In this case, the rate and volume of surface runoff discharges is controlled by the rate of snow melt.

- **Infiltration**—Infiltration occurs as rain water passes into the soil. The ability of soil to infiltrate water depends on a number of factors, including soil properties, soil

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moisture content, vegetation cover, and the presence of impervious structures, such as pavement. Water that infiltrates into the soil can be subject to interflow, ground water recharge, and evapotranspiration.

- **Interflow**—Interflow (i.e., subsurface flow) occurs when water infiltrates into the soil and flows through the soil above the water table. Interflow can occur until water enters a drainage ditch, storm sewer, surface receiving water, or the ground water.

- **Ground Water Recharge**—Ground water recharge occurs when water infiltrates into the soil and enters the water table. Ground water then flows toward and into natural or artificial channels or other receiving waters. The flow of ground water to surface waters maintains flows in natural and manmade drainage ways and impoundments during dry weather conditions.

- **Evapotranspiration**—The term evapotranspiration describes two processes—evaporation and transpiration. Evaporation is the process where liquid water changes to a vapor. Transpiration occurs when water moves through vegetation and is then evaporated.

- **Surface Runoff and Natural Drainage**—Surface runoff (i.e., overland flow) occurs when water generated from precipitation or snow melt moves across the ground to a natural or constructed channel or some other receiving water. Natural drainage defines the flow of water through naturally occurring receiving waters and into the ocean. Because the natural drainage system contains a wide range of receiving waters, including wetlands and intermittent streams, it is often difficult to determine the point at which surface runoff ends and natural drainage begins. Although such distinctions may be important in our legal system, they have limited importance in the workings of the hydrologic cycle.

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B.1.2 Impacts of Land Use Activities on the Hydrology of Watersheds

Typically, a watershed is a geographic region in which surface waters flow towards a common receiving point such as a stream, river, lake, or estuary. The natural drainage system of a watershed may comprise many types of surface water features, including wetlands, intermittent streams, small perennial streams, and larger receiving waters. In other uses of the term, watersheds may also be defined based on ground water flows and aquifers.

As watersheds are developed for urban or agricultural uses, resource extraction, or other purposes, the natural drainage features of the water are often altered. Wetlands are dredged or filled, reducing the natural storage capacity of the drainage system, which, prior to its loss, damped peak flows associated with storm events. Smaller streams can be channelized, rip-rapped, or diverted into underground culverts, all of which allow the flow rates in the channel to increase.

The hydrology of the watershed also is changed by activities occurring on land. The natural drainage features of undeveloped land slow the flow of runoff by incorporating rainfall into the natural hydrologic cycle. Many types of development cause an increase in the volume of surface runoff and its rate of discharge. A given storm event will yield more runoff with a faster rate of discharge for a developed area than for an undeveloped area of the same size. These increases in the rate of flow and the total volume of flow often have a decided effect on pollutant loads, erosion rates, and flooding.

A number of factors can increase the volume and rate at which runoff flows from a developed site. Clearing land removes the vegetation cover that previously intercepted precipitation before it hit the earth. The thick humus layer associated with the vegetative cover is often removed or eroded away during grading activities, decreasing the ability of the surface to infiltrate and retain precipitation. The land is graded to make the surface smoother by removing natural depressions. Site slopes may be increased as part of terracing to improve site drainage. Wetlands, which may have previously soaked up water associated with peak flows, are drained or filled. Impervious structures, such as roads, parking lots, driveways, rooftops and sidewalks, are built. In other heavily used areas, soils become compacted and lose their ability to infiltrate precipitation.

After development has occurred, the natural drainage system (e.g., streams, wetlands, and other receiving waters) is often unable to handle the higher volume flows, resulting in high erosion rates or flooding. Drainage systems that have undergone these changes often need additional "improvement" from channelization or lining projects. In addition, streams are often directed through underground culverts.

The same characteristics of land development that cause higher peak flows also cause less infiltration of rainfall to recharge ground water supplies and a lowering of the water table. One result of lowered water tables is that surface stream flows during dry weather can be lowered significantly. Lower flows during periods between storms may significantly affect the aquatic habitat and the ability of a stream to dilute toxic spills or other dry weather pollutants within the stream system (Bellevue NURP). In some cases, the installation of storm sewers in a watershed results in small, previously perennial, streams running dry several times a year (Long Island NURP).

B.1.3 General Physical Characteristics of Storm Water Discharges

Storm water discharges are diffuse in nature; discharges in a watershed are generated by an extremely large number of points. Three characteristics of storm water discharges are particularly important when analyzing potential impacts of these diffuse sources within a watershed. Storm water discharges 1) may affect broad portions of a watershed, 2) can have high volumes, and 3) are generally of limited duration.

B.1.3.1 Effects on Broad Portions of a Watershed

Unlike many other major point source discharges that are directed to larger receiving water bodies or to relatively remote offshore locations, storm sewers discharge to essentially all of the portions of the drainage system within developed areas of the watershed. As a

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result, the impacts of storm water discharges, although more subtle, may be more widespread and potentially may affect a greater degree of the natural drainage system than traditional point source discharges.

Perhaps the widespread nature of storm water discharges is most evident when considering large urbanized areas.[1] Essentially all receiving waters in urbanized areas receive storm water discharges from some type of urban land, regardless of the sensitivity of the receiving water to potential impacts. This is because typical storm water management practices attempt to drain water from the land as soon as possible and discharge it to the nearest receiving water whether or not the receiving water has the ability to handle increased flows and pollutant loads.

In heavily developed areas, urbanization results in widespread alteration or destruction of much of the natural drainage system. Many of wetlands in these areas are drained or filled, while smaller streams can be heavily modified. These alterations to the natural drainage system decrease the system's ability to remove pollutants, function as habitat, and handle large flows. The cumulative impacts of these widespread effects can potentially affect larger downstream components of the watershed.

B.1.3.2 High Volumes/Velocities

A typical storm may generate a large number of storm water discharges within a watershed. The cumulative volume of these discharges may be high relative to the typical volume of flow of receiving waters. These high volume discharges may dramatically increase flow velocities in streams and drainage channels. High volume storm water discharges and resultant rapid stream velocities cause the combined effect of increasing:

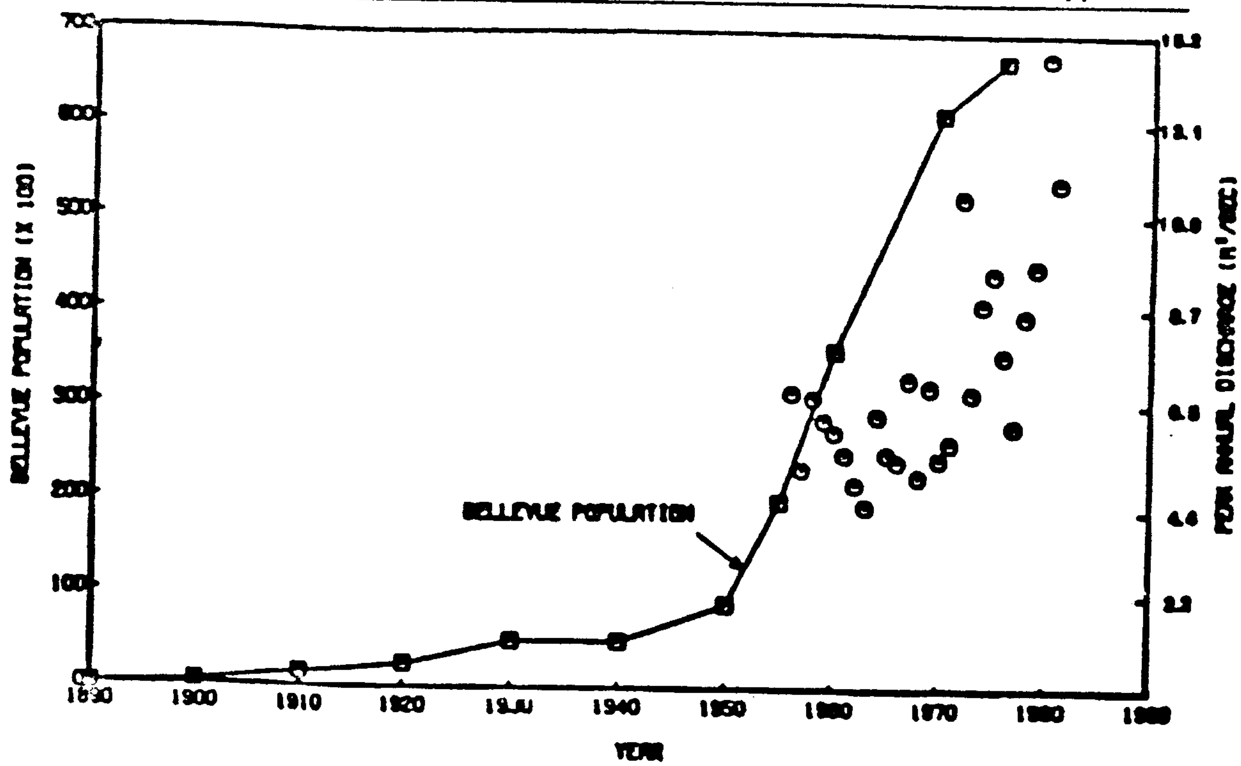
[1] As discussed in more detail in Chapter 3, the 366 urbanized areas designated by the Bureau of Census range in area from 17 square miles (Grand Forks, ND-MN) to more that 2,800 square miles (New York, NY-NJ).

- Pollutant loads
- The ability of discharges to erode the land and carry pollutants off the land
- The ability of streams to resuspend pollutants in bottom sediments and erode stream beds and stream banks
- The ability of streams to carry pollutants to slower flowing water bodies where pollutants may accumulate
- The need for stream channelization, installation of concrete walls, riprap, or other modification projects.

Figure B-1 shows the relationship between population and the volume of the peak annual flow in the Bellevue, Washington, watershed. The volume of the peak annual flow in the watershed almost doubled as the population in the city increased from 10,000 to 67,000. Peak flows that used to return every 10 years can now be expected to return at least every other year. Although the monthly average total volume of flows in the watershed increased only slightly over pre-urbanization years, the volume of flows during peak events increased two to three times as a result of urbanization. This increase in the volume of the peak annual watershed flow volumes increased stream bank erosion and stream bed scour, as well as the frequency of flooding. The increase in intensity of runoff has created unstable stream banks, which have eroded at a rapid rate. The stream channel is narrower and deeper than those of typical undisturbed streams serving similar watersheds. Pools and other sites along the stream bed that had slowed flows in the past have been removed by the higher flows.

B.1.3.3 Limited Duration

Although storm events and the resulting storm water discharges are of limited duration, pollutants in these discharges can cause both short- and long-term impacts on receiving waters. Short-term impacts generally occur during or shortly after a storm event. These impacts are usually caused by high levels of pollutants associated with the storm water discharges. Materials other than storm water, such as spills or dumped material, that discharge from a separate storm sewer may also cause short-term water quality impacts.



Source: Scott, Steward, and Stober

Figure B-1. Population of Bellevue and Peak Annual Discharge in Kelsey Creek (O). Data From U.S.G.S. and Bellevue Planning Dept. 1977

Long-term water quality impacts associated with storm water may be caused by pollutants accumulating in a watershed or by repeated exposures to pollutants from a large number of events. In addition, habitat destruction and other physical impacts, such as stream bed scour, can occur over a long period of time.

Although individual storm events are of relatively short duration, receiving waters may be affected by storm water discharges for time periods that are significantly longer than the storm event. The length of time that pollutants from storm water discharges remain in a receiving water will depend on four factors: 1) the duration of the storm event, 2) the size of the watershed, 3) flow rates in the receiving water, and 4) the tendency for pollutants to accumulate in bottom sediments.

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Small streams with small drainage basins respond immediately to the pollutants in storm water discharges, with pollutants passing through at relatively high velocities as a discrete pulse. High pollutant levels in large flowing rivers may occur at downstream locations for an extended period of time. Pollutant concentrations in large rivers initially rise with the onset of a storm event. After a storm is over, pollutants from storm water discharges to feeder streams draining upstream portions of a watershed can keep pollutant levels elevated at downstream locations of the river for an extended period of time. Pollutants in storm water discharges from upstream land uses may continue to impact a location for several days after the event.

Receiving waters with slower flows and longer resident times, such as impoundments, lakes, reservoirs and estuaries, may be affected for long time periods by pollutants from short-duration storms. Hence, the limited duration of individual storm water discharge events is of less importance when considering potential impacts on these receiving waters. In these receiving waters, slower velocities will result in many types of pollutants accumulating in bottom sediments where they may cause long-term impacts.

B.2 TYPES OF ADVERSE IMPACTS ASSOCIATED WITH STORM WATER DISCHARGES

Table B-1 summarizes the pollutant classes and pollutant sources identified in the 1992 National Water Quality Inventory as major causes of water quality impairment. The National Water Quality Inventory summarizes information regarding water quality impacts that is submitted by States in Section 305(b) reports. The summary generally identifies conventional pollutants, such as nutrients, sediment (siltation), oxygen demand, and pathogens, as the leading causes of surface water impairment reported by the States. Toxicity, caused by metals, priority organics, pesticides, oil and grease, and inorganic pollutants, is also identified as a major cause of impairment.

Table B-1. Top Five Pollution Sources and Contaminants

Five Leading Sources of Water Quality Impairment			
Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Municipal Point Sources
2	Municipal Point Sources	Urban Runoff/Storm Sewers	Urban Runoff/Storm Sewers
3	Urban Runoff/Storm Sewers	Hydrologic/Habitat Modification	Agriculture
4	Resource Extraction	Municipal Point Sources	Industrial Point Sources
5	Industrial Point Sources	Onsite Wastewater Disposal	Resource Extraction
Five Leading Causes of Water Quality Impairment			
Rank	**Rivers**	**Lakes**	**Estuaries**
1	Siltation	Metals	Nutrients
2	Nutrients	Nutrients	Pathogens
3	Pathogens	Organic Enrichment/Low DO	Organic Enrichment/Low DO
4	Pesticides	Siltation	Siltation
5	Organic Enrichment/Low DO	Priority Organic Chemicals	Suspended Solids

Source: National Water Quality Inventory, 1992 Report to Congress, EPA, 1994.

The National Water Quality Inventory primarily addresses larger receiving water bodies and does not address major portions of the natural drainage system of most watersheds, such as smaller feeder streams and wetlands.

This section briefly describes the major classes of pollutants associated with water quality impacts. For each class, special considerations regarding storm water discharges are discussed. Three additional pollutant classes, acidity, temperature, and floatables, that are of special concern when addressing storm water discharges are also discussed.

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B.2.1 Siltation/Sedimentation

Siltation from sediment pollutant loads can cause a broad range of interrelated impacts in receiving waters, including the following:

- **Loss of Benthic Habitat**—Increased stream flows and velocities produced by high volume storm water discharges may cause channel scour and bank erosion that result in habitat destruction. Suspended solids are deposited as sediment bars or sediment blankets in pools and other areas of reduced stream energy. These blankets can smother benthic organisms, including the eggs and immature forms of free-swimming organisms (Gupta, 1981; Novotny and Chesters, 1981).

- **Reduced Water Storage Capacity**—Increased sediment loads reduce water storage capacity in reservoirs (Novotny and Chesters, 1981). Nationwide, the average annual depletion rate of reservoir storage capacity caused by sedimentation is estimated at 0.2 percent (Tourbier, 1981). Sediment loads also decrease the depths of streams, which decreases the retention and conveyance capacity of streams and may result in increased flooding.

- **Impaired Oxygen Exchange**—Increased turbidity levels impair the ability of aquatic organisms to obtain dissolved oxygen from the water by interfering with the gill movements and associated water circulation (Novotny and Chesters, 1981).

- **Decreased Light Penetration**—The depth of light penetration into surface waters is sharply diminished by turbidity. As a result, photosynthetic activity and food sources are reduced. Loss of submerged aquatic vegetation may also remove habitat for juvenile fish and shellfish.

- **Impaired Navigation**—Accumulated sediments in river channels limit the passage of deeper draft boats, preventing navigational access or increasing the frequency of required channel maintenance dredging (Gupta et al., 1981; Novotny and Chesters, 1981). In some locations, sediments are so contaminated with pollutants that they should be handled as hazardous wastes, which dramatically increases disposal costs. Dredging activities result in re-suspension of pollutants in the sediment, causing additional water quality and aquatic habitat impacts (Novotny and Chesters, 1981).

- **Increased Water Treatment Costs**—Sediments can increase the costs of treating potable water supplies. Inadequate sediment removal may limit the germ-killing effects of chlorination.

- **Accumulation of Pollutants**—Many of the pollutants associated with many types of storm water discharges become chemically or physically bound with sediment particles. As these particles settle, the attached pollutants also sink (Brown et al., 1985; Novotny and Chesters, 1981). Sediments with attached pollutants can act as a source of contamination to the overlying water, to the benthic biota, and to the food chain. Over long periods of time, sediments may accumulate such high levels of toxics and other pollutants that exceedances of ambient water quality standards may occur in the water columns, increasing exposure of organisms to toxic chemicals (Harrington, 1986). Oxygen demanding pollutants in sediment deposits may also create oxygen deficits during and after storm water discharge events (Heaney and Huber, 1984; Mancini and Plummer, 1986; Novotny and Chesters, 1981).

- **Resuspension of Pollutants**—Highly variable flows in receiving waters can resuspend sediments, thereby increasing water column concentrations of those pollutants that had accumulated in bottom sediments. The repetitive process of deposition, re-suspension, and re-deposition of sediments may result in pollutants associated with sediments taking a long time to pass through a receiving stream (Novotny and Chesters, 1981).

B.2.2 Nutrients

Nutrients support and stimulate aquatic plant life. Natural nutrient cycles may be altered by land use activities within a watershed. Excessive nutrients overstimulate the growth of

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aquatic plants, which may result in low oxygen levels, accelerate eutrophication, cause unsightly conditions, interfere with navigation, interfere with treatment processes, and cause unpleasant and disagreeable tastes and odors. Eutrophic conditions are evidenced by surface algal scums, reduced water clarity, odors, and dense algal growth on shallow water substrates (Schueler, 1987). Algal blooms block light from submerged aquatic vegetation, which may remove habitat for juvenile fish and shellfish. After blooms or at the end of a growing season, the decomposition of dead vegetation may cause reduced oxygen levels. Reduced oxygen levels may, in turn, cause fish kills and mass mortality of benthic organisms.

Excessive nutrients may have more adverse effects in surface water bodies that have slow flushing rates, such as slow moving rivers, lakes, and estuaries. Nutrients delivered during storm events settle to sediments of such waters. Once in sediments, the nutrients can be solubilized or re-suspended by anaerobic conditions, currents, changes in concentration gradients, or the mixing effects of boat wakes (Field and Turkeltaub, 1981).

Aquatic vegetation requires both nitrogen and phosphorus to grow. Excess quantities of nitrogen are commonly present in fresh water, so plant growth is usually controlled by the levels of phosphorus input (Schueler, 1987). In marine waters, however, phosphorus is often in greater supply, and plant growth is controlled by nitrogen concentrations. In either case, when the controlling nutrient is added, greater plant growth is expected.

Several forms of phosphorus occur in the aquatic environment. Major forms of phosphorus include orthophosphorus (OP), dissolved or soluble phosphorus (DP), particulate phosphorus (PP), and total phosphorus. Orthophosphorus is the form immediately available for algal growth. Particulate phosphorus is considered to be potentially available after conversion to OP. During stream transport, OP is likely to become incorporated into the particulate fraction. A portion of the phosphorus bound to sediment particles can also be released as OP. Exchange between available and potentially available forms continues though processes of sediment and algal uptake and release. Transport distance from phosphorus sources to impacted receiving waters is recognized as a major factor in determining the availability and timing of load delivery. Strict control of phosphorus levels from direct and proximal discharges to affected receiving waters is recommended because of the high level of OP delivered from these discharges.[2]

Nutrient loading is directly related to the frequency of runoff events in developed watersheds and can vary by a factor of 3.5 between wet and dry years at the same location (Lung, 1986). High quantities of nitrogen and phosphorus may be transported in surface run-off in the dissolved form or attached to sediments; the relative significance of these two forms may vary seasonally, reflecting differing winter and summer runoff conditions (Jones, 1986; Urbonas and Roesner, 1986). Nitrogen and phosphorus concentrations in storm water from residential and commercial areas may occur at levels sufficient to stimulate excess growth of algae and aquatic macrophytes (i.e., eutrophication), partly because most of these nutrients occur in soluble forms that are readily assimilated by plants (Schueler, 1987).

Nitrate (generally the most stable form of nitrogen) at levels above the drinking water standard of 10 milligrams per liter can cause methemoglobinemia in infants under six months. This rare, but potentially fatal disease limits the oxygen carrying ability of the blood.

B.2.3 Organic Enrichment/Oxygen Demand

Aquatic organisms, such as fish and water-dwelling insects, require minimum levels of dissolved oxygen (DO). Excessive oxygen demanding pollutants can lead to periods of oxygen sag, which may cause fish kills and create anoxic conditions accompanied by foul-smelling odors. Oxygen levels in receiving waters can be lowered by the decomposition of organic matter by microorganisms, by the chemical oxidation of material, or by aquatic vegetation, which uses more oxygen at night than it produces.

Oxygen demand is the term applied to pollutant loads that result in reduced dissolved oxygen levels. The two parameters most commonly used to describe the oxygen demand of

[2] *Phosphorus: A Summary of Information Regarding Lake Water Quality*, IL EPA, August 1986.

pollutants are the 5-day biochemical oxygen demand (BOD5) and chemical oxygen demand (COD). BOD measures oxygen demanding substances that can be metabolized by bacteria and is an indicator of biodegradable organic matter. COD measures oxygen demanding substances that react with an oxidizing chemical in a heated acid bath. COD is an indicator of both organic matter and reduced inorganic chemicals. Of the two, COD is more accurate for the purpose of comparing the oxygen demand of storm water discharges to the oxygen demand of other types of discharges. The BOD5 test underestimates the true oxygen demand of storm water because the heavy metals in the storm water slow the bacterial action used in the test.

Storm water runoff may contain both organic and inorganic pollutants that consume oxygen in receiving waters. Storm water discharges generally occur on overcast days when the amount of sunlight available to oxygen producing plants in water is limited. Lower oxygen production rates increase the adverse impacts of oxygen demanding pollutant loads. Much of the oxygen demanding pollutant load of many types of storm water discharges is associated with suspended solids, which may form deposits in receiving waters. These deposits may result in long periods of low dissolved oxygen through gradual decomposition or may re-suspend during later runoff events. The impacts of oxygen demanding pollutants may be more dramatic in shallow, slow-moving waters due to limited aeration and the tendency of these pollutants to accumulate in bottom sediments of slow-moving waters.

Dissolved oxygen depletions may occur at times substantially different from the actual storm event, which originally discharged the oxygen demanding pollutants. Re-suspension of sediments with attached oxygen demanding pollutants during high flows worsen and delay the dissolved oxygen depletions.

B.2.4 <u>Pathogens</u>

Pathogens are disease-causing organisms, including viruses and some bacteria. Waterborne pathogens may be transmitted to humans or animals through direct recreational contact, drinking water supplies, or through eating contaminated shellfish. Major pathogen sources include human and animal wastes.

Separate storm sewers, unlike combined storm sewers, are not designed to carry sanitary sewage. However, pathogens may enter separate storm sewers from leaking sanitary sewers, illegal cross connections with sanitary sewers, and malfunctioning septic tanks. In addition, runoff can pick up pathogens from animal wastes on the land. Conditions inside a storm sewer system are often conducive to pathogen reproduction.

Due to difficulties and expenses associated with measuring pathogens directly, bacteria, including total coliform, fecal coliform, and fecal streptococci, are used as indicators of pathogens even though many of these bacteria are harmless. EPA studies indicate that although fecal coliforms are a good indicator of human pathogens for POTW discharges, they are inadequate indicators of human pathogens for many types of storm water discharges (51 *FR* 8012, March 7, 1986). However, most State and local health criteria for recreational contact and shellfish are based on fecal coliform levels, partially due to the low cost of testing procedures. As a result, storm water discharges are responsible for a significant number of restrictions placed on recreational uses and shellfishing.

B.2.5 Toxicity (metals, toxic organics, pesticides, inorganics, and oil and grease)

A wide range of chemicals may exhibit toxicity. Five major classes of chemicals that have toxic impacts recognized in the National Water Quality Inventory are metals, toxic organics, pesticides, inorganic pollutants, and oil and grease.

Toxic impacts may be classified in terms of acute and chronic effects. Acute toxicity refers to lethal concentrations or doses of toxic materials, which result in death of aquatic organisms in a relatively short time. Chronic toxicity refers to impacts, such as the formation of tumors, lowered reproductive, growth, or survival rates, that occur after a longer exposure to toxic substances. Bioaccumulation, or the accumulation of toxic chemicals in tissues of organisms, is another long-term effect of toxic substances that may affect the organism

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directly exposed to the chemical, or other animals, including humans, that consume contaminated organisms. For a given chemical constituent (or a mix of constituents) chronic toxicity occurs at lower concentrations than the concentrations that may cause acute effects. However, the exposure time necessary to trigger chronic effects is longer than the exposure times that cause acute effects.

Pollutants that are highly resistant to natural degradation processes are referred to as conservative pollutants. Conservative pollutants have a greater opportunity to cause chronic toxic effects or to bioaccumulate in organisms. Conservative pollutants also have the potential for wider dispersal in the environment through bioaccumulation and subsequent transfer in living organisms, such as fish, plankton, and fish eating birds and mammals. Toxic conservative pollutants include trace metals and some organic compounds, such as chlordane, polychlorinated biphenyls, and other halogenated hydrocarbons. Metals do not degrade, and some organic compounds degrade so slowly that they may remain in sediments for decades.

Many of the toxic metals and other toxic constituents in storm water discharges are attached to suspended solids in the discharge and settle out and accumulate in the bottom sediments of receiving waters where they may persist for long periods of time. Toxics concentrated in bottom sediments may cause adverse impacts on benthic organisms, may become resuspended during high flows resulting from other large storm events, or may dissolve into the water as parameters such as pH and dissolved oxygen change. Accumulated pollutants in bottom sediments may also adversely affect fish during periods of continuous low flow.

B.2.6 Flow Alterations

Activities on the land may cause dramatic changes to the natural hydrologic cycle. Changes in peak flow rates of receiving streams and associated increases in flow velocities cause changes in the stream shape and structure. Increased flow velocities have a greater ability to erode stream beds or stream banks. Stream channels may either be widened or made deeper, with large amounts of soils being swept downstream, forming shifting sandbars

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or other sediment deposits. Streams may widen to two to four times their pre-development width if storm water is uncontrolled from developed areas. High erosion rates adversely affect habitat by destroying benthic structures and habitat. High creek flows may also sweep poor swimming fish from the creeks and transport leaf material at higher rates, limiting the availability of food for macroinvertebrate organisms. Channelization projects that drain natural wetlands for development may dramatically alter natural flow patterns. These projects will greatly diminish or destroy the pollutant removal and flow attenuation abilities of the wetlands.

Increased flows associated with urbanization are often accompanied by the installation of extensive channelization projects to increase the flow capacity of the water course and limit erosion damage during storm conditions. Typical channelization projects include riprap, concrete retention walls or lining along stream banks, channel realignment, and diversion of streams through culverts.

After the initial construction of a channelization project is completed, both direct and indirect sources of pollution occur. Channelization projects reduce channel roughness to further increase flow velocities. Increased flow velocities that exceed the stability velocities of the bottom or bank materials cause erosion or scour. Such activity degrades the channel and furnishes sediment for stream transport, destroys natural habitats, and detracts from the aesthetics of the stream. In general, the more extensive the modification, the more damage caused to habitat areas. For example, concrete lining of channels eliminates habitat areas and aesthetic values for practical purposes. Increased channel dimensions may deprive the stream flow of shade from trees along streams banks, resulting in increased water temperatures. These types of projects may worsen downstream flood problems where storm flows are unable to spread out onto a flood plain and increased velocities increase erosion along unprotected banks downstream.

B.2.7 Acidity

Aquatic life may only be supported in a limited range of pHs. Receiving waters that are highly acidic (have a low pH) may be totally devoid of life. In other receiving waters, fish kills may be caused by periodic highly acidic conditions. Periodic episodes of acidity may be particularly harmful to juvenile fish, which tend to be more sensitive and reside in the smaller streams of a watershed, which are more likely to experience wider pH swings. In addition, acidic rain generally will have higher concentrations of heavy metals and other pollutants, which leach under acidic conditions.

Acidity in storm water may be caused by two sources—air pollutants and certain land use activities. Mining is the land use with the most well known acidic storm water discharges. Coal mining in the eastern United States generally involves coal that is high in sulfur and is historically associated with some of the most dramatic water quality impacts caused by acidity.

Nitrogen oxides (NO_x) and sulfur dioxide (SO_2) are the primary air pollutants that result in acid rain and, hence, highly acidic storm water. Acid rain occurs when SO_2, emitted primarily by electric utilities fired by eastern coal, and nitrogen oxides (NO_x), emitted primarily by transportation sources and utilities, are deposited in the form of wet or dry deposition. Rain in the western United States typically has a regional pH of 5.5 or above. Rain in the eastern United States is more acidic, with regional pH values below 4.2 in some regions. More than 80 percent of the SO_2 emissions in the United States originates in the 31 States bordering or east of the Mississippi River, with a heavy concentration from States in or adjacent to the Ohio River Valley. These airborne emissions are transported by prevailing winds to the east. Figure B-2 indicates regional acid rain patterns.

Several aspects of urbanization tend to create local conditions that may make receiving waters susceptible to impacts from acidity. High levels of airborne SO_2 and NO_x in large urbanized areas increases the acidity of the rainfall in the urbanized area to levels above those typically found for the region. Runoff from paved surfaces and other impervious surfaces

Data from four networks are plotted: Canada, CANSAP (circles) and AAPN (squares); United States, NADP (circles) and MAP3S (squares).

Source: Barrie and Hales, 1984.

Figure B-2. Spatial Distribution of the Precipitation-Amount-Weighted Annual Mean Hydrogen-Ion Concentration (expressed as pH) in North America in 1980

may have little or no opportunity to contact soils that may buffer the acidity of the rainfall. In urbanized areas with acidic rain, higher runoff volumes and rates associated with the urban development can increase the acidity of receiving streams rapidly and to high peak acidity levels. This results from more acid being deposited to receiving streams in a shorter amount of time.

B.2.8 Temperature

Increased temperature may have detrimental effects on fish and other aquatic life during various stages of their life cycle. Water holds less oxygen as it gets warmer, which may affect habitat and make the water more susceptible to oxygen demanding pollutants. Sustained water temperatures in excess of 70°F are considered stressful or lethal to many cold water fish species and stream insects. The availability of food, attendant life cycle chemistry, and water quality changes are all affected by water temperature.

During warm weather, the temperature of storm water discharges is generally higher than receiving water temperatures. High volumes of runoff from hot paved surfaces and rooftops may cause a rapid increase in surface water temperatures. Discharges from storm water management devices, which retain collected runoff in unshaded ponds for extended time periods, may also increase stream temperatures.

B.2.9 Floatables, Including Plastics

A large percentage of the litter and plastics that is found on land, if not removed, will eventually be flushed, swept, or blown down a storm sewer. Plastics, metals, and many other types of floatables degrade at extremely slow rates, increasing the time that they remain in receiving waters.

Litter and other floatables degrade aesthetic values, which play a role in the recreational uses of receiving waters, property values of nearby lands, and other broad community-level values. Economic losses caused by the aesthetic degradation of recreational areas, such as beaches, are significant. Plastic debris presents hazards to wildlife. Ingestion of plastic material by turtles and seabirds appears to present the biggest threat to wildlife. Floatables and plastics may also clog outlet structures of various types of storm water management devices, resulting in flooding or other system malfunctions.

B.3 ADVERSE IMPACTS BY TYPE OF RECEIVING WATER

Impacts on receiving waters associated with storm water discharges may be discussed in terms of three general classes: 1) short-term changes in water quality, 2) long-term water quality impacts, and 3) physical impacts.

Use impairment of receiving streams often is caused by a combination of all three types of impacts. Physical impacts and short-term water quality changes are generally more critical than long-term water quality impacts for receiving waters with relatively short residence times (such as smaller streams and rivers). Receiving waters with long residence times (lakes, estuaries) are generally more sensitive to long-term water quality changes, although certain physical changes, such as loss of reservoir capacity due to siltation, can be important.

Short-term changes in water quality occur during and shortly after storm events. Examples include periodic dissolved oxygen depressions due to oxidation of pollutants, short-term increases in the receiving water concentrations of one or more toxic pollutants, high bacteria levels, and high acidity. These conditions can result in fish kills, loss of submerged macrophytes, and other temporary use impairments.

Long-term water quality impacts are caused by the cumulative effects associated with repeated storm water discharges. These impacts often result from the cumulative effects of pollutants from a number of different types of sources. When evaluating long-term impacts, the cumulative and relative effects of seasonal and long-term pollutant loadings from all relevant sources (e.g., storm water, publicly owned treatment works, industrial discharges, nonpoint sources, atmospheric deposition, in-place pollutants) should be considered.

Examples of the long-term water quality impacts that storm water discharges may cause or contribute to include depressed dissolved oxygen caused by the oxygen demanding pollutants in bottom sediments, biological accumulation of toxics as a result of uptake by organisms in the food chain, chronic toxicity to organisms subject to repeated exposures of toxic pollutants, destruction of benthic habitat, loss of storage capacity in receiving waters, and increased lake eutrophication. Long-term water quality impacts are also caused by pollutants attached to suspended solids that settle in receiving waters and by nutrients that enter receiving water systems with long retention times. In both cases, long-term water quality impacts are caused by increased residence times of pollutants in receiving waters. Long-term water quality impacts of pollutants from storm water discharges may be manifested during critical periods other than during storm events (e.g., during low stream flow conditions and/or during sensitive life cycle stages of organisms).

Physical impacts may occur due to the erosional effects of high-volume flows and high-stream velocities that occur after the natural hydrologic cycle is altered. These changes are often accompanied by the installation of engineered structures, such as concrete walls or underground culverts, which may further degrade the habitat and aesthetic values of the receiving water. In addition, if ground water recharge is limited by the placement of impervious structures on the land, dry weather base flows may be lowered to the detriment of the receiving water.

B.3.1 Rivers and Streams

The *National Water Quality Inventory - 1992 Report to Congress* (EPA, 1992) indicates that the States identified the most extensive causes of impairment in the Nation's rivers as siltation (affecting 45 percent of impaired river miles), nutrients (affecting 37 percent), pathogen indicators (affecting 27 percent), pesticides (affecting 26 percent) organic enrichment/low dissolved oxygen (affecting 24 percent), and metals (affecting 19 percent). Discharges from storm sewers are identified as affecting 11 percent of the impaired river miles. The assessments focused primarily on larger streams and rivers and did not address many of the heavily degraded small streams found in urban areas and elsewhere.

The effect of human activities on the natural hydrologic system may be most evident on smaller streams. Development of a site may dramatically increase the volume and the maximum discharge rate of storm water discharges. Where a sufficient number of sites within the drainage basins of smaller rivers and streams occurs, the stream may experience increases in the magnitude and frequency of flooding, as well as extremely high-stream velocities associated with storm events.

Such changes in the hydrology of a stream may result in accelerated stream bank or stream bed erosion. Such erosion may cause or contribute to a number of generally detrimental effects, including widening or deepening of the stream channel, elimination of pools and other structures in the stream, and shifting of gravel or sand bars. In addition, base flows may be lowered during dry weather.

Streams that have experienced increased flooding or peak velocities often undergo a high degree of additional human flow modification, including channel excavation, lining, realignment, or diversion through underground culverts, which may have, for all practicable purposes, destroyed both fish and wildlife habitat and natural aesthetics. In many cases, highly modified streams are considered to be part of the storm sewer system.

Pollutant concentrations in smaller streams and rivers may experience relatively short-duration increases due to storm water discharges. However, in smaller streams, the concentration of pollutants may be almost as high as the concentrations found in discharges where dry weather base flows are significantly lower than wet weather flows and provide only limited dilution.

Larger rivers often respond slower to storm events than do smaller streams. After a storm event hits a large drainage basin, a given segment of the river may experience degraded water quality for several days because a single location on the river is sequentially affected by pollutants from different upstream sources caused by the same storm. For example, a segment may be influenced by urban runoff, only to then be influenced by agricultural runoff generated upstream of the storm water source, followed by silvicultural runoff from the river's headwaters.

In many streams, flow velocities slow substantially with increases in stream width or decreases in stream gradient. At these points, sedimentation of fine particles and associated pollutants result. The settled sediments can act as a reservoir for pollutants affecting the water column and the food chain long after the rain has ceased. In addition, disturbance of the deposited sediments by scouring from storm water discharges or combined sewer outfalls, navigation, construction, or dredging may re-introduce the sediments and their pollutants to the water column. The result can be a recurrence of adverse impacts originally associated with the storm water discharge.

The degree of impact on the river or stream depends on a number of factors, including the frequency and duration of the storm water discharges, the quality and quantity of storm water discharges, the occurrence of other wet weather discharges (combined sewer overflow discharges), and the quantity and quality of the base flow (dry weather flow) of the stream. Because larger rivers receive pollutants from a wide variety of sources in urbanized areas, the quality of the base flow may be marginal or poor, thereby increasing the sensitivity of the receiving stream to storm water discharges. In streams with very low base flows, on the other hand, the storm water discharge may be the major determinant of the water quality of the stream.

B.3.2 Lakes and Reservoirs

The most extensive causes of use impairment in lakes are metals (affecting 47 percent of impaired acres), nutrients (affecting 40 percent), organic enrichment/low dissolved oxygen (affecting 34 percent), siltation (affecting 42 percent of impaired acres), and priority organic chemicals (affecting 20 percent). The States reported that 63 percent of lake acres assessed were not fully supporting designated beneficial uses. In addition, the States reported that discharges from separate storm sewers affect 24 percent of the impaired acres of lakes excluding the Great Lakes. Onsite wastewater disposal impaired 16 percent of the impaired acres. For the Great Lakes, discharges from storm sewers were identified as affecting 11 percent of the impaired shore miles, and land disposal 31 percent of impaired shore miles.

Compared with rivers and streams, lakes and reservoirs have long residence times. The time scale of water quality impacts and recovery may be on the order of years, decades, or even centuries (Manning et al., 1977). The impacts that occur are more likely to be the result of seasonal or annual loadings of pollutants rather than loadings from individual events. Lakes and reservoirs, with longer residence times and slower flow rates, tend to become sinks for many pollutants that attach to the sediments typically carried by storm water. Longer residence time, coupled with poorer aeration, also increases the impacts of nutrients and other oxygen demanding pollutants. The peak concentrations of pollutants in storm water discharges are less important in determining the severity of adverse impacts than the total loading of pollutants delivered to the lake because of the larger capacitance of the system.

In lakes and reservoirs that are deep enough to become thermally stratified, the impacts of introduced pollutants vary seasonally. Pollutants that settled to the bottom attached to solids may become re-introduced into the water column during the strong currents and mixing that can accompany storms, particularly in autumn. This effect has been illustrated dramatically in the Great Lakes (Rosa, 1985; Eadie et al., 1984; Charlton and Lean, 1987).

B.3.3 Estuaries and Coastal Waters

The States reported that the most extensive causes of use impairment in estuaries are nutrients (affecting 55 percent of impaired square miles), pathogen indicators (affecting 42 percent) and organic enrichment/low dissolved oxygen (affecting 34 percent). Discharges from separate storm sewers affected 43 percent of the impaired estuarine area. The States reported that storm sewers affected 59 percent of ocean shore miles and land disposal affected 42 percent of ocean shore miles.

The pattern of water flow in a given estuary results from the effects of tides and density differences between surface and deeper waters. In most estuaries, fresh waters have an

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outward, seaward current. Pollutants are initially carried by the fresh water currents. As pollutants attach to sediment and as the flow rates in the estuary slow due to larger flow basins, the pollutants and sediment sink and their outward flow is reversed when they enter heavier, saltier bottom waters that have a net flow landward. As a result, many pollutants remain trapped in estuaries and never reach open waters. Once these sediments have been deposited, they exert long-term effects on water quality through toxicity, bioaccumulation, or nutrient release.

Much of the nutrient load that is present in surface waters can be incorporated into algae, which then settle. As the algae settle, nutrients are released back into the deeper, inflowing waters. As the inflowing waters mix with outflowing surface waters, the nutrients are once again incorporated into algae. This vertical cycling of nutrients in estuaries, referred to as the nutrient trap, allows the slow accumulation of nutrients in the water column. Contributions of nutrients from storm water discharges increase the rate of this nutrient accumulation, worsening the problems of estuarine eutrophication, which is increasingly one of the major focuses of many of the National Estuary Program projects.

B.3.4 Wetlands

Wetlands are generally located adjacent to the other kinds of surface waters. Wetlands buffer the ultimate receiving water by slowing and storing high, wet weather flows and by removing pollutants. In addition, the intensive levels of biological activity in wetlands play an important role in the ecology of the receiving water.

Wetlands are often dredged or filled when development occurs near surface water or near the floodplain. The destruction of wetlands without appropriate storm water management destroys the capability of wetlands to hold runoff and remove pollutants before discharging to other surface waters. This, in turn, results in higher runoff volumes, which discharge to receiving waters at a faster rate.

Wetlands that are used to receive storm water discharges from upland development may also experience impacts. In some cases, the large flow volumes, flow velocities, and pollutant loads delivered by storm water discharges can alter or destroy stable wetland ecosystems. Storm water discharges with high sediment levels from sources such as uncontrolled construction site runoff may fill or alter flow patterns in wetlands over a long time period. Persistent toxics may also accumulate in sediments, vegetation, and the food chain.

If the adverse physical impacts of the storm water discharges can be minimized, the organically rich, shallow, biologically productive wetlands may act as a buffer or treatment for nutrients in storm water, thereby mitigating the impacts of storm water discharges on the receiving waters.

B.3.5 Ground Water

Due to hydrological connections between surface water and ground water, storm water management may affect ground water in two major ways. First, human activities on the land may have dramatic impacts on the hydrologic cycle, increasing the amount of surface runoff and decreasing the amount of infiltration that recharges ground water supplies. Decreasing ground water recharge can lower the water table, which results in lower dry weather base flows in surface waters and may make the operation of wells more costly. Second, pollutants in precipitation and runoff that infiltrates into an aquifer may not be removed by the soil and may enter an aquifer. This may be a particular concern where storm water management techniques used to control flooding and to improve surface water quality infiltrate surface runoff generated by development to an aquifer.

The types of pollutants in the infiltrated precipitation and the subsurface geology determine the beneficial value of infiltrated precipitation for recharging an aquifer or the potential for polluting ground water. Pollutants that are highly soluble in water (e.g., chlorides, nitrates) pass through the overlying soils into the ground water without attenuation. For example, chlorides from highway runoff containing road salt are shown to have adverse impacts on ground water, as well as surface waters. Other chemical parameters that are less soluble in water tend to adsorb to the soils before reaching ground water supplies.

The potential for ground water contamination strongly depends on the types of land use activities occurring on the surface. Two NURP projects (Long Island, New York, and Fresno, California) addressed sole-source aquifers recharged by runoff from residential and commercial areas for more than two decades. These studies concluded that no change in the use of these practices was warranted. Both studies found that soil processes at the sites were efficient in retaining the pollutants in the runoff close to the land surface, and pollutant breakthrough of the upper soil had not occurred. The EPA report *Class V Injection Wells: Current Inventory; Effects on Ground Water; and Technical Recommendations* (1987), rated the ground water contamination potential of storm water and industrial drainage wells as moderate.

B.4 REGIONAL AND SEASONAL DIFFERENCES

Precipitation patterns vary dramatically in different parts of the United States. A number of parameters are important in characterizing these regional differences, including the duration, intensity, frequency, and annual number of storm events of a given region. Variations in the precipitation patterns of a given region also occur seasonally. These variations affect the volume of storm water discharges produced, can result in seasonal impacts, and may affect management practices. In addition, snow removal and management activities have a special impact on the quality of discharges.

Among the more dominant regional characteristics are the dry summers on the west coast, the abrupt changes in the desert States of the southwest, the peaks occurring in spring and winter in the central gulf and Ohio Valley States, the uniformity of monthly totals throughout the year in the New England States, and snowfall and melt runoff occurring in the northern States.

Seasonal differences may change the nature of storm water discharges and the characteristics of receiving waters. Many smaller rivers in areas with extended dry seasons do not flow all year. The dry seasons in areas like the west coast result in higher than normal pollutant loads associated with the first several storms of the wet season. These discharges may occur when rivers and receiving waters are at low flow levels. Areas with higher intensity storms are prone to flooding and high erosion. Accumulation of pollutants in snow and snow removal activities may adversely affect the quality of snowmelt. In areas were rainfall patterns are non-uniform, soils can become saturated during wet seasons, resulting in higher storm water discharge volumes and erosion rates, as well as overloading of storm water management controls, such as retention and infiltration basins.

Figure B-3 shows 15 rainfall zones for the continental United States that EPA has defined based on annual precipitation statistics.[3] These zones are defined to provide a guide for defining regional patterns, with the geographical area assigned to a zone made as large as possible. Table B-2 summarizes annual precipitation statistics for these zones. The annual precipitation statistics shown in the table only include storm events that were greater than 0.1 inches and consider multiple storms separated by less than a 6-hour period of dry weather as one event. It should be noted that, in general, site-specific data should be used for developing designs for a specific location and that local deviations could be significant, particularly in western parts of the country where mountains, deserts, and coastal patterns result in large differences over relatively small distances.

[3] EPA, *Analysis of Storm Event Characteristics for Selected Rainfall Gages Throughout the United States*, Draft, Driscoll, E.D., et al., November 1989. These 15 rainfall zones represent a refinement of the 10 rainfall zones which appeared in a 1986 draft of the Driscoll reference and which are used in 40 CFR Part 122 Appendix E for the purposes of group applications for storm water discharges associated with industrial activity.

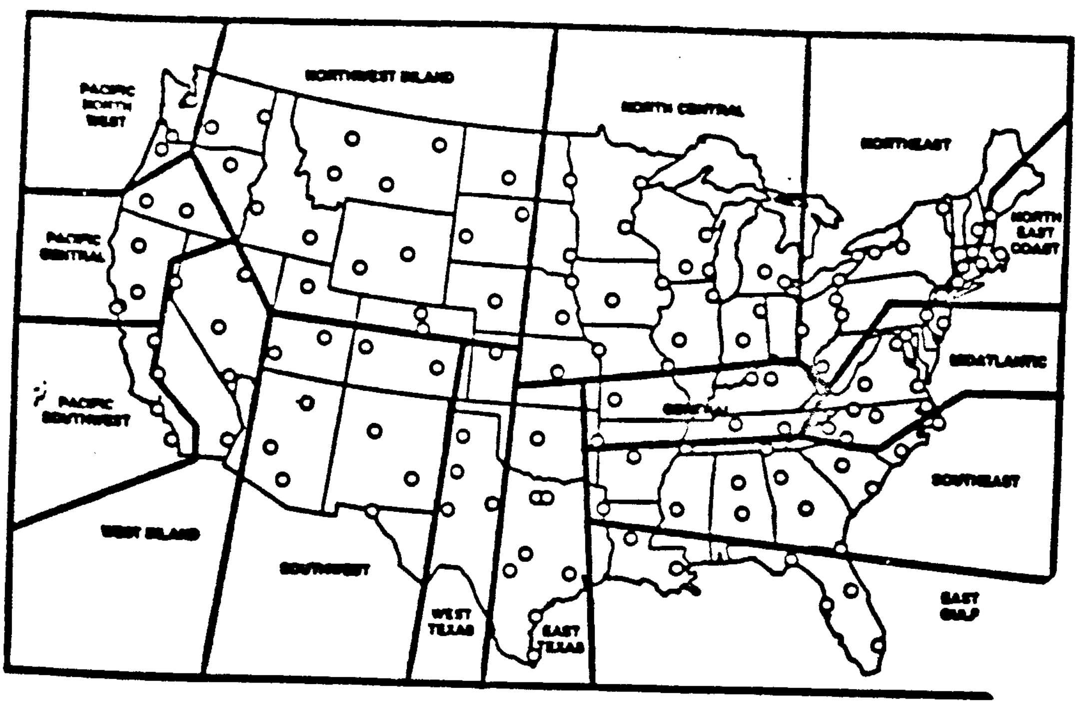

Figure B-3. Rain Zones of the United States

Table B-2. Typical Values of Annual Storm Event Statistics for Rain Zones

Rain Zone	Annual Statistics				Independent Storm Event Statistics							
	No. of Storms		Precipitation		Duration		Intensity		Volume		DELTA	
	Avg	COV	Avg (in)	COV	Avg (hrs)	COV	Avg (in/hr)	COV	Avg (in)	COV	Avg (hr)	COV
Northeast	70	0.13	34.6	0.18	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
Northeast-Coastal	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.66	1.03	140	0.87
Mid-Atlantic	62	0.13	39.5	0.18	10.1	0.84	0.092	1.20	0.64	1.01	143	0.97
Central	68	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
North Central	55	0.16	29.8	0.22	9.5	0.83	0.087	1.20	0.55	1.01	167	1.17
Southeast	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.10	136	1.03
East Gulf	68	0.17	53.7	0.23	6.4	1.05	0.178	1.03	0.80	1.19	130	1.25
East Texas	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.18	213	1.28
West Texas	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
Southwest	20	0.30	7.4	0.37	7.8	0.88	0.079	1.16	0.37	0.88	473	1.46
West Inland	14	0.38	4.9	0.43	9.4	0.75	0.055	1.06	0.36	0.87	786	1.54
Pacific South	19	0.36	10.2	0.42	11.6	0.78	0.054	0.76	0.54	0.98	476	2.09
Northwest Inland	31	0.23	11.5	0.29	10.4	0.82	0.057	1.20	0.37	0.93	304	1.43
Pacific Central	32	0.25	18.4	0.33	13.7	0.80	0.048	0.85	0.58	1.05	265	2.00
Pacific Northwest	71	0.15	35.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV = Coefficient of Variation = Standard Deviation/Mean
DELTA = Interval between storm midpoints

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APPENDIX C

NON-STORM WATER DISCHARGES TO STORM WATER CONVEYANCES

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APPENDIX C—NON-STORM WATER DISCHARGES TO STORM WATER CONVEYANCES

Although separate storm sewers are primarily designed to remove runoff from storm events, materials other than storm water find their way into and are ultimately discharged from separate storm sewers. Non-storm water discharges to storm sewers come from a variety of sources (EPA, 1990), including:

- Illicit connections and cross connections from industrial, commercial, and sanitary sewage sources
- Improper disposal of wastes, wastewaters, and litter
- Spills
- Leaking sanitary sewage systems
- Malfunctioning septic tanks
- Infiltration of ground water contaminated by a variety of sources, including leaking underground storage tanks.

One of the significant differences between storm water discharges and discharges from separate storm sewers affected by non-storm water is that non-storm water discharges may occur during dry weather when certain recreational uses of the receiving waters are more prevalent and stream flows are lower. In addition, pollutants from non-storm water discharges may accumulate in separate storm sewers until they are flushed out during a storm event, thereby contributing to higher pollutant concentrations and loads.

A wide range of pollutants may be contributed to storm sewers from non-storm water discharges, including pathogens, metals, nutrients, oil and grease, metals, phenols, and solvents. Removal of these non-storm water sources of pollutants often improves the quality of discharges from separate storm sewers dramatically.

The non-storm water discharges listed previously have a high potential for contributing pollutants to storm sewers (EPA, Pitt, 1992). Other non-storm water discharges may have less potential for contributing pollutants[1]:

- Water from street cleaning drainage
- Water from fire hydrant flushing
- Water from fire fighting activities
- Runoff from noncommercial residential activities, such as lawn watering, car washing, swimming pool discharges
- Water from water line breaks
- Certain cleaning water from commercial activities
- Condensate from residential and commercial air conditioning units
- Infiltration of uncontaminated ground water
- Industrial process wastewater, which has been issued a National Pollutant Discharge Elimination System (NPDES) permit.[2]

C.1 ILLICIT OR CROSS CONNECTIONS

Illicit connections, also referred to as cross connections, to separate storm water sewers are physically connected conveyances used to carry untreated wastewaters other than storm water. For many of these connections, there is a mistaken belief that materials are going to a sanitary sewer or some other type of treatment facility.

[1] See 55 *FR* 47990 (November 16, 1990) and "Investigations of Inappropriate Pollutant Entries Into Storm Drainage Systems", EPA, January 1993.

[2] EPA has clarified that it does not interpret the effective prohibition on non-storm water discharges to municipal separate storm sewers of Section 402(p)(3) of the CWA to prohibit non-storm water discharges in compliance with the conditions of an NPDES permit that discharge through a municipal separate storm sewer (see November 16, 1990, 55 *FR* 48037).

Illicit connections may take a variety of forms, including improper connections of residential sewer service lines or sumps, cross-connections with sanitary sewers, improper connections of industry sewer lines, and improper disposal of wastes to floor drains or outdoor drains connected to the separate storm sewer.

C.1.1 Improper Installation

In older sections of cities with separate storm sewers, the potential for improper connections to a separate storm sewer may be high. Problems with illicit connections in the oldest developed areas are often traced to the initial development of the storm sewer system (AWPA, 1990). Early storm sewers preceded the development of sanitary sewers. Once storm sewers were in place, however, they received other non-storm water sources of pollutants, some by direct connections and others from wastes dumped into the streets or storm sewers. Many cities prohibited the discharge of domestic sewage to storm sewers but failed to provide public sanitary sewers, resulting in secret illegal connections built without public supervision. Other illegal connections to the storm sewer were overlooked by municipal officials because of the lack of proper sanitary sewers or because the municipality did not have a program addressing the quality of discharges from the storm sewer system.

During redevelopment or infill development, illicit connections may arise when storm sewers are either mistaken for sanitary lines or the developer intentionally installs improper connections to a storm sewer that is more easily accessed than a sanitary sewer. Expanding or retrofitting large, older industrial complexes creates special problems if maps of the sanitary and storm sewer lines do not exist or are inaccurate and confusion arises regarding the appropriate function of the sewer lines. In addition, when the activities within an industrial facility change, floor drains and other discharge points, which are connected to the separate storm sewer, may begin to receive drainage and discharges that should be sent to a treatment plant. Such floor drains may receive a wide variety of discharges, including spills, rinse waters, cooling waters, and even process wastewaters.

Numerous factors may cause floor drains to be directed toward separate storm sewers. Many floor drains in commercial and industrial facilities are positioned so that they collect storm water running into a building, as well as cleaning water, spillage, and other non-storm water discharges generated within a building. Urbanized areas have experienced rapid growth since 1950. During much of that time, many municipalities did not provide adequate publicly owned treatment works (POTW) service; the development of POTW capacity often lagged far behind the rapid development of the urbanized area. When faced with limited POTW capacity or inadequate POTWs, which could not handle toxic materials (e.g., solvents and heavy greases), many municipalities encouraged developers to connect floor drains and other nonsanitary sewage lines from commercial and industrial facilities to separate storm sewers. Some municipal ordinances prohibited floor drains from being connected to the sanitary sewer system.[3] The operators of facilities with these types of improper connections usually do not know whether floor drains and other types of drains discharge to a separate storm sewer or to a sanitary sewer.

Recent studies in Michigan recognized that development that occurred while undersized POTWs were in operation can create wide-spread illicit connections. For example, the Huron River Pollution Abatement Program inspected 660 businesses, homes, and other buildings discharging storm water to the Allen Creek drain in Washtenaw County, Michigan. Of the buildings inspected, 14 percent were identified as having improper storm drain connections. Illicit discharges were detected at a higher rate of 60 percent for automobile-related businesses, including service stations, automobile dealerships, car washes, body shops, and light industrial facilities. While some of the problems discovered in this study were the result of improper plumbing or illegal connections, most connections were approved at the time they were built.

[3] Some municipalities have prohibited floor drain connections to sanitary sewers in overbroad efforts to comply with EPA regulations at 40 *CFR* 35.927-4, which require grant applicants to demonstrate that municipalities have sewer use ordinances prohibiting any new connections from inflow sources into the sanitary sewer portions of the sewer system.

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C.1.2 Sewer Maintenance/Restoration

As urban development grows, flows in the sanitary sewer system increase. In some systems where flows during dry or wet weather have grown to exceed the hydraulic capacity of sanitary sewers, the sanitary sewer has been intentionally cross connected to a storm sewer systems. In some cases, formal connections or overflow devices have been installed and, in others, holes are punched into the sanitary sewer to relieve the sanitary sewer of high flows. Some cross-connections result in wet weather combined sewer overflows; others discharge during dry weather events. Discharges from malfunctioning sanitary sewage pumping stations are often directed toward storm sewers.

Incomplete separation of combined sewers may result in significant numbers of cross-connections between the sanitary sewer system and the storm sewer system. Most municipalities separate sewers primarily to prevent basement and street floodings, with secondary consideration given to water quality concerns. Because separation operations are expensive and can cause significant disruptions to street usage, short cuts may be taken to satisfy flooding concerns at the lowest cost. EPA has recently issued a Combined Sewer Overflow (CSO) Control Policy.[4]

C.2 INTERACTIONS WITH SEWAGE SYSTEMS

As sanitary sewage collection systems age, the systems develop leaks and cracks. Municipalities have long recognized the problems of storm water infiltrating into sanitary sewers, because this type of infiltration disrupts the operation of a POTW. However, the reverse problem of sewage exfiltrating out of the sanitary sewer collection system can occur during dry weather periods. Many sanitary collection systems were initially built between the early 1900s and the mid-1950s. Sewer mains were constructed of asbestos cement, bituminous fiber, brick, cast iron, redwood, or vitrified clay. Manholes were prepared from brick and mortar or reinforced concrete. These aged materials, poorly constructed manholes and joints, and main breaks may permit exfiltration. Sewage from a leaky sanitary system

[4] Combined Sewer Overflow (CSO) Control Policy, EPA, 59 *FR* 18688 (April 19, 1994)

can flow to a storm sewer or contaminate ground water supplies. An EPA study on sewer exfiltration found significant ratios of the rate of exfiltration of raw sewage to the rate of infiltration of ground water or storm water into sanitary sewers. Field and laboratory results determined that this ratio varied between 1.5 to 1 and 14 to 1.[5] Not only are the ratio to rates high, but exfiltration can occur during dry periods, as well as wet weather periods; infiltration is more limited to wet weather periods or periods when the water table is high.

Separate storm sewers and sanitary sewers interactions can be caused by numerous conditions. For example, interaction may occur at manholes and where sanitary sewer laterals and storm sewer trenches cross. In addition, separate storm sewers and sanitary sewers may share the same trench, which is generally filled with very porous material, such as gravel.

C.3 IMPROPER DISPOSAL

Improper disposal of materials may result in contaminated discharges from separate storm sewers in two major ways. First, materials may be disposed of directly to a catchbasin or other storm water conveyance. Second, materials disposed of on the ground may either drain directly to a storm sewer or be washed into a storm sewer during a storm event.

Improper disposal to a separate storm sewer often occurs because many believe that disposal of materials to street catchbasins and other separate storm sewer inlets is an environmentally sound practice. Part of the confusion occurs because some areas are served by combined sewers, which are part of the sanitary sewer collection system, and people assume materials discharged to a catchbasin will reach an appropriate sewage treatment plant.

Materials that are commonly disposed of improperly include used oil; household toxic materials; radiator fluids; and litter, such as disposable cups, cans, and fast-food packages.

[5] U.S. EPA, "Results of the Evaluation of Groundwater Impacts of Sewer Exfiltration", Municipal Facilities Division, February 1989, Washington, DC.

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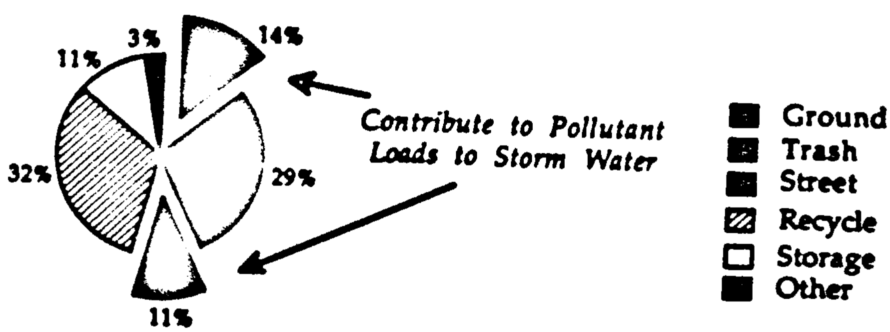
A 1984 survey of household disposal practices estimated that the following percentages of households typically disposed of the materials listed directly to a storm sewer or a street:

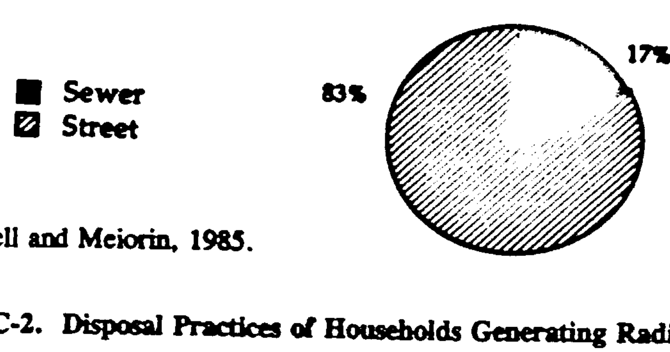
- 3 percent of households—paints and thinners
- 11 percent of households—used motor oil
- 83 percent of households that flushed their own auto radiators—used radiator fluid (anti-freeze contaminated with metals).

In addition, although common practice may have changed since 1985, the study estimated that an additional 14 percent of households that changed their own motor oil disposed of the motor oil by pouring it on the ground. Figures C-1 through C-3 depict these data.



Source: Russell and Meiorin, 1985.

Figure C-1. Disposal Practices of Households Generating Used Motor Oil



Source: Russell and Meiorin, 1985.

Figure C-2. Disposal Practices of Households Generating Radiator Flushings

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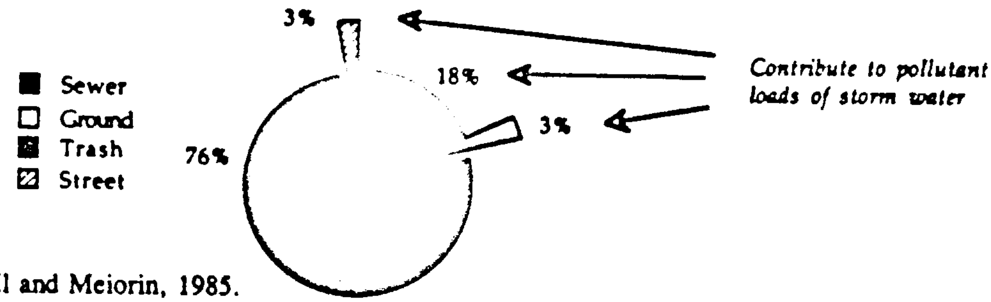
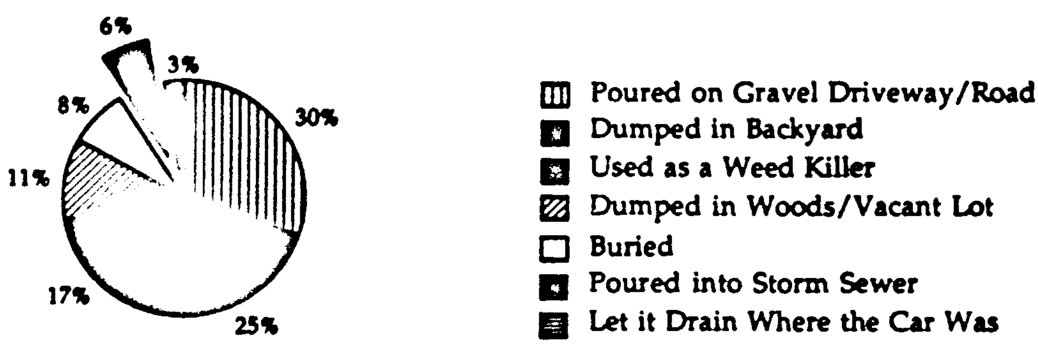


Source: Russell and Meiorin, 1985.

Figure C-3. Disposal Practices for Households Generating Waste Paints and Thinner

A Department of Energy study (Brinkman, 1981) addresses common disposal methods of used oil produced by do-it-yourself (DIY) oil changers. The study estimated that 342 million gallons of used oil were drained during DIY oil changes annually and that 40 percent of this used oil was poured on the ground. Figure C-4 shows the variety of types of oil disposal methods used for the 40 percent of DIY oil disposed of by pouring on the ground. EPA estimates that, 267 million gallons of used oil, including 135 million gallons of used oil from DIY automobile oil changes, are disposed of improperly each year.



Source: Brinkman, 1981.

Figure C-4. Disposal Practices of Households Pouring Used Oil on the Ground

The General Accounting Office (GAO) report, *Illegal Disposal of Hazardous Waste: Difficult to Detect or Deter* (1985) investigated illegal dumping of materials defined as hazardous wastes under the Resource Conservation and Recovery Act (RCRA). Although the report was unable to estimate the extent of illegal dumping of hazardous wastes, it reported that, based on surveyed officials in four States (i.e., Illinois, California, New Jersey, and Massachusetts), some officials believed that many cases of illegal disposal occurred. The report indicated that the Director of EPA's National Enforcement Investigation Center thinks that many cases of criminal disposal occur on a widespread basis, and that EPA receives more allegations than it can handle. The Director stated that the center received about 240 allegations that were judged as having good potential to involve violations during fiscal years 1982 through 1984.

The report indicated that cases of onsite waste disposal where pollutants were added to runoff, which eventually ended up in drainage systems, and cases where a generator dumped wastes directly down a drain, were common. Of the 36 cases of illegal dumping investigated in the GAO report, 14 cases involved disposal of hazardous material directly to or with drainage to a storm sewer, flood control structure, or side of a road. An additional 10 sites involved disposal to the ground, landfills (other than those receiving hazardous wastes), trash bins, which can then result in adding pollutants to subsequent storm water discharges. Disposal scenarios in several other cases could not be determined.

The GAO report concluded that because RCRA regulations and compliance inspections for generators and transporters were not designed to detect illegal disposal, local government agencies, including flood control agencies and departments of transportation were particularly important for detecting illegal dumping.

Businesses disposing of small amounts of hazardous waste may be of concern because they do not fully understand hazardous waste disposal regulations and employee training programs necessary to ensure proper disposal.

C.4 SPILLS

Spilled material may have a have a high potential for entering human-made drainage systems. Until recently, an accepted practice to responding to spills was to flush the spilled material away. These removal methods may often result in flushing the spilled material into a separate storm sewer.

A wide variety of materials, such as petroleum products, other liquid products, and waste chemicals, may spill during transportation, transfer, use, and storage. The U.S. Coast Guard's National Response Center (NRC) receives thousands of incident reports, involving hundreds of substances each year. Summary data, provided by the NRC, categorized spilled materials as either oil or hazardous substances defined under the CWA or the Comprehensive Environmental Response, Compensation, and Liability Act. The term oil is used to represent more than 90 different materials, including various grades of crude oil, naphtha, coal tar, creosote, refined oils, gasoline, and jet fuel.

Table C-1 summarizes the amounts of reported oil and hazardous substances discharged and the amounts reported in water during 1987 and 1988. As this table shows, significant quantities of pollutants are reported to the NRC as spilled or dumped each year. Cleanup activities are not initiated for each reported discharges. Where cleanup occurs, a significant portion of a spill is often not recoverable. Although no data are available to substantiate the number of unreported discharges, Merryman (1989) estimated that less than half of the reportable incidents occurring each year are reported to the NRC. Many of these incidents probably involve little cleanup activity because they were not reported to responsible authorities.

C.5 MALFUNCTIONING SEPTIC SYSTEMS

In rural and suburban areas served by septic systems, malfunctioning septic systems can contribute pollutants to separate storm sewers. Although septic systems work well in rural, low-density areas with suitable soil and a deep water table, septic systems are often installed in inappropriate areas, such as coastal areas, where rapid residential growth, particularly in second-home development areas, has outdistanced the ability of local governments to build sanitary sewers.

Table C-1. Summary of U.S. Coast Guard National Response Center Data on Discharges of Oil and CERCLA-Regulated Materials During 1987 and 1988

	1987 Gallons	1987 Pounds	1988 Gallons	1988 Pounds
Oil Spills Affecting Land	4,988,282	--	6,426,228	--
Oil Spills Affecting Water	3,613,555	--	4,637,600	--
Oil Spills Amount in Water	5,278,773	--	2,949,694	--
Hazardous Substances Spills Affecting Land	1,969,080	3,354,591	4,201,392	2,565,142
Hazardous Substances Spills Affecting Water	3,664,065	656,843	5,244,696	856,852
Hazardous Substances Spills Amount in Water	3,636,764	347,230	2,320,874	415,204

Oil is defined by the NRC to include 94 materials, including gasoline, crude and refined oils, creosote, jet fuel, diesel, naphtha, and coal tar.

Hazardous Substances include 494 materials either required by or containing substances regulated by CERCLA.

Surface malfunctions are caused by clogged or impermeable soils or when stopped up or collapsed pipes force untreated wastewater to the surface. Surface malfunctions can vary in degree from occasional damp patches on the surface to constant pooling or runoff of wastewater to a storm sewer. These discharges have high bacteria, nitrate, and nutrient levels and can contain a variety of household chemicals. One type of improper remedy to a surface malfunction is to install a pipe or trench over soil absorption systems to route untreated surface malfunction overflow away from the septic system, resulting in direct discharges to drainage ditches, empty lots, or surface waters.

Malfunctioning septic systems may be a more significant surface runoff pollution problem than a ground water problem. This is because a malfunctioning septic system is less likely to cause ground water contamination where a bacterial mat in the soil retards the downward movement of wastewater. (Poorly located septic systems that are operating properly are the greatest threat to ground water.)

In addition to surface malfunctions, insufficiently treated wastewater from a septic system may contaminate ground water, which may infiltrate into storm sewers, which serve as a conduit to surface waters. Also, seepage of sewage or effluent into underground portions of buildings can be pumped to separate storm sewers.

The 1992 Needs Survey estimates that approximately 30 percent of the population in the United States is served by septic systems[6].

C.6 INFILTRATION OF CONTAMINATED GROUND WATER

Many separate storm sewers discharge ground water that infiltrates into the storm sewer. Usually, these discharges are not contaminated and, in general, do not pose direct pollutant threats to surface waters. However, if ground water sources are contaminated by industrial or other sources, the separate storm sewer serves as a conduit for the contaminated ground water to surface waters. This process can greatly reduce pollutant removal associated with ground water migration through soils, as well as reduce the dilution processes associated with ground water plume migration. Conversely, observing contaminated discharges from separate storm sewers during dry weather may be used as a tool to detect sources of ground water contamination.

In addition to traditional industrial sources, ground water may be contaminated by a number of commercial activities. One leading cause of ground water contamination from commercial activities includes leaks from underground storage tanks (USTs) and underground pipes. Underground storage tanks are used to store large amounts of potential pollutants, such as petroleum products and chemicals. In 1987, EPA estimated that 676,000 UST systems stored retail motor fuel, 651,000 stored other petroleum products, and 54,000 stored hazardous chemicals in the United States. In addition, EPA estimated that potentially millions of other small UST systems, such as hydraulic lift tanks and power cable conduits, contain dielectric fluid. Pollutants leaking from these tanks may infiltrate through soil into either nearby ditches or storm water pipes (Fields, 1989). A draft EPA report (Kaschak and Hargrove, 1988) reviewed corrective action case histories of 50 leaking UST sites. The report indicated

[6] "1992 Needs Survey Report to Congress", EPA, September 1993.

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that surface water impacts were of concern at 14 percent of these sites, where fuels entered storm drains or flowed over the surface, or where the source was located close to a stream or surface waters.

C.7 ROAD OILING

EPA estimates that 70 million gallons of used oil, primarily supplied by service stations and repair shops, are used for road oiling.

A study of two rural roads in New Jersey treated with waste crankcase oil indicated that only 1 percent of the total oil applied to the road may remain on the road surface (Freestone "Runoff of oils from rural roads treated to suppress dust" NERC, EPA, Cincinnati, OH, 1972). The study concluded that oil could have left the road surface by several means such as volatilization, runoff, adhesion to vehicles, adhesion to dust particles with wind transport, and biodegradation.

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APPENDIX D

NPDES STORM WATER PROGRAM QUESTION AND ANSWER DOCUMENT VOLUMES I AND II

NPDES

Storm Water Program

Question and Answer Document

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U.S. Environmental Protection Agency
Office of Wastewater Enforcement and Compliance
Permits Division
401 M Street, SW
Washington, DC 20460

March 1992

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INDUSTRIAL PERMIT APPLICATION QUESTIONS AND ANSWERS

Category I - Facilities subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards.

1. **What kinds of facilities are included under category (i)?**

   Category (i) includes facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under Title 40 subchapter N of the Code of Federal Regulations (CFR) (except facilities with toxic pollutant effluent standards which are exempted under category (xi) of the definition of storm water discharge associated with industrial activity). The term "storm water" modifies only "effluent limitations guidelines." Facilities subject to subcategories with new source performance standards, toxic pollutant effluent standards, or storm water effluent limitation guidelines are required to submit a National Pollutant Discharge Elimination System (NPDES) permit application for storm water discharges associated with industrial activity.

2. **What kinds of facilities are subject to storm water effluent guidelines?**

   The following categories of facilities have storm water effluent guidelines for at least one of their subcategories: cement manufacturing (40 CFR 411); feedlots (40 CFR 412); fertilizer manufacturing (40 CFR 418); petroleum refining (40 CFR 419); phosphate manufacturing (40 CFR 422); steam electric power generation (40 CFR 423); coal mining (40 CFR 434); mineral mining and processing (40 CFR 436); ore mining and dressing (40 CFR 440); and asphalt (40 CFR 443). A facility that falls into one of these general categories should examine the effluent guideline to determine if it is categorized in one of the subcategories that have storm water effluent guidelines. If a facility is classified as one of those subcategories, that facility is subject to the standards listed in the CFR for that category, and as such, is required to submit a storm water discharge permit application.

3. **What kinds of facilities are subject to "toxic pollutant effluent standards"?**

   First, it is important to understand the term toxic pollutant. Toxic pollutants refers to the priority pollutants listed in Tables II and III of Appendix D to 40 CFR part 122 (not 40 CFR Part 129). If any of these toxic pollutants are limited in an effluent guideline to which the facility is subject (including pretreatment standards), then the facility must apply for a storm water permit.

The following categories of facilities have toxic pollutant effluent standards for at least one subcategory:

Textile mills (40 CFR 410)
Electroplating (40 CFR 413)
Organic chemicals, plastics, and synthetic fibers (40 CFR 414)
Inorganic chemicals (40 CFR 415)
Petroleum refining (40 CFR 419)
Iron and steel manufacturing (40 CFR 420)
Nonferrous metals manufacturing (40 CFR 421)
Steam electric power generating (40 CFR 423)
Ferroalloy manufacturing (40 CFR 424)
Leather tanning and finishing (40 CFR 425)
Glass manufacturing (40 CFR 426)
Rubber manufacturing (40 CFR 428)
Timber products processing (40 CFR 429)
Pulp, paper, and paperboard (40 CFR 430)
Metal finishing (40 CFR 433)
Pharmaceutical manufacturing (40 CFR 439)
Ore mining and dressing (40 CFR 440)
Pesticide chemicals (40 CFR 455)
Photographic processing (40 CFR 459)
Battery manufacturing (40 CFR 461)
Metal molding and casting (40 CFR 464)
Coil coating (40 CFR 465)
Porcelain enameling (40 CFR 466)
Aluminum forming (40 CFR 467)
Copper forming (40 CFR 468)
Electrical and electronic components (40 CFR 469)
Nonferrous metals forming and metal powders (40 CFR 471)

4. What kinds of facilities are subject to "new source performance standards"?

Most effluent guidelines listed in subchapter N contain New Source Performance Standards (NSPS). A facility that is subject to a NSPS as defined for that particular effluent guideline is required to submit a permit application for the storm water discharges associated with industrial activity at that site. The definition of a new source varies based on the publication date of the particular effluent guideline.

The following categories of 40 CFR Subchapter N facilities do not have new source performance standards. All other categories have at least one subcategory with new source performance standards.

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Oil and Gas Extraction (40 CFR 435)
Mineral Mining and Processing (40 CFR 436)
Gum and Wood Chemicals Manufacturing (40 CFR 454)
Pesticide Chemicals (40 CFR 455)
Explosives Manufacturing (40 CFR 457)
Photographic (40 CFR 459)
Hospital (40 CFR 460)

5. **If a facility is included under the description of both category (i) and category (xi), is that facility required to submit a storm water permit application if material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are not exposed to storm water?**

The answer depends on why the facility is included in category (i). If the facility is included in category (i) because it is subject to storm water effluent standards or new source performance standards, the facility is required to apply for a permit regardless of whether it has exposure or not. Facilities that are included in category (i) only because they have toxic pollutant effluent standards are not required to submit an application if they indeed have no exposure to material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery.

Categories ii, iii, vi, viii, and xi

6. **What industrial groups are covered by Standard Industrial Classification (SIC) codes that are used in the definition of storm water discharge associated with industrial activity?**

The following SIC codes and associated industries are included in the indicated categories of the definition:

Category (ii)
24 (except 2434) - Lumber and Wood Products (except wood kitchen cabinets)
26 (except 265 and 267) - Paper and Allied Products (except paperboard containers and products)
28 (except 283 and 285) - Chemicals and Allied Products (except drugs and paints)
29 - Petroleum Refining Industries
311 - Leather Tanning and Finishing

32 (except 323) - Stone/Clay/Glass and Concrete Products (except glass products made of purchased glass)
33 - Primary Metal Industries
3441 - Fabricated Structural Metals
373 - Ship and Boat Building and Repairing

Category (iii)
10 - Metal Mining
12 - Coal Mining
13 - Oil and Gas Extraction
14 - Nonmetallic Minerals

Category (vi)
5015 - Motor Vehicles Parts, Used
5093 - Scrap and Waste Materials

Category (viii)
40 - Railroad Transportation
41 - Local Passenger Transportation
42 (except 4221-4225) - Trucking and Warehousing (except public warehousing and storage)
43 - U.S. Postal Service
44 - Water Transportation
45 - Transportation by Air
5171 - Petroleum Bulk Stations and Terminals

Category (xi)
20 - Food and Kindred Products
21 - Tobacco Products
22 - Textile Mill Products
23 - Apparel Related Products
2434 - Wood Kitchen Cabinets Manufacturing
25 - Furniture and Fixtures
265 - Paperboard Containers and Boxes
267 - Converted Paper and Paperboard Products
27 - Printing, Publishing, and Allied Industries
283 - Drugs
285 - Paints, Varnishes, Lacquer, Enamels, and Allied Products
30 - Rubber and Plastics
31 (except 311) - Leather and Leather Products (except leather tanning and finishing)
323 - Glass Products
34 (except 3441) - Fabricated Metal Products (except fabricated structural metal)

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35 - Industrial and Commercial Machinery and Computer Equipment
36 - Electronic and Other Electrical Equipment and Components
37 (except 373) - Transportation Equipment (except ship and boat building and repairing)
38 - Measuring, Analyzing, and Controlling Instruments
39 - Miscellaneous Manufacturing Industries
4221-4225 - Public Warehousing and Storage

Category III - Mining and Oil & Gas Operations

7. Are inactive mines included in the regulation?

Two conditions must be met for an inactive mine to be required to submit a storm water discharge permit application. First, the facility must have a discharge of storm water that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts, or waste products located on the site of the facility. The second condition depends on the type of mining activity.

Inactive non-coal mining operations must apply until such sites are released from applicable State or Federal reclamation requirements after December 17, 1990. Non-coal mining operations released from applicable State or Federal requirements before December 17, 1990, must apply for an NPDES storm water discharge permit if the storm water discharges are contaminated as discussed above.

Inactive coal mining operations must apply unless the performance bond issued to the facility by the appropriate Surface Mining Control and Reclamation Act (SMCRA) authority has been released.

8. Are any oil & gas exploration, production, processing, or treatment operations, or transmission facilities classified under SIC code 13, exempt from having to apply for a storm water permit?

Yes, such facilities are exempt unless they have discharged storm water after November 16, 1987, containing a Reportable Quantity (RQ) of a pollutant for which notification is or was required pursuant to 40 CFR 117.21, 40 CFR 302.6, or 40 CFR 110.6; or if a storm water discharge from the facility contributes to a violation of a water quality standard, as set forth in 40 CFR 122.26(c)(1)(iii).

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9. **What is a reportable quantity for discharges from an oil or gas operations?**

As defined at 40 CFR 110.6, an RQ is the amount of oil that violates applicable water quality standards or causes a film or sheen upon or a discoloration of the surface of the water or adjoining shorelines or causes a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines (40 CFR part 110.6). The RQs for other substances are listed in 40 CFR 117.3 and 302.4 in terms of pounds released over any 24-hour period.

10. **Are access roads for mining operations covered?**

Any construction that disturbs 5 acres or more of total land area must apply for a storm water discharge permit.

After construction, roads for mining operations would not be included unless storm water runoff from such roads mixes with storm water that is contaminated by contact with overburden, raw materials, intermediate products, finished products, byproducts, or waste products. When roads are constructed out of materials such as overburden or byproducts, an application for an NPDES storm water discharge permit would be required.

Category iv - Hazardous Waste Treatment, Storage, or Disposal Facilities

11. **Is a facility that stores hazardous waste less than 90 days required to submit an application?**

It is EPA's intent to cover those facilities that are operating under interim status or permit under the Resource Conservation and Recovery Act (RCRA) subtitle C. As such, only facilities meeting the definition of a hazardous waste treatment, storage, or disposal facility under RCRA are expressly included in this category. A facility that stores hazardous waste less than 90 days is not considered to be a treatment, storage, or disposal facility, and therefore is not required to submit a storm water permit application.

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Category v - Landfills, Land Application Sites and Open Dumps

12. Do closed or inactive landfills need to apply for a permit?

Yes. Any landfill, active, inactive or closed, must apply for a permit if it receives, or has received, wastes from the industrial facilities identified under 122.26(b)(14)(i)-(xi). To the extent that control measures and best management practices address storm water, the permit may incorporate those control measures.

13. Does a landfill that receives only the office waste and/or cafeteria waste from industrial facilities have to apply for an NPDES permit?

No. Only landfills that receive or have received waste from manufacturing portions of industrial facilities need to apply for a permit.

Category vi - Recycling Facilities

14. Are gas stations or repair shops that collect tires or batteries classified in the "recycling" category?

No. Only those facilities classified in SIC codes 5015 (used motor vehicle parts) and 5093 (scrap and waste materials) are in the "recycling" category. This includes facilities such as metal scrap yards, battery reclaimers, salvage yards, and automobile junk yards.

15. Are municipal waste collection sites included in category (vi)?

No. Municipal waste collection sites where bottles, cans, and newspapers are collected for recycling purposes are not classified as SIC codes 5015 or 5093.

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Category vii - Steam Electric Power Generating Facilities

16. Are offsite transformer areas regulated under the NPDES storm water rule?

No. Upon examination of the Toxic Substances Control Act, EPA determined that the regulation of storm water discharges from these facilities should be studied under Section 402(p)(5) of the Clean Water Act (CWA) (55 FR 48013). Future regulations may be developed to address these areas.

17. Are storm water discharges from electrical substations included in the definition of industrial activity?

No. Electrical substations are not covered by this regulation.

18. Are storm water discharges from coal piles that are located offsite from the power station included in the definition of industrial activity?

No. Offsite coal piles are not covered by this regulation. In order to be included, a coal pile must be located on the site of a facility defined by the regulation as being "engaged in an industrial activity."

19. Are storm water discharges from co-generation facilities included in the definition of industrial activity?

A heat capture co-generation facility is not covered under the definition of storm water discharge associated with industrial activity; however, a dual fuel co-generation facility is included and therefore must submit an application for the storm water discharges associated with industrial activity.

20. Are university power plants included in the definition of industrial activity?

Yes. A university steam electric power generating facility is required to apply for a storm water discharge permit.

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Category viii - Transportation Facilities

21. Are gas stations and automotive repair shops required to apply for an NPDES storm water discharge permit?

No. These facilities are classified in SIC codes 5541 (gasoline filling stations) and 7538 (automotive repair shops). The storm water rule generally does not address facilities with SIC classifications pertaining to wholesale, retail, service or commercial activities. Additional regulations addressing these sources may be developed under Section 403(p)(6) of the CWA if studies required under Section 402(p)(5) indicate the need for regulation.

22. Does a vehicle maintenance shop or an equipment cleaning facility need to apply for a permit?

Yes, if the shop is categorized by the SIC codes listed in the transportation category of facilities engaged in industrial activity [i.e., SIC codes 40, 41, 42 (except 4221-25) 43, 44, 45 and 5171]. Only the vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication) and equipment cleaning areas (such as truck washing areas) must be addressed in the application.

As explained above, gas stations are classified in SIC code 5541 and automotive repair services are classified as SIC code 75, which are not included in the regulatory definition of industrial activity, and therefore are not required to submit NPDES storm water discharge permit applications.

23. Are municipally owned and/or operated school bus maintenance facilities required to apply for an NPDES permit?

No. The SIC Manual states that "school bus establishments operated by educational institutions should be treated as auxiliaries" to the educational institution. Since the SIC code assigned to educational institutions is 82, the municipally operated (i.e., by a school board, district, or other municipal entity) school bus establishments would not be required to apply for an NPDES permit for their storm water discharges. Private contract school bus services are required to apply for an NPDES permit for their storm water discharges.

24. Is SIC code 4212 always assigned to facilities with dump trucks?

No. The maintenance facility must be primarily engaged in maintaining the dump truck to be characterized as SIC code 4212. Dump trucks used for road maintenance and construction and facilities that maintain these trucks are classified under SIC code 16 (heavy construction other than building construction) and therefore would not be characterized as engaging in industrial activity.

25. How does a municipality determine what type of vehicle a particular maintenance facility is primarily engaged in servicing?

The SIC Manual recommends using a value of receipts or revenues approach to determine what is the primary activity of a facility. For example, if a maintenance facility services both school buses and intercity buses, the facility would total receipts for each type of vehicle and whichever generated the most revenue, would be the vehicle type that the facility is primarily engaged in servicing. If data on revenues and receipts are not available, the number of vehicles and frequency of service may be compared. If a facility services more than two types of vehicles, whichever type generates the most (not necessarily greater than half of the total) revenue, or is most frequently serviced, is the vehicle type the facility is primarily engaged in servicing.

26. Is a municipal maintenance facility that is <u>primarily</u> engaged in servicing garbage trucks required to apply for a permit?

The answer depends on the SIC code assigned to the establishment. If the municipality also owns the disposal facility (e.g., landfill, incinerator) that receives refuse transported by the trucks, then the maintenance facility would be classified as SIC code 4953 and thus would not be required to apply for a permit unless the maintenance facility was located at a facility covered under one of the other categories of industrial activity (e.g., a landfill that receives industrial waste). If, however, the municipality does not own the disposal facility, the truck maintenance facility would be classified as SIC code 4212 and thus would be required to apply for a permit. If other vehicles are serviced at the same maintenance facility, the facility may not be required to submit a permit application (see question #25 above).

27. Are fire trucks or police cars included in the transportation SIC codes?

No. The operation of fire trucks and police cars are classified under public order and safety (SIC code 92); therefore, the operator of a facility primarily engaged in servicing those vehicles would not be required to apply for a permit.

28. Do all airports need to apply for a storm water discharge permit?

No, only those airports classified as SIC code 45. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning, or airport deicing or which are otherwise identified under 122.26(b)(14)(i)-(vii) or (ix-xi) are required to be permitted. Airports that are not engaged in such activities do not require storm water discharge permits. Facilities primarily engaged in performing services that incidentally use airplanes (e.g., crop dusting and aerial photography) are classified according to the service performed.

29. Is the deicing of airplanes, runways, or both included in airport deicing operations?

Airports or airline companies must apply for a storm water discharge permit for locations where deicing chemicals are applied. This includes, but is not limited to, runways, taxiways, ramps, and areas used for the deicing of airplanes. The operator of the airport should apply for the storm water discharge permit with individual airline companies included as co-applicants.

30. Who is responsible for seeking permit coverage at an airport that has many companies using the facility and discharging storm water?

The operator is responsible for seeking coverage. EPA strongly encourages cooperation between the airport authority and all operating airlines at that airport. Each operator is responsible for coordinating with the others and they may act as co-applicants. Please note that under 122.26(a)(6) the Director has the discretion to issue individual permits to each discharger or to issue an individual permit to the airport operator and have other dischargers to the same system act as co-permittees to the permit issued to the airport operator.

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31. **Are railroad facilities included?**

Railroad facilities, classified as SIC code 40, which have vehicle maintenance activities, equipment cleaning operations or are otherwise identified under 122.26(b)(14)(i)-(vii) or (ix)-(xi) need to apply for a permit.

32. **Are repairs along a railroad system considered to be vehicle maintenance and thus regulated?**

No. Only nontransient vehicle maintenance shops are included in the transportation category.

33. **Are tank farms at petroleum bulk storage stations covered by the rule?**

No, unless the storm water discharge from the tank farm area commingles with storm water from any vehicle maintenance shops or equipment cleaning operations located onsite. However, tank farms located onsite with other industrial facilities, as defined in 122.26(b)(14), are included in the regulation.

34. **Is a parking lot associated with a vehicle maintenance shop included in the regulation?**

Yes. Under 122.26 (b)(14)(viii) vehicle maintenance and equipment cleaning operations are considered industrial activity. Parking lots used to store vehicles prior to maintenance are considered to be a component of the vehicle maintenance activity.

35. **Is the fueling operation of a transportation facility (SIC codes 40 through 45) covered if there are no other vehicle maintenance activities taking place at the facility?**

Yes. A nonretail fueling operation is considered vehicle maintenance [see 122.26(b)(14)(viii)] and requires an NPDES storm water discharge permit application.

36. **Is a manufacturing facility's offsite vehicle maintenance facility required to apply for a permit under the transportation category?**

No. An offsite vehicle maintenance facility supporting one company would not be required to apply for a permit if that company is not primarily engaged in providing transportation services and therefore would not be classified as SIC

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code 42. The maintenance facility would be considered an auxiliary operation to the manufacturing facility. For a full discussion on auxiliary facilities see page 13 through 17 of the 1987 Standard Industrial Classification Manual. If the maintenance facility is located on the same site as the manufacturing operation, it would be included in the areas associated with industrial activity and must be addressed in an application.

37. **Is a marina required to apply for a storm water permit if it operates a retail fueling operation, but other vehicle maintenance or equipment cleaning activities are not conducted onsite?**

Facilities that are "primarily engaged" in operating marinas are best classified as SIC 4493 - marinas. These facilities rent boat slips, store boats, and generally perform a range of other marine services including boat cleaning and incidental boat repair. They frequently sell food, fuel, fishing supplies, and may sell boats. For facilities classified as 4493 that are involved in vehicle (boat) maintenance activities (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication) or equipment cleaning operations, those portions of the facility that are involved in such vehicle maintenance activities are considered to be associated with industrial activity and are covered under the storm water regulations.

Facilities classified as 4493 that are not involved in equipment cleaning or vehicle maintenance activities (including vehicle rehabilitation, mechanical repairs, painting, and lubrication) are not intended to be covered under 40 CFR Section 122.26(b)(14)(viii) of the storm water permit application regulations. The retail sale of fuel alone at marinas, without any other vehicle maintenance or equipment cleaning operations, is not considered to be grounds for coverage under the storm water regulations.

Marine facilities that are "primarily engaged" in the retail sale of fuel and lubricating oils are best classified as SIC code 5541 - marine service stations - and are not covered under 40 CFR Section 122.26(b)(14)(viii) of the storm water permit application regulations. These facilities may also sell other merchandise or perform minor repair work.

Facilities "primarily engaged" in the operation of sports and recreation services such as boat rental, canoe rental, and party fishing, are best classified under SIC code 7999 - miscellaneous recreational facilities - and are not covered under 40 CFR Section 122.26(b)(14)(viii).

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Category ix - Sewage Treatment Works

38. Are storm water permit applications required for offsite (i.e., physically separated from the main treatment works property) pumping stations?

No, storm water permit applications are not required for such sites.

39. Are separate permit applications required for vehicle maintenance/ washing facilities (located either onsite or offsite) associated with a wastewater treatment plant and owned/operated by the wastewater treatment agency?

Offsite vehicle maintenance facilities would not be required to submit applications unless they serve multiple clients since they do not fit the SIC codes listed in the transportation category of facilities engaged in industrial activity. Onsite vehicle maintenance/cleaning operations are associated with industrial activity and must be included in the application.

40. Do wastewater treatment facilities that collect their storm water runoff and treat the storm water as part of the normal inflow that is processed through the treatment plant have to apply for a permit?

No. If a facility discharges its storm water into the headworks of the treatment plant, it is essentially the same as discharging to a combined system or to a sanitary system and is therefore exempt from the requirements of 122.26(c).

41. The definition states that offsite areas where sludge is beneficially reused are not included as storm water discharges associated with industrial activity. How is beneficial reuse defined?

Beneficial sludge reuse is the application of sludge as a nutrient builder or soil conditioner. Examples include agricultural or domestic application.

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Category x - Construction Activities

42. Is a construction site of five acres or more subject to the same deadline as other industrial facilities?

The individual application deadline for all storm water discharges associated with industrial activity is 10/1/92. If a construction activity is completed by 10/1/92, an application is not required.

43. What is the duration of an NPDES permit issued for a construction activity?

The permit will be effective as long the construction activity continues, but no longer than five years. If the construction continues beyond five years, the owner/operator must apply for a new permit.

44. Does the construction category only include construction of industrial buildings?

No. Any construction activity, including clearing, grading, and excavation, that results in the disturbance of five acres of land or more in total is covered by the rule. Such activities may include road building, construction of residential houses, office buildings, or industrial buildings, and demolition activity. However, this does not apply to agricultural or silvicultural activities, which are exempt from NPDES permit requirements under 40 CFR 122.4.

45. Does the rule require that storm water discharges after construction be addressed?

Yes. The individual application must describe proposed measures to control pollutants in storm water discharges that will occur after construction operations are complete, including a description of State and local erosion and sediment control specifications.

<u>Please Note</u>: EPA believes that construction activities should be covered under a storm water general permit wherever possible. 40 CFR 122.21(c)(1) allows the permitting authority to establish different and shorter submittal dates under the specific terms of a particular general permit.

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46. **The definition states that the operators of construction activity that disturb less than five acres are not required to apply for a permit unless that construction is part of a larger common plan of development or sale. What is meant by "part of a larger common plan of development or sale"?**

"Part of a larger common plan of development or sale" is a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan. Thus, if a distinct construction activity has been identified onsite by the time the application would be submitted, that distinct activity should be included as part of the larger plan.

47. **Who is responsible for applying for a storm water permit?**

The operator is responsible for applying for the permit as required by 122.21(b). In the case of construction, the owner may submit an application for a construction activity if the operators have not yet been identified. However, once the operators have been identified, they must become either sole permittees or co-permittees with the owner. The operator is determined by who has day to day supervision and control of activities occurring at a site. In some cases, the operator may be the owner or the developer, at other sites the operator may be the general contractor.

Category xi - Light Industrial Facilities

48. **If a category (xi) facility has determined that there is no exposure of certain activities or areas listed in the definition to storm water and the operator does not file a permit application, how does the operator prove, if asked, that he/she did not need to apply?**

There are no requirements set forth under the November 16, 1990, rule. However, the operator may want to document the facility evaluation which led to the conclusion that there is no exposure to storm water. This documentation should be retained onsite. Some States may have specific requirements. A facility is advised to check with its NPDES permitting authority for additional requirements.

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49. Do those industries listed in 122.26(b)(14)(xi) that only have access roads and rail lines exposed to storm water need to apply for a permit?

No. As stated in 122.26 (b)(14), facilities in category (xi) do not have to apply for a permit if storm water only is exposed to access roads and rail lines.

50. If air pollution control equipment vents on the roof are exposed to storm water, does this constitute exposure and trigger a permit condition?

No. The exposure of air pollution control equipment vents does not in itself constitute exposure. It is possible, however, that even with the use of air pollution control equipment, significant pollutants may be exposed to storm water. For example, if a cyclone, a common particulate control device, is used alone, only about 80 percent of the potential pollutants would be removed. 20 percent of the pollutants may then come into contact with storm water. In this case, a permit application is required.

51. If there has been past exposure, can a facility change its operation to eliminate exposure, and thus become exempt?

Yes. If a category (xi) facility can change its operation and eliminate all exposure, the facility may be exempt from the regulation. It is important to note, however, that eliminating exposure may include clean up as well.

52. Is a covered dumpster containing waste material kept outside considered exposure?

No, as long as the container is completely covered and nothing can drain out holes in bottom, or is lost in loading onto a garbage truck, this would not be considered exposure.

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General Applicability

53. How is a storm water outfall from an industrial site defined for the purpose of sampling?

An industrial outfall is the point at which storm water associated with industrial activity discharges to waters of the United States or a separate storm sewer. Separate storm sewers may be roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains.

54. Are tank farms considered to be associated with industrial activity?

Yes, if they are located at a facility described in the definition of storm water discharge associated with industrial activity. Tank farms are used to store products and materials used or created by industrial facilities, and therefore are directly related to manufacturing processes. However, tank farms associated with petroleum bulk storage stations, classified as SIC code 5171, at which no vehicle maintenance or equipment cleaning operations occur, are exempt.

55. Is an offsite warehouse associated with a regulated industrial facility required to submit an application?

No. As stated on page 48011 of the preamble to the November 16, 1990, rule, warehouses of either preassembly parts or finished products that are not located at an industrial facility are not required to submit an application unless otherwise covered by the rule.

56. If a facility has more than one industrial activity, how many applications are required?

Only one application is required per facility. Permit conditions will address the various operations at the facility. The application must reflect all storm water discharges from areas associated with industrial activity as described in the definition at 122.26(b)(14). The activity in which a facility is primarily engaged determines what SIC code is assigned to that facility. To determine the activity in which a facility is primarily engaged, The SIC Manual recommends using a value of receipts or revenues approach. For example, if a facility manufactures both metal and plastic products, the facility would total receipts for each operation and the operation that generated the most revenue for the facility is the operation in which the facility is primarily engaged. If revenues and receipts are not available for a particular facility, the number of employees or production rate may be compared. If a facility performs more than two types of operations, whichever operation generates the most (not necessarily the majority) revenue or employs the most personnel, is the operation in which the facility is primarily engaged.

57. Are industrial facilities located in municipalities with fewer than 100,000 residents required to apply for a permit?

Yes. All industrial discharges of storm water through separate storm sewers or into waters of the United States must apply for an NPDES permit.

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58. If the SIC code for the activity in which a facility is primarily engaged is not included in the definition of storm water discharge associated with industrial activity, but the facility has a secondary SIC code that is included in the definition, is the facility required to submit an NPDES storm water permit application?

For purposes of this regulation, a facility's SIC code is determined based on the primary activity taking place at that facility. In the case described above, the facility is not required to apply for an NPDES storm water discharge permit. However, if the facility conducts an activity on the site identified in the narrative descriptions of categories (i), (iv), (v), (vii), or (x), then the facility would be required to submit an NPDES storm water permit application for portions of the facility used for the activities described in those categories.

59. Are military bases or other Federal facilities regulated under this rule?

Yes. Industrial activities identified under 122.26(b)(14)(i)-(xi) that Federal, State, or Municipal governments own or operate are subject to the regulation.

60. Does the regulation require a permit for storm water discharges to a publicly owned treatment works?

No. A discharge to a sanitary sewer or a combined sewer system is not regulated under the storm water regulation. Storm water discharges either to waters of the United States or separate storm sewer systems require a permit if associated with any of the industrial facilities listed in 122.26(b)(i) - (xi).

61. Are there any limits or size restrictions which narrow the scope of facilities requiring an application?

The only restrictions regarding size are for construction activities and sewage treatment works. All construction activities must apply for permit coverage except for operations that disturb less than five acres of total land which are not part of a larger common plan of development or sale. Sewage treatment works designed to treat one million gallons per day or more must submit an NPDES permit application.

62. **Do pilot plants or research and development facilities classified within one of the regulated SIC codes need to apply for a permit?**

A pilot plant or research facility classified by an SIC code which is specified under 122.26(b)(14)(i)-(xi) would be required to submit an application. A pilot plant or research facility's operations can be directly related to the manufacturing operations of the full-scale facility and therefore warrant a permit.

63. **Are stockpiles of a final product from an industrial site that are located away from the industrial plant site, included under the definition of storm water discharge associated with industrial activity?**

Such stockpiles would not be covered because they are not located at the site of the industrial facility.

64. **If a facility has a NPDES permit for its process wastewater and some, but not all, of its storm water discharges associated with industrial activity, does the operator need to apply?**

The operator must ensure that all storm water discharges associated with industrial activity are covered by an NPDES permit. The operator may wish to submit an individual application, participate in a group application, or seek coverage under a general permit for any remaining outfalls that are not covered by an existing NPDES permit. The permitting authority may also wish to modify the existing NPDES permit to cover the other storm water discharges.

65. **A facility holds a recently renewed NPDES permit which does not cover storm water discharges. Does that facility need to apply?**

Yes. If the facility is identified in paragraph 122.26(b)(14)(i) through (xi) of the rule, that facility may wish to submit an individual application, participate in a group application, or seek coverage under a general permit for any remaining outfalls that are not covered by an existing NPDES permit. The permitting authority may also wish to modify or reissue the existing NPDES permit to cover the other storm water discharges.

66. **If a regulated company owns and operates a subsidiary which is of a wholesale or commercial nature, would the subsidiary need to apply?**

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No. Since the subsidiary facility's operations are of a wholesale or commercial orientation, the operations are not considered to be industrial and therefore would not be covered by this rule unless they are specifically covered by one of the SIC codes or narrative descriptions in 122.26(b)(14).

67. Can an applicant claim confidentiality on information contained in an NPDES permit application?

No. Under 40 CFR 122.7(b), the permitting authority will deny claims of confidentiality for the name and address of any permit applicant or permittee, permit applications, permits, and effluent data.

68. Do the November 16, 1990, regulations modify the requirements of existing storm water effluent guidelines?

No. Existing storm water effluent guidelines are still applicable.

69. Which application forms are industries responsible for submitting?

- For discharges composed entirely of storm water, operators should submit Form 1 and Form 2F.
- For discharges of storm water combined with process wastewater, operators should submit Form 1, Form 2F, and Form 2C.
- For storm water discharged in combination with nonprocess wastewater, operators should submit Form 1, Form 2F, and Form 2E.
- For new sources or new discharges of storm water which will be combined with other non-storm water, operators should submit Form 1, Form 2F, and Form 2D.

70. Are Superfund sites regulated under this rule?

Yes, if the site is assigned an SIC code or fits the description of one of the categories listed in the definition of storm water discharge associated with industrial activity. Under the Superfund Amendment and Reauthorization Act (SARA) section 121(E), Superfund sites are required to "substantively comply" with all environmental regulations.

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71. **Are areas used for the disposal of industrial wastewaters and sanitary wastewaters included in the definition of "associated with industrial activity"?**

Yes, the definition includes sites used for process water land application that are not used for agricultural activities.

72. **Do inactive industrial facilities need to apply?**

Yes, if the facility is included in the definition of storm water discharge associated with industrial activity and significant materials remain on site and are exposed to storm water runoff (p.48009 of 11/16/91 Federal Register). The regulation defines significant materials at 122.26 (b)(13) as including, but not limited to, raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act; any chemical the facility is required to report pursuant to section 313 of title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

73. **Can a facility apply for an individual permit after completing the group application or applying for coverage under a general permit?**

This option is available, but the operator is advised to discuss the matter directly with the permitting authority.

74. **If a facility is totally enclosed with no materials or activities exposed to storm water, but has a point source discharge of storm water, is a permit application required?**

If the facility is described in categories 122.26(b)(14)(i-x) a permit application is required regardless of the actual exposure of materials or activities to storm water. If the facility is described in 122.26(b)(14)(xi), a permit application is required only if there is exposure of materials or activities to storm water.

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75. **How does a municipally owned industrial facility apply for an NPDES permit?**

Such a facility must meet the same application requirements as any other industrial facility. The facility may submit an individual permit application (Forms 1 and 2F), participate in a group application, or seek coverage under an available general permit.

76. **Who is required to submit Form 1?**

Anyone submitting NPDES application Forms 2C, 2D, 2E, 2F, or a construction individual application is required to submit Form 1.

77. **Before the October 1, 1992, individual application deadline, which forms must a facility submit to renew its NPDES permit for a storm water discharge?**

Since the individual storm water application is not due until October 1, 1992, EPA is allowing such facilities to choose whether the storm water discharges are identified on a Form 2C or a Form 2F. After October 1, 1992, a facility must submit an application in accordance with 40 CFR 122.26(c) (i.e., Forms 1 and 2F).

78. **Are washwaters and/or noncontact cooling waters (e.g., air conditioner condensate) included in the definition of storm water?**

No. "Storm water" means storm water runoff, snow melt runoff, and surface runoff and drainage. Washwaters are usually considered to be process wastewater. Noncontact cooling waters are considered a nonprocess wastewater.

NPDES
Storm Water Program

Question and Answer Document

Volume II

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U.S. Environmental Protection Agency
Office of Wastewater Enforcement and Compliance
Permits Division
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USEFUL ACRONYMS

BAT	Best Available Technology
BCT	Best Conventional Technology
BMP	Best Management Practice
CFR	Code of Federal Regulations
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FR	Federal Register
MS4	Municipal Separate Storm Sewer System
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
OMB	Office of Management and Budget
POTW	Publicly Owned Treatment Works
RCRA	Resource Conservation and Recovery Act
RQ	"Reportable Quantity" release
SIC	Standard Industrial Classification
TSDF	Treatment, Storage or Disposal Facility (hazardous waste)
TSS	Total Suspended Solids
WQA	Water Quality Act
WRDA	Water Resources Development Act

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STORM WATER QUESTIONS AND ANSWERS PART II

I.	General Applicability

1. What kinds of storm water discharges are required to obtain an NPDES permit under Phase I of the storm water program?

A. The National Pollutant Discharge Elimination System (NPDES) storm water permit application regulations, promulgated by the U.S. Environmental Protection Agency (EPA), require that the following storm water discharges apply for an NPDES permit: (1) a discharge associated with industrial activity; (2) a discharge from a large or medium municipal separate storm sewer system; or (3) a discharge which EPA or the State determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. The permit application deadlines are specified in EPA's regulations.

2. **What is a "storm water discharge associated with industrial activity?"**

A. The term "storm water discharge associated with industrial activity" means a storm water discharge from one of the eleven categories of industrial activity defined at 40 Code of Federal Regulations (CFR) 122.26(b)(14)(i) through (xi). Five of these categories are identified by Standard Industrial Classification (SIC) code and the other six categories provide narrative descriptions of the industrial activity. The complete definition is included in Section XIII of this document.

If any activity at a facility is covered by one of the five categories which provide narrative descriptions, storm water discharges from that activity of facility are subject to storm water permit application requirements. If the primary SIC code of the facility is identified in one of the remaining six categories, the facility is subject to the storm water permit application requirements. Note that only those facilities/activities described above having <u>point source</u> discharges of storm water to waters of the United States or to a municipal separate storm sewer system or other conveyance are required to submit a storm water permit application. The definition of "point source" is provided at 40 CFR 122.2. The definition is included in Section XIII of this document.

3. **What are SIC codes and how can a facility find out its proper SIC code?**

A. SIC codes are four-digit industry codes that were created by the Office of Management and Budget (OMB) for statistical purposes. Other governmental organizations sometimes use these codes when classifying business establishments. To find the correct SIC code, an applicant might check his or her unemployment insurance forms or contact the appropriate State unemployment services department. In addition, applicants may consult the Standard Industrial Classification Manual (SIC Manual), published by OMB in 1987. This manual is available in the resource section of most public libraries. Questions regarding assignment of particular codes can be addressed to your State permitting authority. A list of telephone numbers and addresses for State storm water contacts is provided as an attachment to this document.

4. What SIC code should a facility use when there are multiple activities occurring at the site?

A. For the purposes of the storm water program, a facility must determine its primary SIC code based on the primary activity occurring at the site. To determine the primary industrial activity, the SIC Manual recommends using the value of receipts or revenues. If such information is not available for a particular facility, the number of employees or production rate for each process may be compared. The operation that generates the most revenue or employs the most personnel is the operation in which the facility is primarily engaged. For case-specific determinations, contact the permitting authority for your State.

5. How is a facility regulated when multiple activities conducted by different operators are occurring on the same site (airports, for example)?

A. When multiple activities are conducted by different operators at a single location, each industrial activity is assigned its own SIC code. At an airport, for example, a passenger airline carrier will receive one SIC code, but an overnight courier located in the same hanger may receive another SIC code. Whereas the SIC codes may differ, if both are regulated industrial activities, EPA generally encourages these operators to become co-applicants (submit storm water permit application forms together) when they are located at the same site and when industrial areas/drainage basins are shared. When a permit is issued (or if the operators are filing for a general permit) the co-applicants will become co-permittees and share responsibility of permit compliance.

6. If a facility's primary SIC code is not listed in the regulations, but an activity that occurs on site is described in one of the narrative categories of industrial activity, does that facility have to apply for a permit?

A. If a facility conducts an activity on the site identified in the narrative descriptions of categories (i), (iv), (v), (vii), (ix) or (x), then the facility would be required to submit a storm water permit application for discharges from those portions of the facility where the activity occurs. Such narrative activities/facilities include: (i) activities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards; (iv) hazardous waste treatment storage, or disposal facilities including those that are operating under interim status or a permit under subtitle C of the Resource Conservation and Recovery Act (RCRA); (v) landfills, land application sites and open dumps that receive or have received industrial wastes; (vii) steam electric power generating facilities; (ix) sewage treatment works with a design flow of 1.0 mgd or more; and (x) construction activity disturbing five or more acres of land.

7. Do storm water discharges from non-industrial areas at an industrial facility (employee parking lots, rental car operations at an airport) have to be addressed in an NPDES permit?

A. No. Only storm water discharges from those areas that are associated with industrial activity, as defined at 40 CFR 122.26(b)(14) must be addressed in the permit. However, if storm water runoff from a non-industrial area commingles with runoff from a regulated industrial area, the combined discharge would require permit coverage.

8. How are off site facilities (such as distribution centers, storage facilities, vehicle maintenance shops) regulated under the storm water program?

A. To determine the regulatory status of off site facilities, first the operator of a facility must determine if that off site operation can be classified according to its own SIC code. If there is no SIC code which describes the off site facility independently, then it would assume the SIC code of the parent facility it supports. However, certain off site facilities that fall within the categories of auxiliary facilities described in Section XIV of this document (or which are specifically described in the SIC code description) would, in most cases, be classified according to the parent facility they support. Such supporting establishments include central administrative offices, research and development laboratories, maintenance garages, and local trucking terminals.

EPA has determined that off site vehicle maintenance facilities that service trucks used for local transportation of goods or for local services are generally considered supporting establishments which would not be assigned a transportation SIC code; rather, such facilities are classified

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according to the SIC code of the facility they support. Please refer to Section II of this document for a discussion of off-site vehicle maintenance facilities.

9. **Can authorized NPDES States be more expansive in their use of the assignment of SIC codes? For example, can they make the rule applicable to secondary activities?**

A. Yes, State storm water regulations can be more expansive and cover more activities than the Federal regulations.

10. **Are all storm water discharges to sanitary sewers exempt from storm water permitting requirements? What about discharges to combined sewer systems?**

A. Any storm water discharge to a Publicly Owned Treatment Works (POTW) or to a sanitary sewer is exempt from storm water permit application requirements. However, it may be subject to EPA's pretreatment program under Section 307(b) of the CWA. Discharges to combined sewer systems are also exempt from NPDES permitting but may be subject to pretreatment requirements.

11. **Is a storm water permit application required for an industrial facility that has constructed a holding pond that usually does not discharge storm water, but could in the event of a large enough storm?**

A. All point source discharges of storm water associated with industrial activity that discharge to waters of the U.S. or through a municipal separate storm sewer system must be permitted. Therefore, if an industrial facility does not have a storm water discharge from its holding pond during typical storm events but has a storm water discharge in the event of a large storm, that discharge must be covered under an NPDES permit. In NPDES authorized States (a list is provided in Section XII of this document), facilities should consult their permitting authority for State-specific determinations on such "potential discharges."

12. **If a facility is <u>not</u> engaged in industrial activity as defined under 40 CFR 122.26(b)(14)(i)-(xi), but discharges contaminated flows comprised entirely of storm water into a nearby municipal separate storm sewer system, is the facility required to obtain a storm water permit?**

A. No, unless EPA or the State designates the discharge as contributing to a violation of a water quality standard or as significantly contributing pollutants to waters of the United States. However, industrial dischargers should note that large and medium municipalities (population 100,000 or more) are currently designing storm water management programs that will control contaminated storm water discharges from entering their separate storm sewer systems. Additional storm water discharges may be regulated under Phase II of the storm water program. EPA is currently in the process of developing Phase II.

13. **Are activities associated with industrial activity that occur on agricultural lands exempted from storm water permitting requirements?**

A. No. If a storm water discharge is associated with industrial activity as defined at 40 CFR 122.26(b)(14), it is subject to permit application requirements regardless of the location of the industrial activity. For example, if a gravel extraction activity occurred on land leased from a farm, the activity would be classified as mining under SIC code 1442 or 1446 and therefore would be considered a storm water discharge associated with industrial activity and require a permit.

14. **Are NPDES permits transferable from one facility owner to the next?**

A. Individual NPDES permits may be transferred to a new owner or operator if the permit is modified. These procedures are described at 40 CFR 122.61. Under the general permits for storm water discharges, issued by EPA in the September 9, 1992 and September 25, 1992, Federal Register notices (57 FR 41176 and 57 FR 44412), the new operator can submit an NOI two days prior to the change of ownership but must include the facility's existing general permit number on the NOI form. Many NPDES authorized States have similar provisions in their general permits.

15. **How does storm water permitting differ in States with approved State NPDES programs compared to States without NPDES State permit programs?**

A. While Federal storm water regulations (i.e., the November 16, 1990, storm water permit application regulations) establish minimum requirements nationwide. State permitting authorities may impose more stringent requirements or decide to expand the scope of its program to meet State priorities. EPA Regional offices are the permitting authorities for 12 States and most Territories; the remaining 38 States and the Virgin Islands administer their own storm water programs and issue permits to regulate municipalities and industries in their States. Regulated facilities in these States should contact the appropriate State permitting authority for guidance, application forms, general permits and other materials. Please note that some of the NPDES States do not issue permits for Federal facilities located in their States.

For regulated facilities in the 12 non-delegated States (MA, NH, ME, FL, TX, OK, LA, NM, SD, AZ, AK, ID), the Territories (all except the Virgin Islands), the District of Columbia, and for facilities located on Indian lands (in most, if not all, delegated States and in all non-delegated States), and for Federal facilities in the States of DE, CO, IA, KS, NH, NY, OH, SC, VT and WA, the storm water program is administered through EPA Regional offices. Such facilities may be eligible for coverage under the general permits issued by EPA in the September 9, 1992, and September 25, 1992, Federal Register notices (57 FR 41176 and 57 FR 44412).

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II. Definition of Storm Water Discharge Associated With Industrial Activity

Category (i): Facilities subject to storm water effluent limitations guidelines, new source performance standards or toxic pollutant effluent standards under 40 CFR subchapter N.

16. What are toxic pollutant effluent standards?

A. 40 CFR 122.26(b)(14)(i) includes facilities that are subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards. The phrase "toxic pollutant effluent standards" refers to the standards established pursuant to CWA section 307(a)(2) and codified at 40 CFR Part 129. Part 129 applies only to manufacturers of six specific pesticide products which are defined as toxic pollutants. Please note that the phrase "facilities subject to toxic pollutant effluent standards" does not refer to those industries subject to effluent limitation guidelines for toxics under 40 CFR subchapter N.

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Category (iii): Mining and oil and gas operations classified as SIC codes 10-14.

17. What constitutes "contamination" at an oil and gas facility?

A. Oil and gas facilities classified as SIC code 13 are required to apply for a storm water permit if the facility has had a release of a Reportable Quantity (RQ) in storm water for which notification has been required any time since November 16, 1987, or if the discharge contributes to a violation of a water quality standard. RQs for which notification is required are defined at 40 CFR Parts 110, 117, and 302. An RQ for oil is defined at 40 CFR 110 as the amount of oil that violates applicable water quality standards or causes a film or sheen upon or a discoloration of the water surface or adjoining shorelines, or causes a sludge or emulsion to be deposited beneath the water surface or upon adjoining shorelines. For other substances, RQ levels are expressed in terms of pounds released over any 24 hour period and are listed at 40 CFR 117.3 and 40 CFR 302.4. A list of these RQ levels is available from the Storm Water Hotline at (703) 821-4823.

18. **Do EPA's industrial storm water general permits apply to discharges from mine sites that are subject to storm water effluent limitations guidelines, but which are not covered by an existing NPDES permit?**

A. No, storm water discharges from mine sites that are subject to storm water effluent limitation guidelines are not authorized by industrial storm water general permits issued by EPA in the September 9, 1992, and September 25, 1992, Federal Register notices (57 FR 41176 and 57 FR 44412). In States without NPDES permitting authority, the mine operators submit an individual application to address those storm water discharges, or could have participated in a group application prior to October 1, 1992 (note: any facility which did not submit an individual application prior to October 1, 1992 or participate in a timely group application missed EPA's regulatory deadline and may be subject to enforcement action). However, certain authorized States may issue general permits authorizing such storm water discharges from mine sites provided that those permits contain the applicable guideline requirements.

19. **Can point source discharges of contaminated ground water from mine adits and seeps at active or inactive mine sites be permitted under the storm water program?**

Point source discharges of non-storm water to waters of the United States must be authorized by an NPDES permit. Point source discharges of either contaminated ground water from a mine adit or seep that are not related to specific storm events would not be considered to be storm water. Discharges that are composed in whole or in part of non-storm water cannot be addressed solely by the permit applications for storm water (Forms 1 and 2F), and cannot be authorized by NPDES permits that only authorize discharges composed entirely of storm water. Rather, Forms 1 and 2C or 2D (and Form 2F if the discharge is mixed with storm water) must be used when applying for a NPDES permit for non-storm water.

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Category (iv): Hazardous waste treatment, storage or disposal facilities.

20. If the primary SIC code of a facility is not covered under the regulations, but there is a hazardous waste treatment, storage or disposal facility (TSDF) on site, is the TSDF subject to storm water permitting requirements?

A. Yes. If the hazardous waste TSDF is or should be operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA), regardless of the facility's primary activity, the storm water discharges from that portion of the site are subject to the narrative definition of storm water discharges associated with industrial activity under category (iv). Even if a facility's SIC code is not included in the regulations, any activity described by one of the narrative categories of "industrial activity" that is occurring on the site would be regulated under the storm water program.

Category (v): Landfills, land application sites and open dumps that receive industrial waste.

21. At what point does an inactive, closed, or capped landfill cease being an industrial activity?

A. An inactive, closed or capped landfill is no longer subject to storm water permit application requirements when the permitting authority determines the land use has been altered such that there is no exposure of significant materials to storm water at the site. For example, if an impervious surface (such as a parking lot or shopping center) now covers the closed landfill, the permitting authority could determine that storm water discharges from the area are no longer associated with the previous landfill activity. These determinations must be made by the permitting authority on a case-by-case basis.

22. If construction of cells at a landfill disturbs greater than five acres of land, is coverage under EPA's construction general permits required?

A. No. EPA considers construction of new cells to be routine landfill operations that are covered by the landfill's industrial storm water general permit. However, the storm water pollution prevention plan for the landfill must incorporate best management practices (BMPs) that address sediment and erosion control. Where a new landfill is being constructed

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and five or more acres of land are being disturbed, such activity would need to be covered under EPA's construction general permit until the time that initial construction is completed and industrial waste is received. Please note that NPDES authorized States may address this situation differently.

Category (viii): Transportation facilities

23. **If all vehicle maintenance and equipment cleaning operations occur indoors at a transportation facility, as defined at 40 CFR 122.26(b)(14)(viii), is a permit application required for discharges from the roofs of these buildings?**

A. Yes. Storm water discharges from all areas that are "associated with industrial activity," described at 40 CFR 122.26(b)(14), are subject to the storm water permit application requirements. This would include discharges from roofs of buildings that are within areas associated with industrial activity. In addition, storage areas of materials used in vehicle maintenance or equipment cleaning operations and holding yards or parking lots used to store vehicles awaiting maintenance are also considered areas associated with industrial activity.

24. **For a facility classified as SIC code 5171 (bulk petroleum storage), is the transfer of petroleum product from the storage tanks to the distribution truck considered "fueling", and therefore an industrial activity as defined by the regulations?**

A. No. The transfer of petroleum product from the storage tanks to the tanker truck is not considered fueling and would not require a storm water permit. However, fueling of the tanker truck itself at the 5171 facility is considered to be part of routine vehicle maintenance, and storm water discharges from these areas must be covered under a storm water permit application.

25. **Is a retail fueling operation that occurs at an SIC code 5171 petroleum bulk storage facility regulated?**

A. No. The provisions of 40 CFR 122.26(b)(14)(viii) apply to fueling operations conducted at petroleum bulk storage facilities where the vehicles being fueled are involved with the petroleum bulk storage operation. Retail fueling of vehicles at such sites does not constitute "vehicle maintenance" (as defined in the November 16, 1990 Federal

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Register page 48066), and a storm water permit is not required for the discharges from that area. Only those portions of the SIC code 5171 facility where vehicle maintenance operations (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication) and equipment cleaning take place are required to be covered under a storm water permit application.

26. **Are off site vehicle maintenance areas required to submit permit applications for their storm water discharges?**

A. As discussed in Section I of this document, to determine the regulatory status of off site vehicle maintenance operations, the operator of a facility must first determine if that off site operation can be classified according to its own SIC code. If there is no SIC code which describes the off site facility independently, then it would assume the SIC code of the parent facility it supports. However, please note that off-site facilities that fall within the nine categories listed on page 17 of the SIC Manual (or which are specifically described in the SIC code description) would, in most cases, be classified according to the parent facility they support. See Section XIII of this document for the complete list. Such supporting establishments include central administrative offices, research and development laboratories, maintenance garages, and local trucking terminals. EPA has determined that off site vehicle maintenance facilities that primarily service trucks used for local transportation of goods or for local services are generally considered supporting establishments which do not assume a transportation SIC code; rather, such facilities are classified according to the SIC code of the facility they support. Long-distance trucking centers, on the other hand, are generally classified as SIC code 4213, and are subject to regulation under 40 CFR 122.26(b)(14)(viii)).

Category (x): Construction activity

27. **Who must apply for permit coverage for construction activities?**

A. Under the NPDES storm water program, the operator of a regulated activity or discharge must apply for a storm water permit. EPA clarified that the operator of a construction activity is the party or parties that either individually or taken together meet the following two criteria: (1) they have operational control over the site specifications (including the ability to make modifications in specifications); and (2) they have the day-to-day operational control of those activities at the site necessary to ensure compliance with plan requirements and permit conditions (9/9/92 Federal Register page 41190). If more than one party meets the above criteria,

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then each party involved must become a co-permittee with any other operator(s). For example, if the site owner has operational control over site specifications and a general contractor has day-to-day operational control of site activities, then both parties will be co-permittees.

When two or more parties meet EPA's definition of operator, each operator must submit an NOI, and either include a photocopy of the other operators' NOI(s) or the general permit number that was assigned for that project. Under EPA's storm water construction general permits, the co-permittees are expected to join in implementing a common pollution prevention plan prior to submittal of the NOI, and in the retention of all plans and reports required by the permit for a period of at least three years from the date that the site is finally stabilized.

For individual storm water discharge permits, applications must be filed 90 days prior to the commencement of construction. If a contractor has not been selected at the time of application, the owner of the project site would initially file the application and the contractor should sign on when selected. Under an individual storm water permit for construction, multiple operators would have to sign onto the permit, instead of submitting a new application. Please note that authorized NPDES States may have varying NOI and/or permit requirements and should be contacted on this issue.

28. What are the responsibilities of subcontractors at the construction site under EPA's storm water construction general permits?

A. EPA storm water construction general permits require subcontractors to implement the measures stated in the pollution prevention plan and to certify that he/she understands the terms and conditions of the permit requirements. Under EPA's general permits, subcontractors are not required to submit NOIs.

29. What is meant by a "larger common plan of development or sale?"

A. A "larger common plan of development or sale" is a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan. For example, if a developer buys a 20-acre lot and builds roads, installs pipes, and runs electricity with the intention of constructing homes or other structures sometime in the future, this would be considered a common plan of development or sale. If the land is parceled off or sold, and construction occurs on plots that are less than five acres by separate, independent builders, this activity still would be subject to storm water permitting requirements if the smaller plots were included on the original site plan.

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30. Does construction activity encompass repaving of roads?

A. Repaving is not regulated under the storm water program unless five or more acres of underlying and/or surrounding soil are cleared, graded or excavated as part of the repaving operation.

31. Is clearing of lands specifically for agricultural purposes regulated construction activity (40 CFR 122.26(b)(14)(x)) under the storm water program?

A. No. Although the clearing of land may be greater than five acres, any amount of clearing for agricultural purposes is not considered an industrial activity under the storm water regulations. Section 402(l)(1) of the 1987 Water Quality Act exempts agricultural storm water discharges from NPDES permitting requirements including storm water permitting. This exemption only applies, however, if the clearing of land is solely for agricultural purposes. (See Question 13).

32. If a construction activity that disturbs five or more acres commences on a site covered by an existing industrial storm water permit, are the storm water discharges from the construction area covered by the existing permit or is a separate permit required?

A. If the existing permit is an individual permit, than the operator must either request a modification of the existing permit to include the construction storm water discharges or apply for coverage under a separate permit that specifically addresses that construction activity. If the permittee decides to modify the existing individual permit, permit modifications must be approved prior to initiating any construction activity. If the existing permit is an EPA storm water industrial general permit, the operator should submit an NOI for coverage under EPA's storm water general permit for construction activities. States with NPDES permitting authority may have different requirements.

33. If a construction activity that disturbs less than five acres occurs on site of a regulated industrial activity currently covered by EPA's industrial storm water general permit, does the regulated industry have to modify its pollution prevention plan to include controls for the area of construction?

A. Yes. Regulated industrial activities covered by EPA's storm water industrial general permit must revise their pollution prevention plan to address all new sources of pollution and runoff including those from construction activities disturbing less than five acres, that occurred on the site of the regulated industry. However, if less than five acres, a separate storm water permit for the construction activity is not required (see Question 32).

34. For projects such as a 100-mile highway construction project, what location should be provided on the NOI?

A. The midpoint of a linear construction project should be used as the site location on EPA's NOI form. For construction projects that span across more than one State, the project must meet the application requirements of each State.

35. Are long-term maintenance programs for flood control channels (such as vegetation removal) or similar roadside maintenance programs subject to permitting if five or more acres are disturbed?

A. If grading, clearing or excavation activities disturb five or more acres of land either for an individual project or as part of a long-term maintenance plan, then the activity is subject to storm water permit application requirements.

36. **For a construction activity that uses off site "borrow pits" for excavation of fill material or sand and gravel, should the number of disturbed acres at the borrow pit be added to the number of acres at the construction site to determine the total number of disturbed acres?**

A. No, off site borrow pits are not considered part of the on site construction activity. If a borrow pit is specifically used for the removal of materials such as sand, gravel, and clay, the pit is considered a mine and is classified under SIC code 14. Such sites would be regulated as industrial activity as defined at 40 CFR 122.26(b)(14)(iii). However, if the borrow pit is utilized for the removal of general fill material (e.g. dirt) and disturbs five or more acres of land, the pit would be considered a construction activity as defined at 40 CFR 122.26(b)(14)(x).

37. **Would building demolition constitute a land disturbing activity and require a storm water construction permit application?**

A. The definition of land disturbing activity includes but is not limited to clearing, grading and excavation. At a demolition site, disturbed areas might include the site where building materials, demolition equipment, or disturbed soil are situated, which may alter the surface of the land. Therefore, demolition activities that disturb five or more acres of land would be subject to storm water construction permit application requirements.

38. What are the legal responsibilities and liabilities for construction activities disturbing less than five acres, pursuant to the Ninth Circuit U.S. Court of Appeals decision on June 4, 1992?

A. In NRDC v. EPA, 966 F.2d 1292, the Ninth Circuit U.S. Court of Appeals remanded for further rulemaking, EPA's exemption of construction sites less than five acres which are not part of a larger common plan of development or sale. The Agency intends to undergo further rulemaking proceedings for construction sites less than five acres. Until further rulemaking is completed, permit applications for such activities need not be submitted to EPA. However, States with NPDES permitting authority may have more stringent requirements.

39. **Do storm water construction general permits authorize non-storm water discharges?**

A. Under EPA's storm water construction general permits, issued on September 9, 1992, and September 25, 1992, the following non-storm water discharges are conditionally authorized (57 FR 41219) and (57 FR 44419): discharges from fire fighting activities; fire hydrant flushings; waters used to wash vehicles or control dust; potable water sources including waterline flushings; irrigation drainage; routine external building washdown which does not use detergents; pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used; air conditioning condensate; springs; uncontaminated ground water; and foundation or footing drains where flows are not contaminated with process materials such as solvents. These discharges, except for flows from fire fighting activities, must be identified in the pollution prevention plan and the plan must address the appropriate measures for controlling the identified non-storm water discharges. Other non-storm water discharges not listed above or not identified in the storm water pollution prevention plan, must be covered by a different NPDES permit.

Category (xi): Light manufacturing facilities

40. **If oil drums or contained materials are exposed during loading or unloading at a category (xi) facility, are storm water discharges from this area subject to the storm water regulations?**

A. The storm water regulations require category (xi) facilities to apply for a storm water permit where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. If there is a

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reasonable potential for leaks or spills from these drums which could be exposed to storm water, discharges from that area would be subject to storm water permitting requirements. Completely covering loading and unloading activities may eliminate exposure. Note that permitting authorities may have more stringent interpretations with respect to exposure on industrial sites and should be consulted for case-by-case determinations. For a discussion on the 9th Circuit Court of Appeals decision (June 1992) and future EPA rulemakings on category (xi) facilities, please refer to Section IX of this document.

41. Does the storage of materials under a roof at a category (xi) facility constitute exposure?

A. If materials or products at a light industrial facility are stored outside under a roof and there is no reasonable potential for wind blown rain, snow, or runoff coming into contact with the materials or product, then there may not be exposure at that area. However, if materials are stored under a structure without sides and storm water comes into contact with material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products or industrial machinery, the discharge from that area must be permitted. The permitting authority should be contacted for specific issues related to exposure.

III. Individual Permits

42. Will individual permits include requirements for storm water pollution prevention plans and monitoring?

A. EPA anticipates that many individual permits will include storm water pollution prevention plans as a means of satisfying Best Available Technology (BAT)/Best Conventional Technology (BCT) requirements established in the Clean Water Act (CWA). With regard to monitoring requirements under individual permits, such requirements will be determined by the permit writer on a case-by-case basis. At a minimum, all facilities with storm water discharges associated with industrial activity must conduct an annual site inspection as prescribed at 40 CFR 122.44(i)(4)..

43. Do permitting authorities have the option of subjecting facilities that have submitted individual storm water permit applications to general permits?

A. Yes, permitting authorities may subject facilities that have submitted individual permit applications to general permits. Facilities that are covered

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by a general permit may petition the permitting authority to be covered under an individual permit by submitting an individual permit application with reasons supporting the request to the permitting authority, pursuant to 40 CFR 122.28(b)(2)(iii).

44. **What are the benefits/drawbacks of pursuing an individual storm water permit over a general permit?**

A. An individual storm water permit may be advantageous, as it is designed to reflect a facility's site-specific conditions, whereas general permits are much broader in scope, particularly in terms of monitoring requirements. However, the individual permit application is generally more difficult to prepare than submitting EPA's notice of intent (NOI) to be covered under a general permit (in part because the individual permit application requires sampling and EPA's NOI does not). General permits may be advantageous because regulated facilities know, in advance of submitting their NOI, the requirements of the permit. In addition, coverage under a general permit may be automatic (depending on how the permit is written), whereas the individual permitting process takes longer.

45. **When does EPA anticipate that individual permits will be issued?**

A. Issuance of individual permits may vary on a State by State basis, as permitting priorities and resources allow. The December 18, 1992, Federal Register (57 FR 60447) established October 1, 1993, as the deadline by which individual permits are to be issued. Many authorized States are already issuing individual permits.

46. **Can a facility that has submitted an individual permit application obtain general permit coverage upon issuance of a general permit in its State?**

A. Yes, an eligible facility may opt for coverage under a general permit (by submitting an NOI) up until the time that the permitting authority issues such facility its individual permit. Authorized States may require a written request for withdrawal from the individual permit application process. EPA recommends submitting such requests to the appropriate Regional office.

IV.	EPA General Permits (issued on 9/9/92 and 9/25/92)

47. What is the difference between EPA's construction and industrial general permits?

A. Because the nature of construction activity varies considerably from other industrial activities, EPA developed two separate general permits: one covering storm water discharges from construction activity and one for other storm water industrial discharges. Whereas the pollution prevention plan for the construction permit focuses on sediment and erosion controls and storm water management, the pollution prevention plan for industry emphasizes general site management. Note that some authorized States have industrial general permits that authorize storm water discharges from construction activity.

EPA's general permits for storm water discharges associated with industrial activity, issued on 9/9/92 (57 FR 41236) and 9/25/92 (57 FR 44438), authorize storm water discharges from all new and existing point source discharges of storm water associated with industrial activity, as defined at 40 CFR 122.26(b)(14), to waters of the U.S., except for ineligible storm water discharges that are listed at I.B.3. (9/9/92 Federal Register page 41305) and (9/25/92 Federal Register page 44444) in EPA's general permits.

EPA's general permits for storm water discharges associated with construction activity, which were issued on 9/9/92 (57 FR 41176) and 9/25/92 (57 FR 44412), authorize storm water discharges associated with construction activity, as defined at 40 CFR 122.26(b)(14)(x), except for ineligible discharges that are listed at I.B.3 (9/9/92 Federal Register page 41217) and (9/25/92 Federal Register page 44418) in EPA's general permits.

48. What is the procedure for applying for coverage under EPA's industrial or construction general permits?

A. Dischargers of storm water associated with industrial activity located in non-NPDES States must submit a Notice of Intent (NOI) to be authorized to discharge under the general permit. The NOI form is a one-page document requesting basic information about the nature of the facility and the particular storm water discharge under consideration. Under EPA's general permits, monitoring is not required for submittal of the NOI. States with NPDES authority may have different requirements for their NOI and should be contacted directly.

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49. **Will a facility automatically be covered by an EPA general permit upon submittal of an NOI or will it have to cease operations until the Agency provides notification of acceptance?**

A. Permit coverage begins two days after the postmark date on the NOI, provided the storm water discharges from the facility are eligible for coverage as established by the permit conditions (see 9/9/92 Federal Register page 41305 for limitations on coverage). The permitting authority can require the submittal of an individual application at any time. However, the facility may continue to discharge under the general permit until an individual permit is issued or denied.

50. **What are the deadlines for compliance with EPA's general permits?**

A. Individuals who intend to obtain coverage for a storm water discharge associated with industrial activity that commenced on or before October 1, 1992, were required to submit an NOI by October 1, 1992; however, EPA is accepting late NOIs. Regulated facilities wishing to obtain coverage under the general permit that have not yet submitted an NOI should do so immediately. EPA's storm water general permits require permittees to develop and implement a storm water pollution prevention plan. Deadlines for NOI submittal and development and implementation of plans are listed in the table below.

Facilities with salt storage or facilities that were not required to report under Emergency Planning Community Right to Know (EPCRA) Section 313 prior to July 1, 1992, (but must report after that date) must comply with the special requirements for section 313 facilities and salt storage (if applicable) within 3 years of the date on which the facility is required to first report under section 313. All other conditions in the permit must be met within the deadlines listed above. Plans do not have to be submitted to the Agency but must be kept on site and made available upon request.

Type of Discharge	NOI Deadline	Pollution Prevention Plan Development Deadline	Pollution Prevention Plan Implementation Deadline
Existing industrial activities (other than construction)	October 1, 1992	April 1, 1993	October 1, 1993

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Type of Discharge	NOI Deadline	Pollution Prevention Plan Development Deadline	Pollution Prevention Plan Implementation Deadline
Industrial activities (other than construction) that begin between October 1, 1992 and January 1, 1993	2 days prior to the start of industrial activity	Within 60 days of commencement of operations	Within 60 days of commencement of operations
Industrial activities (other than construction) that begin on or after January 1, 1993	2 days prior to the start of industrial activity	Within 60 days of commencement of operations	Upon commencement of operations
Oil and gas facilities previously not required to be permitted that have an RQ after October 1, 1992	Within 14 days of first knowledge of the release	Within 60 days of first knowledge of the release	Within 60 days of first knowledge of the release
Municipally-owned or operated industrial activities that were rejected or denied from a group application	Within 180 days of the date of rejection or denial	Within 365 days of the date of rejection or denial	Within 545 days of the date of rejection or denial
Construction sites in operation on October 1, 1992	October 1, 1992	October 1, 1992	October 1, 1992
Construction sites that begin operation after October 1, 1992	2 days prior to the start of construction	Prior to the submittal of the NOI	With the initiation of construction activities

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51. Is there a fee for NOI applications?

A. EPA's general permits do not require fees at this time. However, authorized NPDES States may levy fees and should be contacted directly.

52. Where should NOIs be submitted?

A. Facilities in States and Territories where EPA is the permitting authority submit NOIs to the central processing center at the following address:

Storm Water Notice of Intent
P.O. Box 1215
Newington, VA 22122.

All permittees in States with NPDES authority submit the NOI to their State permitting authority except those in New York, who submit to the processing center at the above address. Note that authorized NPDES States may develop NOI forms that are different from EPA's NOI form. Under EPA's general permits, the operator of any industrial activity that discharges storm water through a municipal separate storm sewer system in a medium or large municipality must also submit a copy of the NOI to that municipality. In addition, operators of construction activities must provide a copy of all applicable NOIs for a site to the local agency approving sediment and erosion plans or storm water management plans.

53. Is an operating regulated industrial facility required to submit a separate NOI for each outfall that discharges storm water associated with industrial activity at the site?

A. Under EPA's general permits, one NOI is generally sufficient for the entire site, provided there is one operator. In this case, the pollution prevention plan must address all discharges of storm water associated with industrial activity from the site. If there are multiple operators at the site, each operator must submit an NOI. In addition, if a facility that is covered under EPA's industrial storm water general permit undertakes a construction activity disturbing more than five acres of land, then the facility must submit an NOI for those construction-related storm water discharges for coverage under EPA's construction general permit (or submit an individual permit application).

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54. **Will a facility receive any notification from EPA after submitting an NOI under EPA's general permit?**

A. Yes, EPA confirms the receipt of NOIs and will provide the applicant with a permit number and explains how to get a summary of the guidance on preparing storm water pollution prevention plans.

55. **Is an entire facility excluded from coverage under EPA's general permits if a single discharge at the site is excluded from coverage?**

A. No. Eligibility under EPA's general permits should be applied on a discharge-specific basis. Thus, a site with multiple discharges can be covered under two different permits: a general permit for some discharges and a separate NPDES permit for any discharges excluded from coverage under the general permit. NPDES States should be contacted for additional guidance on this issue.

56. **Does an industrial facility operating under an EPA industrial general permit have to apply for a separate permit for all on site construction activities that disturb more than five acres of land?**

A. Storm water discharges from construction activities that disturb five or more acres of land must be covered under a separate NPDES permit that specifically addresses storm water discharges from construction activity. EPA's industrial storm water general permits do not provide coverage for storm water discharges from regulated construction activities. Construction activities that disturb less than five acres of land do not require a storm water permit at this time. The pollution prevention plan for the industrial facility must be modified to address site changes due to that amount of construction activity.

57. **Can a facility submit one NOI for similar but separately located industrial facilities which are owned by the same corporation?**

A. No. One NOI must be submitted by the operator of each individual facility that intends to obtain coverage under a general permit, regardless of common ownership.

58. **Does an asphalt/concrete batch plant have to submit a new NOI each time it changes location?**

A. Under EPA's general permits, an NOI must be submitted each time the plant moves to a new site of operation. However, some authorized States may have different requirements with respect to asphalt/concrete batch plants and, therefore, facilities in such States should contact their permitting authorities.

59. **Who is required to monitor under the conditions of EPA's storm water general permits?**

A. EPA established tiered monitoring requirements in its final industrial storm water general permits based on the potential to contribute pollutants to storm water (4/2/92 Federal Register page 11394). Six classes of facilities are required to monitor semiannually and report annually, ten classes of facilities are required to monitor annually and keep the data on site, and all other classes of facilities are not required to monitor. All facilities authorized by general permits (including those facilities not otherwise required to monitor) must still conduct an annual site inspection, except for inactive mining sites where this may be impractical due to remote location and inaccessibility of sites (inspection no less than once in three years). The sixteen classes of facilities that are required to monitor are specified in EPA's industrial general permits (9/9/92 Federal Register page 41248), which are available from the Storm Water Hotline. EPA's construction storm water general permits require periodic inspections in lieu of monitoring.

60. **If an industrial facility that is required to monitor under EPA's industrial storm water general permits does not have any exposure of materials or activities to storm water, does it still have to conduct sampling?**

A. Under EPA's industrial storm water general permits, industrial facilities can provide a certification in lieu of monitoring results for a given outfall, that materials and activities are not presently exposed to storm water and will not be exposed during the certification period (see 9/9/92 Federal Register page 41314 for a more detailed description). This determination should be applied on outfall-by-outfall basis (e.g., permittees may elect to monitor certain outfalls while providing certification for others). The certification must be updated on an annual basis and retained in the pollution prevention plan. The six classes of facilities that are required to report monitoring results annually must submit this certification to the permitting authority in lieu of the Discharge Monitoring Report (DMR).

61. **Within one drainage area leading to a single outfall, if a facility conducts two separate industrial activities that are subject to both semiannual and annual monitoring requirements, which set of monitoring requirements will apply?**

A. If the discharges cannot be segregated, the combined discharge would be subject to both sets of monitoring requirements. In effect, a combined

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discharge could be subject to annual monitoring requirements for certain parameters and semi-annual monitoring for others. If a facility can segregate the discharges from the different activities, separate monitoring requirements would apply to each discharge.

62. **Is it possible to sample only one of several identical outfalls under the provisions of EPA's general permits?**

Yes. To reduce the monitoring burden on the facility, the permit allows an operator to sample one outfall where it is substantially identical to the other outfalls. Permittees that intend to use this provision must justify and document in writing why one outfall is substantially identical to the others. Criteria for making this determination are presented in the NPDES Storm Water Sampling Guidance Document. Facilities using this provision must include the written justification in their storm water pollution prevention plan. Facilities that are subject to semiannual monitoring requirements must submit the justification of why an outfall is substantially identical to the others with the Discharge Monitoring Report. Other facilities required to monitor under the permit are not required to submit the justification unless it is requested by the permitting authority.

63. **If a facility had to report under section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) when its NOI was submitted but no longer uses the quantity of water priority chemicals that makes such reporting necessary, is that facility still subject to special requirements in EPA's industrial storm water general permits for facilities that handle EPCRA section 313 water priority chemicals?**

A. No. Such facilities are no longer subject to the special EPCRA requirements contained in EPA's industrial storm water general permit and should accordingly modify their pollution prevention plan to indicate the changes in industrial activity at the facility.

64. **Under EPA's general permits, when and where must Discharge Monitoring Reports (DMR) be submitted for semi-annual monitoring facilities?**

A. DMRs must be submitted to the permitting authority according to the following schedule: a) certain EPCRA section 313 facilities and wood treatment facilities monitor from January to June and July to December and report no later than January 28 following the second monitoring period; b) Primary metal facilities, facilities with coal pile runoff, and battery reclaimers monitor from March to August and September to February and report no later than April 28; and c) land disposal facilities monitor from October to March and from April to September and report no later than October 28. For facilities in non-NPDES States, DMRs must be

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submitted to the EPA Regional office (Section XI of this document includes storm water list of contacts for addresses). In States with approved NPDES permit programs, DMRs must be sent to the location specified in the State's general permit. The general permits in such States may also have different schedules for submitting DMRs than the one specified above.

65. Under the industrial general permit, coal-fired steam electric facilities have annual monitoring requirements for storm water discharges from coal handling sites (other than from coal pile runoff). Are access roads considered coal handling sites?

A. Coal handling sites include those areas of the facility where coal is either loaded or unloaded. Therefore, those portions of access roads where loading/unloading operations do not occur are not considered to be coal handling sites and, therefore, are not subject to annual monitoring requirements under EPA's general permits.

66. Are there specific numeric effluent limits in EPA's storm water general permits?

A. EPA's general permits establish pollutant discharge limits for total suspended solids (TSS) and pH in coal pile runoff. In most other situations, EPA's industrial storm water general permits focus on storm water management and the implementation of facility-specific pollution prevention plans; however, EPA's industrial general permits also include State-specific conditions that may include additional numeric effluent limits.

67. What is a storm water "best management practice" (BMP)?

A. A BMP (defined at 9/9/92 Federal Register page 41319) is a technique, process, activity or structure used to reduce the pollutant content of a storm water discharge. BMPs include simple, nonstructural methods such as good housekeeping and preventive maintenance. Additionally, BMPs may include sophisticated, structural modifications such as the installation of sediment basins. The focus of EPA's general permits is on preventative BMPs which limit the release of pollutants into storm water discharges. EPA has published guidance materials to assist in the selection of appropriate BMPs in the preparation of storm water pollution prevention plans, including: *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices (PB-92-235969)* and *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices (PB-*

92-235951). These Manuals are available from NTIS at (703) 487-1650 and the Office of Water Resource Center at (202)260-7786.

68. **What should a facility do when the nature of its activities changes?**

A. When the nature of a facility's activities changes, the facility must modify the pollution prevention plan accordingly. If the facility is subject to new monitoring requirements as a result of the changes, sampling must begin at the start of the next monitoring period.

69. **Is there a procedure for notifying EPA when a storm water discharge associated with industrial activity covered by EPA's general permit has been eliminated?**

A. Yes. EPA's general permits include procedures for filing a Notice of Termination (NOT) form when there is no longer a potential for storm water discharges associated with industrial activity to occur. Operators of construction activities can submit an NOT once they have finally stabilized all areas that were disturbed. For construction activity, final stabilization means that all soil disturbing activities at the site have been completed, and that a uniform perennial vegetative cover has been established or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed with a density of 70% of the previously existing/background cover for unpaved areas and areas not covered by permanent structures. A copy of the NOT can be found in Federal Register notices dated September 9, 1992 (57 FR 41232 and 41341), and September 25, 1992 (57 FR 44434 and 44469).

70. **If a NPDES authorized State has general permitting authority but has not yet finalized an applicable general permit, can a facility still submit an NOI and assume general permit coverage?**

A. No, a facility cannot submit an NOI to obtain coverage under a general permit until that permit has been finalized. Furthermore, a facility located in an NPDES State cannot seek coverage under one of EPA's general permits.

71. **Will State general permit requirements vary and to what extent?**

A. General permit requirements for authorized NPDES States may vary considerably because these States develop and issue permits independently from EPA. However, all NPDES permits must meet minimum technical and water quality-based requirements of the Clean Water Act. Permittees in NPDES authorized States should consult with their permitting authorities regarding particular State conditions. Under EPA's storm water general permits, State-specific requirements vary

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because of different water quality concerns in different States. Each of the 12 non-authorized States and Territories provided certification that EPA's general permits comply with State water quality standards, and added permit requirements where necessary to achieve compliance with those standards in the final general permits.

72. **Can discharges from industrial areas at a construction site such as portable asphalt plants and/or concrete batch plants be covered under EPA's construction general permits?**

A. No. EPA's construction general permits only authorize discharges from the construction area; these permits do not authorize storm water discharges from industrial activities other than construction that are located on the construction site. Portable asphalt plants and/or concrete batch plants are considered to be "industrial activity," as defined 40 CFR 122.26(b)(14)(ii). Therefore, storm water discharges from such industrial activities must be in compliance with a general or individual storm water permit for industrial storm water discharges other than construction. At a construction site which disturbs less than 5 acres of land (and which is, therefore, not subject to storm water permit application requirements for the construction activity), the operator of the mobile asphalt or concrete plant still would be required to obtain storm water permit coverage for discharges from the plant. Please note that States with approved NPDES permit programs may allow portable asphalt plants and/or cement batch plants to be covered under the State's construction general permit.

V. Group Applications

73. **How will group applicants be permitted?**

A. EPA is currently developing a model permit using information from Part I and Part II group applications, and other sources. This model permit will have sections which address a particular type of industrial activity. When the model permit is completed, the permitting authority (EPA or NPDES States) then has the option to propose and issue final permits to cover group members within their state based upon the model permit.

VI. Sampling

74. **For what parameters does a facility have to sample under the individual or group application?**

A. Applicants are required to obtain quantitative data from samples collected during storm events from all outfalls that discharge storm water associated with industrial activity for the following parameters: (1) any pollutant limited in an effluent guideline to which the facility is subject; (2) Any pollutant listed in the facility's permit for its process wastewater (if the facility is operating under an existing NPDES permit); (3) Oil and grease, pH, BOD5, COD, TSS, total phosphorous, total Kjeldahl nitrogen, and nitrate plus nitrite nitrogen; (4) certain toxic pollutants listed in Tables II and III of the Appendix D to 40 CFR Part 122 (also listed as Tables 2F-2 and 2F-3 in the instructions for Form 2F) that are expected to be present in the storm water.

75. For an individual or group application, how many aliquots (portions) of storm water are needed to obtain a flow-weighted composite?

A. A flow-weighted composite may be taken as a combination of a minimum of 3 sample aliquots taken in each hour of discharge for the entire event or for the first three hours of the event, with each aliquot collection being separated by a minimum of 15 minutes. If the storm event lasts less than three hours, aliquots should be collected for as long as there is sufficient flow. Large and medium municipalities may use a different protocol with respect to time duration between collection of aliquots with approval of the permitting authority. EPA's *NPDES Storm Water Sampling Guidance Document* discusses several ways to estimate flows. [This manual is available from the Storm Water Hotline (703) 821-4823) and the Office of Water Resource Center (202)260-7786].

76. How does a facility measure flow if there are numerous small outfalls?

A. Applicants may provide either measurements or estimates of storm water flows. One possible method for estimating flow is to create a conveyance that would combine flows from many of the outfalls. Alternatively, where flows are similar, the flow at one outfall may be measured to calculate flows at the other outfalls, provided that the method of measurement is indicated to the permitting authority. EPA's *NPDES Storm Water Sampling Guidance Document* discusses several ways to estimate flows. [This manual is available from the Storm Water Hotline (703) 821-4823) and the Office of Water Resource Center (202)260-7786.]

77. For what parameters is only a grab sample appropriate?

A. When collecting storm water samples, grab samples are required for the following parameters: pH, temperature, cyanide, total phenols, residual

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chlorine, oil and grease, fecal coliform and fecal streptococcus. Both grab and composite samples are required for all other pollutants.

78. Do both a grab and a composite sample have to be taken from a 24-hour holding pond?

A. No. Only a minimum of one grab sample is required to be taken.for effluent from holding ponds or other impoundments with a retention period of greater than 24 hours for the representative event.

79. Can composite and grab samples be taken from separate events?

A. Grab and composite samples for a given outfall should be taken from the same storm event to provide a basis for comparing the data. If this is impossible, information describing each storm event used for sample collection should be recorded and submitted with sampling results. However, applicants are advised that the permitting authority may request data to be collected from only one storm event.

80. Is a facility required to sample all of its outfalls during a single storm event?

A. No. Unless otherwise specified by the permitting authority, a facility may sample outfalls during different events provided that the storms meet the criteria established in the application regulations or in the applicable permit language. Information describing each storm event used for sample collection should be recorded and submitted with sampling results.

81. If a facility has two conveyences that join and leave the site as one combined discharge, where should a sample be collected?

A. If the discharge is composed entirely of storm water, the sampling point should be at the outfall as it leaves the property. If the discharge is a combination of process wastewater and storm water, the storm water component of the discharge should be sampled before it commingles with the process waste water discharges. If sampling at an outfall at the property boundaries is impossible because of safety reasons, inaccessibility, or a poor conveyance, sampling may be done closer to the discharge source.

82. How long of a 'dry' period does a facility need before sampling?

A. A 'dry' period needs to be at least 72 hours. More specifically, all samples must be collected from the discharge resulting from a storm event that

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occurs at least 72 hours from the previously measurable (greater than 0.1 inches) storm event.

83. If two or more outfalls at a facility have identical discharges, does each outfall have to be sampled?

A. Where a facility has outfalls that discharge "substantially identical effluent," the permitting authority may allow the applicant to test only one outfall and report that the quantitative data are representative of the substantially identical outfalls. EPA's *NPDES Storm Water Sampling Guidance Document* (available from the Storm Water Hotline (703-821-4823)) provides information on how to prepare this petition, or the applicant should contact their permitting authority to determine what information is required.

84. Do analyses for storm water need to be done by a certified lab?

A. There is no Federal requirement to use a certified lab. However, certain States may require that a certified lab be used. Please note, analyses must comply with the analytical procedures set out in 40 CFR Part 136, as discussed below.

85. What analytical methods must be used for the pollutants for which sampling is required?

A. EPA-approved methods must be used where a method for a pollutant has been promulgated. 40 CFR Part 136 discusses required methods. If there is no approved method, the applicant may use any suitable method, but must provide a description of the method in its application. Additional information on general sampling issues can be obtained through the EPA's *NPDES Storm Water Sampling Guidance Document*. The manual is available from the Storm Water Hotline (703-821-4823).

VII. Municipal Permit Applications

86. Once a municipal separate storm sewer system (MS4) has submitted Part 2 of its storm water permit application, when does the term of the permit actually begin?

A. The term of the permit begins when a permit is issued by the permitting authority. Pursuant to 40 CFR 122.26(e)(7), storm water permits for discharges from MS4s are to be issued with in one year after submission of a complete application. Since applications for medium and large

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municipal separate storm sewer systems were due on May 17, 1993 and November 16, 1992, respectively, this results in permit issuance by November 16, 1993 for large municipalities and by May 17, 1994 for medium municipalities.

87. **How is EPA incorporating 1990 census data into the storm water program?**

A. Most of the municipalities that meet the definition of either a large or medium MS4 based on the results of the 1990 Census have already begun to seek an NPDES permit. Headquarters is working with the Regions and States to determine the best way to incorporate the remaining municipal entities into the program.

88. **How does EPA envision the relationship between large and medium MS4 operators and NPDES permitting authorities in terms of addressing industrial storm water discharges to MS4s?**

A. EPA envisions a partnership between NPDES permitting authorities and operators of large and medium municipal separate storm sewer systems in controlling pollutants in storm water discharges associated with industrial activity through MS4s. In addition, NPDES storm water permits provide a basis for enforcement actions directly against the owner or operator of the storm water discharge associated with industrial activity.

A second NPDES permit will be issued to the operator of the large and medium MS4. This permit will establish the responsibilities of the municipal operators in controlling pollutants from storm water associated with industrial activity which discharges through their municipal system. Under this approach, municipal operators will be able to:

- Assist EPA in identifying priority storm water discharges associated with industrial activity through their system;
- Assist EPA in reviewing and evaluating storm water pollution prevention plans that industrial facilities are required to develop; and
- Assist EPA in compliance efforts regarding storm water discharges associated with industrial activity to their municipal system.

A more complete description of this policy is provided in the August 16, 1991 Federal Register (56 FR 40973).

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VIII.	The Intermodal Surface Transportation Efficiency Act of 1991 (Transportation Act)

89. How did the Transportation Act affect permitting requirements for municipalities under 100,000?

A. Storm water discharges from certain industrial activities owned or operated by municipalities with a population of less than 100,000 people were granted a moratorium from the October 1, 1992 deadline for storm water permit applications. Exceptions to this moratorium include discharges from powerplants, airports and uncontrolled sanitary landfills.

90. How does the Transportation Act impact privately owned or operated industrial activities located in municipalities under 100,000?

A. The provisions of the Transportation Act specifically address publicly owned or operated industrial activities. Privately owned facilities that have storm water discharges associated with industrial activity, as defined at 40 CFR 122.26(b)(14), must submit a permit application regardless of the size of the population of the municipality in which they are located.

91. What is an "uncontrolled sanitary landfill?"

A. An uncontrolled sanitary landfill (discussed in the 4/2/92 Federal Register, page 11410) is a landfill or open dump, whether in operation or closed, that does not satisfy the runon/runoff requirements established pursuant to subtitle D of the Solid Waste Disposal Act. However, landfills closed prior to October 9, 1991 are not subject to RCRA runon/runoff requirements, and therefore need not submit storm water permit applications if they are located in municipalities of less than 100,000 population. Landfills closed after October 9, 1991 and others that meet the above definition would be subject to the storm water permit application requirements.

92. If a municipally-owned sewage treatment plant is located in a municipality with a population of less than 100,000 people, but the service population is greater than 100,000 people, is the facility subject to the permitting requirements?

A. Yes, because service populations are used in determining population for publicly-owned treatment works (POTWs) (April 2, 1992 Federal Register page 11394). Additionally, where one sewer district operates a number of POTWs, the entire service population of the district will be used to determine the applicable population classification of all the POTWs operated by the district. For example, if a district with a cumulative

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service population of 160,000 operates two sewage treatment plants, one of which serves 120,000 and the other which serves 40,000, both plants will be considered to be owned or operated by a municipality with a population of 100,000 or more.

93. If a construction operation disturbing five or more acres is owned by a small municipality (a population of less than 100,000 people)but operated by a private contractor, is the activity regulated?

A. No. If the construction activity is either owned or operated by a municipality with a population of less than 100,000 it would not be required to obtain a storm water permit during Phase I of the storm water program. Some States, however, may require that an application be submitted.

IX. 9th Circuit U.S. Court of Appeals Decision

94. What is the current status of light manufacturing facilities without exposure and construction activities under five acres, pursuant to the 9th Circuit Court decision?

A. The 9th Circuit Court decision remanded two "exemptions" provided in the NPDES storm water permit application regulations for light manufacturing facilities without exposure and construction activities under five acres (11/16/90 Federal Register page 48066). Both exemptions were remanded for further proceedings. In response to these two remands, the Agency intends to conduct further rulemakings on both the light manufacturing and construction activities under five acres. In the December 18, 1992, Federal Register, the Agency stated that it is not requiring permit applications from construction activity under five acres or light industry without exposure until this further rulemaking is completed.

X. Phase II of the Storm Water Program

95. What is the difference between Phase I and Phase II of the NPDES storm water program?

A. In the Water Quality Act of 1987, Congress mandated that EPA establish storm water control programs in two phases. While the first Phase I was defined on November 16, 1990, Phase II regulations were to be promulgated by October 1, 1992. However, the Water Resources Development Act (WRDA) of 1992 extended deadlines for Phase II of the

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storm water program as follows: 1) EPA must issue Phase II regulations by October 1, 1993; and 2) permits for Phase II sources may not be required by EPA or the State prior to October 1, 1994. EPA is currently developing regulations that will implement Phase II of the storm water program. (See Question #1 for more information on Phase I).

96. **Will all storm water discharges that are not regulated under Phase I be regulated under Phase II of the storm water program (e.g., service stations, retail and wholesale businesses, parking lots, municipalities with populations of less than 100,000)?**

A. Not necessarily. Statutory provisions require that EPA, in consultation with State and local officials, issue regulations that designate additional Phase II sources for regulation to protect water quality. EPA is currently developing approaches to identify and control high risk Phase II sources. EPA requested initial public comments on a variety of Phase II issues on September 9, 1992 (57 FR 41344). As part of this process, EPA is considering all sources of storm water not regulated under Phase I for potential coverage under Phase II.

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APPENDIX E

GROUP APPLICATION PART 2 SAMPLING DATA AND INDUSTRY DESCRIPTIONS ORGANIZED BY INDUSTRY SECTOR

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APPENDIX E

GROUP APPLICATION PART 2 SAMPLING DATA AND INDUSTRY DESCRIPTIONS ORGANIZED BY INDUSTRY SECTOR

This appendix contains summary descriptions for the 31 industrial sectors that were identified in the group application portion of the Phase I permitting process (four of the sectors were consolidated into two sectors for permit development purposes). The summaries describe the industrial activities, significant materials, and pollutants of concern that were listed in the applications submitted by the industry groups. The descriptions also contain tables which summarize the sampling data submitted by the groups. The tables list the mean values, median values, 95th percentile values, for the grab and composite samples and the mean, median and 90th percentile values for NURP data for a portion of the pollutants sampled within each sector.

INDUSTRIAL SECTORS GROUP APPLICATIONS	
SECTOR	ACTIVITIES REPRESENTED
1	Lumber and Wood Products
2	Paper and Allied Products
3	Chemicals and Allied Products
4	Asphalt and Lubricant Manufacturers
5	Stone, Clay, Glass and Concrete Products
6	Primary Metal Industries
7	Metal Mining
8	Coal and Lignite Mining
9	Oil and Gas Extraction
10	Mining and Quarrying of Nonmetallic Minerals
11	Hazardous Waste Treatment Storage or Disposal Facilities
12	Industrial Landfills, Land Application Sites and Open Dumps
13	Used Motor Vehicle Parts
14	Scrap and Waste Materials
15	Steam Electric Power Generating Facilities
16	Railroad Transportation
17	Local and Suburban Transit and Interurban Highway Passenger Transportation Motor Freight Transportation United States Postal Service Petroleum Bulk Stations
18	Water Transportation
19	Ship Building and Repairing Boat Building and Repairing
20	Transportation By Air
22	Domestic Wastewater Treatment Plants
23	Food and Kindred Products Tobacco Products
24	Textile Mill Products Apparel and Other Finished Products Made From Fabrics and Similar Materials
25	Furniture and Fixtures Manufacturing
26	Printing Publishing and Allied Industries
27	Rubber and Misc. Plastic Products
28	Leather and Leather Products
29	Fabricated Metal Products, Except Machinery and Transportation Equipment Jewelry, Silverware, and Plated Ware
30	Industrial and Commercial Machinery (Except Computer and Office Equipment) Transportation Equipment
31	Electronic and other Electrical Equipment and Components Measuring, Analyzing, and Controlling Instruments; Photographic and Optical Goods; Watches and Clocks

Sector 1: Timber Products Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... category (ii) facilities classified as Standard Industrial Classification (SIC) code 24 (except 2434)." Storm water discharges covered include those from establishments that cut timber and pulpwood, merchant sawmills, lath mills, shingle mills, cooperage stock mills, planing mills, and plywood and veneer mills that produce lumber and wood basic materials; and establishments that manufacture finished articles made entirely of wood or related materials. These facilities use wood as their primary raw material. Industrial activities include the following:

Log Storage and Handling activities include loading and unloading of logs onto trucks or railroad cars for transport to other facilities, log sorting, and storage of logs. In addition, some cutting may be performed, such as chopping off tree branches and sectioning of tree trunks for easier handling during transport. Chipping may be performed at facilities serving pulp industries. Residues generated at these sites may include bark, coarse sawdust, and wood chunks.

Untreated Wood Lumber and Residue Generation Activities occur at the following: saw and planing mills (SIC group 242); millwork, veneer, plywood and structural wood member manufacturing facilities (SIC group 243); wood container manufacturing facilities (SIC group 244); wood building and mobile home manufacturing facilities (SIC group 245); and miscellaneous wood product manufacturers (SIC group 249). These facilities may engage in one or more activities such as log washing, bark removal, milling, sawing, resawing edging, trimming, planing, machining, air drying, and kiln drying. Some facilities generate residue as a product, while other facilities may generate residues as a waste product. A summary of the residues generated include: bark, wood chips, planer shavings, and sawdust.

Wood Surface Protection Activities are accomplished by one of the following three methods: spraying, dipping, and green chain operations. Industrial activities at saw mills with the potential to contaminate storm water include spills from surface protection areas, storage and mixing tank areas, treated wood drippage, transport or storage areas, maintenance and shop areas, and areas used for treatment/disposal of wastes. Fugitive emissions from negative pressure spraying activities and hand spraying surface protection formulations may also result in the contamination of storm water.

Wood Preservation Activities are accomplished by two steps. First, the moisture content of wood is reduced to increase its permeability (this is referred to as conditioning). After conditioning, wood is impregnated with a preservative for fire retardency, insecticidal resistance, and/or fungicidal resistance. Then, the wood stock is often subject to cleaning in order to remove excess preservative prior to stacking treated lumber products outside.

Wood Assembly/Fabrication Activities such as the fabrication of fiberboard, insulation board, and hardboard may involve the use of wax emulsions, paraffin, aluminum sulfate, melamine formaldehyde, and miscellaneous thermosetting resins. These chemicals may be introduced as part of the board formation process or as a coating to maintain the board's integrity. In the formation of fiberboard/insulation board/hardboards, the digestion of pulp and fiber by mechanical, thermal, and sometimes chemical means takes place. Another operation which involves resinous agents is the formation of veneer. In this process, veneer is placed in hot ponds or vats to soften the wood. Veneer strips are removed and often bound by glue or a resinous agent. Glues are also used in the assembly of wood components. Other types of activities include the finishing of wood products. Stains, paints, lacquers, varnish, water repellents and sealants, etc. may be applied to some of the wood products.

Significant materials at timber products facilities which can contribute pollutants to storm water include: uncut logs, wood bark, wood chips wood shavings, sawdust, green lumber, rough and finished lumber, other waste wood material, non-hazardous wood ash, above and below ground fuel storage tanks, finishing chemicals, solvents and cleaners, petroleum, herbicides, pesticides, fertilizers, sawmill equipment, material handling equipment, boiler water treatment chemicals, scrap metals, scrap equipment and plastics, boiler blowdown water, and leachate from decaying organic matter.

Pollutants from timber products facilities generally include biological oxygen demand (BOD^5), total suspended solids (TSS), chemical oxygen demand (COD), leachate, wood wastes, chemicals, heavy metals, and pH.

Table E-1
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 1

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	198	39.63	13.00	193.00	200	45.37	17.00	135.50	12.00	9.00	15.00
COD	19	297.64	131.00	1500.00	198	242.50	122.50	1080.00	82.00	65.00	140.00
Copper	32	0.05	0.03	0.16	29	0.04	0.03	0.12	0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_2+NO_3-N	189	0.95	0.32	2.20	188	0.75	0.34	1.79	0.86	0.68	1.75
Oil & Grease	107	15.21	2.20	55.00					NR	NR	NR
P, Total	198	23.91	0.29	2.66	199	6.29	0.30	1.72	0.42	0.33	0.70
pH	211	7.17	7.30	8.56					NR	NR	NR
TKN	188	2.57	1.62	9.26	188	2.32	1.50	7.50	1.90	1.50	3.30
TSS	198	1108.42	242.00	4800.00	198	575.27	230.00	2288.00	180.00	100.00	300.00
Zinc	16	0.47	0.37	1.70	15	0.36	0.30	1.20	0.20	0.16	0.50

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Sector 2: Paper And Allied Products Manufacturing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (ii) facilities classified as Standard Industrial Classification (SIC) code 26 (except 265 and 267)." Storm water discharges covered include those from establishments primarily engaged in the manufacture of pulps from wood and other cellulose fibers, and from rags; manufacture paper and paperboard; and the manufacture of paper and paperboard into converted products, such as paper coated off the paper machine, paper bags, paper boxes, and envelopes. This major group also includes facilities which manufacture bags of plastics film and sheet.

Significant materials include fuels (diesel and gasoline), lumber, paper, and paperboard.

Pollutants of concern include total suspended solids (TSS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

Table E-2
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 2

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	121	34.72	8.00	115.00	111	24.25	8.00	93.00	12.00	9.00	15.00
COD	121	191.69	61.00	740.00	113	133.90	51.00	530.00	82.00	65.00	140.00
Copper	2	0.03	0.03	0.05	2	0.03	0.03	0.07	0.04	0.04	0.09
Lead	2	0.05	0.05	0.09	2	0.03	0.03	0.05	0.18	0.14	0.35
NO_2+NO_3-N	121	.095	0.50	3.93	111	0.76	0.47	2.44	0.86	0.68	1.75
Oil & Grease	122	3.69	1.00	15.00					NR	NR	NR
P. Total	120	0.39	0.18	1.06	111	0.36	0.16	0.91	0.42	0.33	0.70
pH	121		6.97	8.22					NR	NR	NR
TKN	121	3.83	1.76	10.20	112	3.17	1.77	10.10	1.90	1.50	3.30
TSS	121	152.98	41.00	520.00	111	44.04	13.00	198.00	180.00	100.00	300.00
Zinc	1	0.62	0.62	0.62	1	0.78	0.78	0.78	0.20	0.16	0.50

Sector 3: Chemical and Allied Products Manufacturing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... category (ii) facilities classified as Standard Industrial Classification (SIC) 28 (except 283 and 285)." Storm water discharges covered include those from establishments primarily engaged in manufacturing: industrial inorganic chemicals; plastic and synthetic materials; cleaning agents; paint products and varnishes; industrial organic chemicals; fertilizers; adhesives; explosives; and printing ink. Also covered are storm water discharges from facilities which manufacture inks and paints under SIC 3952. Storm water discharges from drug manufacturing facilities (SIC 283) are not covered.

Pollutants at chemical and allied product facilities include Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Copper, Manganese, and Zinc.

Table E-3
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 3

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	165	36.42	7.00	67.00	156	11.74	6.00	45.00	12.00	9.00	15.00
COD	168	96.14	57.50	290.00	159	77.24	41.00	320.00	82.00	65.00	140.00
Copper	51	0.19	0.01	0.21	46	0.12	0.00	0.19	0.04	0.04	0.09
Lead	47	0.07	0.01	0.17	42	0.02	0.01	0.07	0.18	0.14	0.35
NO_3+NO_3-N	164	5.83	0.80	16.00	154	4.29	0.82	17.00	0.86	0.68	1.75
Oil & Grease	169	3.75	0.50	16.30					NR	NR	NR
P. Total	170	2.82	0.24	12.10	158	9.51	0.23	16.40	0.42	0.33	0.70
pH	166	6.94	7.10	8.50					NR	NR	NR
TKN	171	15.50	1.90	27.00	159	18.30	1.70	23.70	1.90	1.50	3.30
TSS	169	200.33	40.00	793.00	159	93.67	25.00	453.00	180.00	100.00	300.00
Zinc	75	2.11	0.24	7.70	70	1.74	0.24	4.20	0.20	0.16	0.50

Sector 4: Asphalt Paving and Roofing Materials Manufacturers and Lubricant Manufacturers

The definition of storm water discharges associated with an industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... category (ii) which identifies facilities classified as Standard Industrial Classification (SIC) code 29." This covers storm water discharges associated with industrial activities at facilities with a primary SIC code of 2951 (Asphalt Paving Mixtures and Blocks), 2952 (Asphalt Felts and Coatings), and 2992 (Lubricating Oils and Greases) including portable plants. Hereinafter, facilities with primary SIC codes 2951 or 2952 will be referred to as 'Asphalt Facilities,' and facilities with primary SIC code 2992 as 'Lubricant Manufacturers.'

Facilities manufacturing asphalt concrete, paving materials, or block, are classified as SIC code 2951. Facilities primarily engaged in manufacturing asphalt roofing products, such as asphalt felts, shingles, and other products including tars, pitch, and roofing cements, are identified as SIC 2952. Facilities primarily engaged in manufacturing oils and lubricants are identified as SIC 2992.

Manufacturers of Asphalt Paving Mixtures and Blocks: These facilities stockpile a variety of raw materials such as sand, gravel, crushed limestone, and recycled asphalt products (RAP). These facilities produce asphalt concrete, and may also mold and cure asphalt concrete products such as asphalt blocks. There are two types of facilities associated with these activities, batch plants and drum plants.

Manufacturers of Roofing Materials: Manufacturers classified in standard industrial code 2952 typically produce roofing felts, and impregnated roofing felts (shingles) and other products, such as tar papers, impregnated asphalt siding, expansion joints, roofing cements, tars and pitches. Many of the roofing products consist of materials coated with asphalt purchased from a vendor and then cured and stored out of doors until shipped.

Manufacturers of Lubricating Oils and Greases: Facilities primarily engaged in blending, compounding, and re-refining lubricating oils and greases from purchased mineral, animal, and vegetable materials are identified as SIC code 2992. SIC code 2992 includes manufacturers of metalworking fluids, cutting oils, gear oils, hydraulic brake fluid, transmission fluid, and other automotive and industrial oil and greases.

Significant materials at these facilities include additives, asphalt, asphalt cement, asphalt concrete, asphalt felt, asphalt release agents, asphalt shingles, crushed stone, fuel, granite, gravel, limestone, lubricants, mineral spirits, oil, quartzite rock, reclaimed asphalt pavement, sand, sandstone, and slag. The pollutants of concern at facilities which manufacture asphalt and lubricant include total, suspended solids (TSS), oil and grease, chemical oxygen demand (COD), and fuel wastes.

Table E-4
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 4

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	61	39.99	7.00	47.00	51	10.87	4.00	22.00	12.00	9.00	15.00
COD	64	151.55	48.00	485.00	53	86.93	50.00	375.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_2+NO_3-N	62	0.97	0.31	2.63	52	0.82	0.03	2.43	0.86	0.68	1.75
Oil & Grease	64	5.89	1.25	28.00					NR	NR	NR
P, Total	63	0.37	0.13	1.65	54	0.28	0.15	1.28	0.42	0.33	0.70
pH	59	7.1	7.1	8.80					NR	NR	NR
TKN	63	2.13	1.13	7.16	51	1.63	0.99	6.28	1.90	1.50	3.30
TSS	63	286.67	93.00	1330.00	54	165.03	46.00	860.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

Sector 5: Glass, Clay, Cement, Concrete, and Gypsum Product Manufacturing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (ii) which identifies facilities classified as Standard Industrial Classification (SIC) code 32."

Glass Product Manufacturing - Facilities primarily engaged in the manufacturing of glass and glassware, or manufacturing glass products from purchased glass are classified under standard industrial groups 321-323. Manufacturing processes include the storage of raw materials, weighing the materials, charging, melting and forming. Significant materials may include silica sand, limestones, feldspars, borates, soda ash, boric acid, potash and barium carbonate.

Cement Manufacturing - Facilities primarily engaged in manufacturing hydraulic cement (e.g., portland, natural, masonry, and pozzolana cements) are identified as SIC code 3241. The three basic steps in cement manufacturing are: 1) proportioning, grinding and blending raw materials; 2) heating raw materials to produce a hard, stony substance known as "clinker"; and 3) combining the clinker with other materials and grinding the mixture into a fine powdery form.

Clay Product Manufacturing - Facilities primarily engaged in manufacturing clay products, including brick, tile (clay or ceramic), or pottery products are classified as standard industrial groups 325 and 326. Although clay product manufacturing facilities produce a wide variety of final products, there are several similar processing steps shared by most facilities in this industry: 1) storage and preparation of raw materials; 2) forming; 3) drying; 4) firing; and 5) cooling. Manufacturers classified as standard industrial groups 325 and 326 typically use clay (common, silt, kaolin and/or phyllite) and shale (mud, red, blue and/or common) as their primary raw materials. Raw materials are generally stored outside.

Concrete Products - Facilities primarily engaged in manufacturing concrete products, including ready-mixed concrete, are identified as SIC group 327. Although concrete product facilities in SIC group 327 produce a variety of final products, they all have common raw materials and activities.

Concrete products manufacturers combine cement, aggregate, and water to form concrete. Aggregate generally consists of: sand, gravel, crushed stone, cinder, shale, slag, clay, slate, pumice, vermiculite, scoria, perlite, diatomite, barite, limonite, magnetite, or ilmenite. Admixtures including fly ash, calcium chloride, triethanolamine, calcium salt, lignosulfunic acid, vinosol, saponin, keratin, sulfonated hydrocarbon, fatty acid glyceride, vinyl acetate, and styrene copolymer of vinyl acetate may be added to obtain desired characteristics, such as slower or more rapid curing times.

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Gypsum Products Manufacturing - Facilities primarily engaged in manufacturing plaster, wallboard, and other products composed wholly or partially of gypsum (except plaster of paris and papier-mâché) are classified as SIC code 3275. The gypsum product manufacturing process begins with calcining the gypsum: finely ground raw gypsum (referred to as "land plaster") is fed into imp mills or calcining kettles where extreme heat removes 75 percent of the gypsum's molecular moisture. The result is a dry powder called stucco, which is cooled and conveyed to storage bins. To produce wallboard, stucco is fed into pin mixers where it is blended with water and other additives to produce a slurry. The slurry is then applied to continuous sheets of paper to form wallboard. In addition to producing wallboard, some facilities may combine stucco with additives (excluding water) to produce plaster.

As a result of the industrial activities such as materials handling and storage and other industry specific activities, pollutants of concern include: total suspended solids (TSS), chemical oxygen demand (COD), oil and grease, lead, aluminum, zinc, potassium and sulfate.

Table E-5
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 5

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	310	14.30	5.00	32.00	300	7.32	4.20	20.00	12.00	9.00	15.00
COD	313	107.47	51.30	317.00	302	77.53	43.15	240.00	82.00	65.00	140.00
Copper	6	0.13	0.02	0.40	5	0.16	0.04	0.40	0.04	0.04	0.09
Lead	15	0.24	0.01	3.30	15	0.25	0.01	3.40	0.18	0.14	0.35
NO_2+NO_3-N	303	1.99	0.60	3.03	292	1.40	0.55	3.03	0.86	0.68	1.75
Oil & Grease	315	4.67	1.40	17.10					NR	NR	NR
P, Total	313	1.21	0.28	4.96	300	0.87	0.25	3.24	0.42	0.33	0.70
pH	297	8.59	8.50	11.30					NR	NR	NR
TKN	304	3.82	1.16	7.00	292	2.37	1.00	5.00	1.90	1.50	3.30
TSS	311	1066.79	200.00	2620.00	302	385.51	149.00	1440.00	180.00	100.00	300.00
Zinc	8	0.35	0.14	1.17	7	0.39	0.18	1.12	0.20	0.16	0.50

Sector 6: Primary Metals Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges from eleven major categories of facilities, including: "(ii) facilities classified as Standard Industrial Classification (SIC) 33 [primary metals facilities]." Storm water discharges covered include those from the following types of activities: Steel works, blast furnaces, and rolling and finishing mills (SIC 331); Iron and steel foundries (SIC 332) Primary smelting and refining of nonferrous metals (SIC 333); Secondary smelting and refining of nonferrous metals (SIC 334); Rolling, drawing, and extruding of nonferrous metals (SIC 335); Nonferrous foundries (SIC 336); and Miscellaneous primary metal products, not elsewhere classified (SIC 339).

Facilities in the primary metals industry are typically involved in one or more of the following general operations: raw material storage and handling; furnace and oven related processes; preparation of molds, casts, or dies; metal cleaning, treating and finishing; and waste handling and disposal.

Pollutants at primary metals facilities include Aluminum, Copper, Iron, Manganese, Total Suspended Solids (TSS), and Zinc.

Table E-6
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 6

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	163	32.15	11.00	83.00	140	34.08	8.30	61.50	12.00	9.00	15.00
COD	162	221.34	70.50	870.00	151	109.84	60.00	420.00	82.00	65.00	140.00
Copper	143	3.46	0.10	3.40	131	2.25	0.07	3.10	0.04	0.04	0.09
Lead	136	0.78	0.02	1.41	123	0.19	0.02	1.00	0.18	0.14	0.35
NO_2+NO_3-N	148	1.17	0.68	3.60	135	1.38	0.77	4.30	0.86	0.68	1.75
Oil & Grease	163	8.88	1.00	47.00					NR	NR	NR
P, Total	163	1.25	0.17	1.80	149	0.52	0.14	0.96	0.42	0.33	0.70
pH	163	7.07	7.30	8.90					NR	NR	NR
TKN	160	3.56	1.98	13.00	149	3.05	1.60	9.70	1.90	1.50	3.30
TSS	162	368.45	71.75	1700.00	149	162.28	69.00	717.00	180.00	100.00	300.00
Zinc	144	8.85	0.46	11.80	132	6.55	0.43	9.67	0.20	0.16	0.50

Sector 7: Metal Mining (Ore Mining and Dressing)

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (iii) facilities classified by Standard Industrial Classification (SIC) codes 10 through 14 including active or inactive mining operations (except for areas coal mining operations no longer meeting the definition of reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration production, processing or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations." The following is a listing of the types of mining milling facilities that are covered under SIC code 10:

- Iron Ores (SIC 1011)
- Copper Ores (SIC 1021)
- Lead and Zinc Ores (SIC 1031)
- Gold Ores (SIC 1041)
- Silver Ores (SIC 1044)
- Ferroalloy Ores, Except Vanadium (SIC 1061)
- Metal Mining Services (SIC 1081)
- Uranium-Radium-Vanadium Ores (SIC 1094)
- Miscellaneous Metal Ores, Not Elsewhere Classified (SIC 1099)

The term "metal mining" includes all ore mining and/or dressing and beneficiating operations, whether performed at mills operated in conjunction with the mines served or at mills, such as custom mills, operated separately. The above establishments are primarily engaged in mining, developing mines, or exploring for metallic minerals (ores). This group also includes all ore dressing and beneficiating operations, whether performed at mills operated in conjunction with the mines served or at mills, such as custom mills, operated separately. These include mills which crush, grind, wash, dry, sinter, calcine, or leach ore, or perform gravity separation or flotation operations.

Pollutants of concern include total suspended solids (TSS), total dissolved solids (TDS), heavy metals, oil and grease, dust, and turbidity.

Table E-7
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 7

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	18	10.02	9.00	27.00	12	10.63	6.00	44.00	12.00	9.00	15.00
COD	18	144.54	71.10	630.00	15	195.07	160.00	740.00	82.00	65.00	140.00
Copper	19	3.88	0.14	46.80	13	0.59	0.09	3.40	0.04	0.04	0.09
Lead	23	0.89	0.00	1.20	13	6.07	0.05	65.00	0.18	0.14	0.35
NO_3+NO_2-N	16	1.10	0.75	5.30	13	0.90	0.86	2.10	0.86	0.68	1.75
Oil & Grease	16	2.36	0.00	22.00					NR	NR	NR
P, Total	21	1.83	0.30	11.00	16	1.06	0.38	7.00	0.42	0.33	0.70
pH	24	7.23	7.45	8.00					NR	NR	NR
TKN	15	3.27	2.60	9.40	13	3.39	3.20	11.80	1.90	1.50	3.30
TSS	17	6995.78	403.00	100000.00	15	623.09	330.00	3049.00	180.00	100.00	300.00
Zinc	14	3.04	0.59	16.30	8	3.87	0.66	20.90	0.20	0.16	0.50

Sector 8: Coal Mines and Coal Mining-Related Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (iii) facilities classified by Standard Industrial Classification (SIC) codes 10 through 14 including active or inactive mining operations (except for areas coal mining operations no longer meeting the definition of reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration production, processing or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations." Coal mining activities are classified as Standard Industrial Classification (SIC) code 12, and includes the following operations:

- Bituminous Coal and Lignite Surface Mining (SIC 1221)
- Bituminous Coal Underground Mining (SIC 1222)
- Anthracite Mining (SIC 1231)
- Coal Mining Services (SIC 1241)

Storm water discharges are covered at all inactive facilities and only from haul roads and rail lines at active facilities. Haul roads are non-public roads on which coal or coal refuse is conveyed. Access roads are non-public roads providing light vehicular traffic within the facility property and to public roadways. Railroad spurs, sidings, and internal haulage lines are rail lines used for hauling coal within the facility property and to off-site commercial railroad lines or loading areas. Inactive coal mines and related areas are abandoned and other inactive mines, refuse disposal sites and other mining-related areas.

Significant materials include coal, refuse coal, used equipment, and other equipment used to haul coal.

Pollutants of concern include total suspended solids (TSS), total dissolved solids (TDS), turbidity, oil and grease, dust, heavy metals, and acid/alkaline wastes.

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Table E-8
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 8

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	7	3.63	1.80	9.00	4	6.55	3.90	17.40	12.00	9.00	15.00
COD	13	16.45	6.00	83.90	8	26.86	13.50	115.00	82.00	65.00	140.00
Copper	1	0.00	0.00	0.00	2	0.00	0.00	0.00	0.04	0.04	0.09
Lead	2	0.02	0.02	0.04	2	0.00	0.00	0.00	0.18	0.14	0.35
NO_2+NO_3-N	8	0.77	0.40	3.12	6	1.00	0.61	3.12	0.86	0.68	1.75
Oil & Grease	19	2.17	1.20	13.90					NR	NR	NR
P, Total	8	0.12	0.04	0.66	5	0.12	0.00	0.58	0.42	0.33	0.70
pH	21	7.40	7.58	8.45					NR	NR	NR
TKN	9	2.56	2.60	5.20	8	2.65	1.46	7.40	1.90	1.50	3.30
TSS	10	5607.60	150.00	33240.00	8	689.75	251.00	3880.00	180.00	100.00	300.00
Zinc	2	0.17	0.17	0.30	2	0.06	0.06	0.09	0.20	0.16	0.50

Sector 9: Oil and Gas Extraction Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (iii)...oil and gas exploration production, processing or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations." Oil and gas extraction facilities are classified as Standard Industrial Classification (SIC) code 13. The activities subject to storm water regulations include the following types of operations:

- Crude Petroleum and Natural Gas (SIC 1311)
- Natural Gas Liquids (SIC 1321)
- Drilling Oil and Gas Wells (SIC 1321)
- Oil and Gas Field Exploration Services (SIC 1382)
- Oil and Gas Field Services, Not Elsewhere Classified (SIC 1389)

Table E-9
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 9

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	35	13.79	9.71	44.00	33	10.59	7.00	21.80	12.00	9.00	15.00
COD	36	140.12	82.00	352.00	31	115.94	92.00	445.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_3+NO_2-N	35	0.52	0.15	4.10	31	0.60	0.12	3.30	0.86	0.68	1.75
Oil & Grease	36	10.18	3.00	49.00					NR	NR	NR
P, Total	36	15.82	0.18	144.90	33	3.41	0.07	19.46	0.42	0.33	0.70
pH	36	7.45	7.14	9.41					NR	NR	NR
TKN	36	1.39	0.76	5.20	30	1.69	0.93	5.67	1.90	1.50	3.30
TSS	37	353.00	75.00	1520.00	30	413.00	48.00	2056.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

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Sector 10: Mineral Mining and Processing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...(iii) facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or storm water contaminated by contact with, any overburden, raw material, intermediate products, finished products, by-products or waste products located on the site of such operations."

Mineral mining and processing facilities subject to storm water regulations include the following types of operations:

- Dimension Stone, (SIC Code 1411);
- Crushed and Broken Limestone, (SIC Code 1422);
- Crushed and Broken Granite, (SIC Code 1423);
- Crushed and Broken Stone, (SIC Code 1429);
- Construction Sand and Gravel, (SIC Code 1442);
- Industrial Sand and Gravel, (SIC Code 1446);
- Kaolin and Ball Clay, (SIC Code 1455);
- Clay, Ceramic, and Refractory Minerals, (SIC Code 1459);
- Potash, Soda, and Borate Minerals, (SIC Code 1474);
- Phosphate Rock, (SIC Code 1475);
- Chemical and Fertilizer Mineral Mining, (SIC Code 1479); and
- Miscellaneous Nonmetallic Minerals, Except Fuels, (SIC Code 1499).

There are typically three phases to a mining operation: the exploration and construction phase; the active phase; and the reclamation phase. The exploration and construction phase entails exploration and a certain amount of land disturbance to determine the financial viability of a site. Construction includes building of site access roads, and removal of overburden and waste rock to expose minable ore. These land-disturbing activities are significant potential sources of storm water contaminants. The active phase includes each step from extraction through production of a saleable product. The active phase may include periods of inactivity due to the seasonal nature of these mineral mining activities. The final phase of reclamation is intended to return the land to its pre-mining state. Non-metallic minerals are recovered using four basic forms of extraction techniques: open pit, open face or quarry mining; dredging; solution mining; and underground mining. Each type of extraction method may be followed by varying methods of beneficiation and processing.

Storm water discharges covered include all discharges where precipitation and run-on come into contact with significant materials commonly found at mining facilities which include:

overburden; waste rock; sub-ore piles; tailings; petroleum-based products; solvents and detergents; manufactured products; and other waste materials. This includes storm water discharges from haul roads, access roads, and rail lines used or traveled by carriers of raw materials, manufactured products, waste materials, or by-products created by the facility. In addition, overflows from facilities governed by effluent limitation guidelines with impoundments such as settling or sedimentation ponds, tailings ponds or piles, or other impoundments designed to contain a 10-year, 24-hour storm event are also covered.

Because of the land-disturbing nature of the mineral mining and processing industry, contaminants of concern generated by industrial activities in this industry include total suspended solids (TSS), total dissolved solids (TDS), turbidity, pH, dust, heavy metals, solvents, and oils.

Table E-10
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 10

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	55	7.09	5.00	24.00	51	6.89	5.00	17.00	12.00	9.00	15.00
COD	56	58.79	33.00	247.00	51	66.20	37.00	185.00	82.00	65.00	140.00
Copper	6	0.05	0.01	0.15	4	0.01	0.01	0.01	0.04	0.04	0.09
Lead	6	0.00	0.00	0.00	4	0.00	0.00	0.00	0.18	0.14	0.35
NO_3+NO_2-N	50	0.98	0.65	3.00	45	1.27	0.76	4.17	0.86	0.68	1.75
Oil & Grease	60	1.08	0.00	5.45					NR	NR	NR
P, Total	55	0.84	0.20	4.69	51	1.13	0.24	2.61	0.42	0.33	0.70
pH	58	7.60	7.55	9.10					NR	NR	NR
TKN	55	1.81	1.05	8.00	50	2.41	0.84	6.89	1.90	1.50	3.30
TSS	55	1848.14	181.00	11120.00	51	1576.24	296.00	10080.00	180.00	100.00	300.00
Zinc	5	0.18	0.18	0.34	3	0.29	0.30	0.30	0.20	0.16	0.50

Sector 11: Hazardous Waste, Treatment, Storage, or Disposal Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...(iv) hazardous waste treatment, storage, or disposal facilities, including those that are operating under Subtitle C of RCRA [Resource Conservation and Recovery Act] ...." Industrial activities at treatment, storage, or disposal facilities (TSDF) can be described as follows:

At TSDFs, some wastes are disposed without any intervening storage or treatment, while other wastes are held in storage prior to treatment or disposal. Hazardous wastes are generally stored in containers and tanks, which are enclosed by a bermed area to prevent any releases to the environment from the storage units.

The processes for treating hazardous wastes can be divided into two major categories based on whether the waste is organic or inorganic in nature. Organic wastes are treated by destructive technologies, such as incineration, whereas inorganic wastes are treated using fixation technologies, such as stabilization, in which the hazardous constituents are immobilized in the residual matrix. Residuals from fixation processes are usually land-disposed.

Hazardous waste disposal units include landfills, surface impoundments, waste piles, and land treatment units. Wastes are also disposed of in incinerators. Some liquid hazardous wastes are underground-injected into deep wells regulated under the Underground Injection Control (UIC) program.

Hazardous wastes are also recycled at TSDFs. Recycling is considered a form of treatment, however, the recycling process itself is not generally regulated under RCRA. Recycling activities include reclamation, regeneration, reuse, burning for energy or materials recovery, and use in a manner constituting disposal (i.e., land application of hazardous waste or products containing hazardous waste).

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Table E-11
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 11

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BODS	8	17.75	11.50	45.00	9	9.44	7.00	45.00	12.00	9.00	15.00
COD	8	177.40	41.00	500.00	9	48.90	34.00	131.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_3+NO_3-N	9	0.46	0.47	0.79	9	0.39	0.34	0.67	0.86	0.68	1.75
Oil & Grease	9	9.33	0.00	74.00					NR	NR	NR
P, Total	9	0.24	0.07	1.60	9	0.11	0.09	0.32	0.42	0.33	0.70
pH	7	6.93	7.29	7.79					NR	NR	NR
TKN	9	1.43	1.30	3.00	9	1.07	0.92	3.92	1.90	1.50	3.30
TSS	8	337.63	127.50	1100.00	9	82.67	32.00	304.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

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R0037696

Sector 12: Landfills/Land Application Sites

The definition of storm water discharge associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (v) landfills, land application sites and open dumps that receive industrial wastes." Special conditions apply to land disposal sites which meet the definition of a landfill under RCRA Subtitle D. Landfills are defined as areas of land or excavation in which wastes are placed for permanent disposal, and that are not land application units, surface impoundments, injection wells, or waste piles. Included in this definition are municipal solid waste landfills (MSWLFs) and industrial solid non-hazardous waste landfills. Land application sites are defined as facilities at which wastes are applied onto or incorporated into the soil surface for the purpose of beneficial use or waste treatment and disposal. Open dumps are defined as solid waste disposal units not in compliance with State/Federal criteria established under RCRA Subtitle D.

Municipal Solid Waste Landfills are constructed according to one of two generic designs, the trench method, area method, or a combination of both. The trench method requires the excavation of a trench into which wastes will be placed. In the area method, wastes are placed directly on the ground surface and disposal follows the natural contours of the land. Some landfills use combinations of the two methods at different times depending on the location of the active unit.

Most modern landfills contain one or more separate "units," which are final waste containment areas. Active units continue to receive wastes until they have reached disposal capacity. When capacity is reached, a unit is capped with a final cover, and additional wastes are placed in other active units. Within each unit, wastes are added in layers referred to as lifts. Received wastes are spread across the working face of the landfill to a depth of six to twenty feet and then compacted. At the end of each working day a thin layer of soil (daily cover) is spread on top of the added wastes and compacted. A large unit may consist of multiple lifts, depending on the planned final depth. When a landfill (or landfill unit) has reached disposal capacity, a final cover is applied. Final covers generally provide a relatively impermeable cap over which topsoil is placed and vegetation is established.

Industrial Landfills are similar to MSWLFs, but only receive wastes from industrial facilities such as factories, processing plants, and manufacturing sites. These facilities may also receive hazardous wastes from very small quantity hazardous waste generators (less than one hundred kilograms per month), as defined in RCRA Subtitle C.

Land Application Sites receive wastes (primarily wastewaters and sludges) from facilities in virtually every major industrial category. Typically, individual land application sites will only dispose of wastes with specific characteristics. However, the criteria for selection are site-specific, depending on type of process used and the soil characteristics.

The significant materials at land disposal sites consist of the wastes and the equipment used to handle the wastes. Examples of wastes disposed at these sites include household waste

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(including household hazardous waste which is excluded from RCRA hazardous waste regulation), non-hazardous incinerator ashes, commercial wastes, yard wastes, tires, white goods, construction wastes, municipal and industrial sludges, asbestos, and other industrial wastes from various industrial facilities.

Pollutants of concern at land disposal sites include total suspended solids (TSS), oil and grease, heavy metals, leachate, organics, and chemical oxygen demand (COD) and other toxic pollutants.

Table E-12
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 12

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	51	13.66	7.00	59.00	48	9.04	4.40	34.00	12.00	9.00	15.00
COD	51	114.46	31.00	825.00	48	102.02	27.50	548.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead	9	9.62	0.08	83.70	7	20.64	0.18	143.00	0.18	0.14	0.35
NO_3+NO_2-N	50	1.57	0.55	4.10	47	1.38	0.50	6.02	0.86	0.68	1.75
Oil & Grease	53	2.97	0.00	14.00					NR	NR	NR
P, Total	50	0.91	0.50	3.35	47	0.95	0.38	4.08	0.42	0.33	0.70
pH	54	7.41	7.32	8.40					NR	NR	NR
TKN	51	3.36	1.10	12.00	48	3.03	1.04	14.20	1.90	1.50	3.30
TSS	51	2978.97	633.00	19370.00	47	1850.17	370.00	9140.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

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Sector 13: Automobile Salvage Yards

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven categories of facilities, including: "... category (vi) facilities classified as Standard Industrial Classification (SIC) code 5015." That SIC code includes battery reclaimers, salvage yards, and automobile junkyards.

Storm water discharges include discharges where precipitation and storm water runon come into contact with significant materials including, but are not limited to parts storage and cleaning, storage of junked vehicles, waste products, by-products, stored materials, fuels, and areas used for dismantling operations. Dismantlers are a major source for replacement parts for motor vehicles in service. The primary activity involves the dismantling or wrecking of used motor vehicles. Some facilities, however, perform vehicle maintenance and may rebuild vehicles for resale.

Typically, automobile dismantling facilities receive vehicles that are either uneconomical to run or wrecks that are uneconomical to repair. The nature of operations generally depends on the size and location of the facility. In urban areas where land is more valuable, vehicles are typically dismantled upon arrival, parts are segregated, cleaned, and stored. Remaining hulks are generally sold to scrap dealers rather than stored on site due to limited space. In more rural areas, discarded vehicles are typically stored on the lot and parts removed as necessary. Remaining hulks are sold to scrap dealers less frequently.

Once a used vehicle is brought to the site, fluids may be drained and the tires, gas tank, radiator, engine and seats may be removed. The dismantler may separate and clean parts. Such cleaning may include steam cleaning of the engine and transmission as well as the use of solvents to remove oil and grease and other residues. Usable parts are then inventoried and stored for resale. The remaining car and/or truck bodies are stored on site for future sale of the sheet metal and glass. Stripped vehicles and parts that have no resale value are typically crushed and sold to a steel scrapper. Some operations may, however, convert used vehicles and parts into steel scrap as a secondary operation. This is accomplished by incineration, shearing (bale shearer), shredding, or baling.

Significant materials include automobile parts (e.g., engine blocks, mufflers, batteries), solvents, oils, cleaning agents (e.g., detergents), used equipment, and junked automobiles. Due to the nature of the industrial activities at these facilities, pollutants of concern include: oil and grease, ethylene glycol, heavy metals, petroleum hydrocarbons, solvents, suspended solids, acid/alkaline wastes, detergents, phosphorus and salts.

Table E-13
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 13

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	95%
BOD5	13	7.15	6.00	16.00	30	12.61	6.50	48.00	12.00	9.00	15.00
COD	30	135.00	61.00	250.00	13	66.23	60.00	155.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_2+NO_3-N	13	1.70	0.83	5.65	30	1.62	1.32	4.87	0.86	0.68	1.75
Oil & Grease	30	5.35	3.00	32.00					NR	NR	NR
P, Total	13	0.19	0.05	1.08	30	3.05	0.26	15.70	0.42	0.33	0.70
pH	29	7.38	7.41	8.20					NR	NR	NR
TKN	13	2.17	1.90	4.87	30	2.27	1.77	6.63	1.90	1.50	3.30
TSS	13	474.39	183.00	2300.00	30	839.07	226.00	5100.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

Sector 14: Scrap and Waste Material Processing and Recycling Facilities

The definition of storm water discharge associated with industrial activity includes point source discharges from eleven major categories of facilities, including: ". . . category (vi) facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards and automobile junk yards, including but limited to those classified as Standard Industrial Classification (SIC) 5093 and 5015." Automobile junk yards (SIC 5015) are addressed under Sector 13.

SIC 5093 includes establishments engaged in assembling, breaking up, sorting and the wholesale distribution of scrap and recyclable waste materials including bag, bottle and box wastes, fur cuttings, iron and steel scrap, metal and non-ferrous metal scrap, oil, plastics, rags, rubber, textiles, waste paper and rag wastes.

Table E-14.1
Materials and Sources of Pollutants of Concern

Significant Materials: White Goods (Appliances) Potential Sources: Leaking oil-filled capacitors, ballasts, leaking compressors, pumps, leaking pressure vessels, reservoirs, sealed electrical components and chipped or deteriorated painted surfaces Pollutants of Concern: PCBs, oil, lubricants, paint pigments or additives such as lead, and other heavy metals
Significant Materials: Ferrous and Non-ferrous turnings and cuttings Potential Sources: Cutting oil residue, metallic fines Pollutants of Concern: Oil, heavy metals
Significant Materials: Materials from Demolition projects Potential Source: Deteriorated/damaged insulation, chipped painted surfaces, lead, copper, and steel pipes Pollutants of Concern: asbestos fibers, lead, copper, zinc, cadmium, other metals

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Table E-14.1
Materials and Sources of Pollutants of Concern (continued)

Significant Materials: Electrical Components, transformers, switch gear, mercury float switches, sensors Potential Sources: Leaking oil-filled transformer casings, oil-filled switch, float switches, radioactive materials in gauges, sensors Pollutants of Concern: PCBs, oils, mercury, ionizing radioactive isotopes
Significant Materials: Fluorescent lights, light fixtures Potential Sources: Leaking ballasts Pollutants of Concern: PCBs, oil
Significant Materials: Food/Beverage Dispensing Equipment Potential Sources: Leaking fluorescent light ballasts, chipped painted surfaces Pollutants of Concern: PCBs, oil, heavy metals from paint pigments and additives
Significant Materials: Hospital and Dental Waste & Equipment Potential Sources: Drums/containers of hospital waste, shielding from diagnostic and other medical equipment, radioactive materials from gauges, sensors and diagnostic equipment Pollutants of Concern: Infectious/bacterial contamination, lead, ionizing radioactive isotopes
Significant Materials: Instruments Potential Sources: Radioactive material from thickness gages Pollutants of Concern: Ionizing radioactive isotopes
Significant Materials: Insulated wire Potential Sources: Insulation and other coatings, wire Pollutants of Concern: Lead, zinc, copper

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Table E-14.1
Materials and Sources of Pollutants of Concern (continued)

Significant Materials: Lawnmowers, snowmobiles, motorcycles Potential Sources: Leaking engines, transmissions, fuel, oil reservoirs,leaking batteries Pollutants of Concern: Oils, transmission and brake fluids, fuel, grease, battery acid, lead acid
Significant Materials: Light gage materials Potential Sources: Deteriorating insulation, painted surfaces and other coatings Pollutants of Concern: Asbestos, lead, chromium
Significant Materials: Locomotives, rail cars Potential Sources: Leaking fuel reservoirs, fittings, hydraulic components, engines, bearings, compressors, oil reservoirs, worn brake pads, damaged insulation Pollutants of Concern: PCBs, diesel fuel, hydraulic oil, oil, brake fluid, grease from fittings, asbestos,
Significant Materials: Motor Vehicle Bodies, Engines, Transmissions, Exhaust systems Potential Sources: Leaking fuel tanks, oil reservoirs, transmission housings, brake fluid reservoir and lines, brake cylinders, shock absorber casing, engine coolant, wheel weights, leaking battery casings/housings and corroded terminals, painted surfaces and corrosion inhibitors, exhaust system, catalytic converters Pollutants of Concern: Fuel, benzene, oil, hydraulic oil, transmission fluids, brake fluids, ethylene glycol (antifreeze), lead, lead acid, lead oxides, cadmium, zinc, other heavy metals
Significant Materials: Misc. Machinery and obsolete equipment Potential Sources: Leaking reservoirs, damaged or chipped painted surfaces/coatings Pollutants of Concern: Fuel, oil, lubricants, lead, cadmium, zinc

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Table E-14.1
Materials and Sources of Pollutants of Concern (continued)

Significant Materials: Pipes/Materials from Chemical and Industrial Plants Potential Sources: Chemical residue, insulation, lead piping, chipped or damaged painted surfaces and protective coatings Pollutants of Concern: Chemical residue, oil, lubricants, damaged insulation (asbestos), lead, cadmium, zinc, copper
Significant Materials: Sealed containers, hydraulic cylinders Potential Sources: Leaking liquid reservoirs, containers, cylinders, misc. chemicals Pollutants of Concern: Oil, PCBs, solvents, chemical residue
Significant Materials: Salvaged Construction Materials Potential Sources: Chemical residues, oils, solvents, lubricants, damaged insulation, chipped painted surfaces and protective coatings Pollutants of Concern: Chemical residue, oily wastes, asbestos, lead, cadmium, zinc
Significant Materials: Tanks, containers, vessels, cans, drums Potential Sources: Leaking or damaged containers Pollutants of Concern: Chemical residue, oily wastes, petroleum products, heating oil
Significant Materials: Transformers (oil filled) Potential Sources: Leaking transformer housings Pollutants of Concern: PCBs, oil

[1] Institute of Scrap Recycling Industries, Inc.'s Environmental Operating Guidelines, (April 1992)

(2) Material Processing. The type of processes employed at a particular facility depends on the type of recyclable and waste material. Typical processes include; torch cutting, shredding, baling, briquetting, wire stripping and chopping, and compacting. Processes such as shredding and shearing reduce the bulk size of recyclable scrap and waste into a size that is more easily transportable and which allows separation into uniform grades based on

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manufacturer specifications. Processes such as shredding of automotive bodies include a means of segregating materials into their ferrous and non-ferrous fractions.

(3) Segregation of Processed Materials into Uniform Grades. Processing, e.g., shearing, shredding, baling, etc, of recyclable materials is followed by its segregation into uniform grades to meet a particular manufacturer's specifications. If segregated recyclable material remains exposed to precipitation, the potential still exists for storm water contamination.

(4) Disposal of Non-recyclable Waste Materials. During recycling of scrap and waste materials, a significant fraction is non-recyclable waste materials and must be disposed. The volume or quantity of material that remains un-recyclable may be too large to permit covered storage prior to shipment. Consequently, un-recyclable waste materials may be left exposed to both precipitation and runoff and, therefore, they are a likely source of storm water pollutants.

(5) Other Operations of Concern. There are a number of activities that frequently occur at scrap and waste recycling facilities including, heavy vehicle traffic over unstabilized areas, vehicle maintenance and fueling, and material handling operations. Operations associated with the receipt, handling, and processing of scrap and waste material frequently occur over areas that are not stabilized to prevent erosion. Erosion of unstabilized soils is potentially a significant source of suspended solids in storm water runoff. For example, sampling results for total suspended solids (TSS) concentrations provided in sampling data indicated a mean concentration of 466 mg/l. Unless specific measures or controls are provided to either prevent erosion or trap the sediment, this material will be carried away in storm water runoff and eventually exit the site. Suspended solids are of significant concern given the potential amount of unstabilized area and the significant amount of particulate matter that is often produced at these facilities. Both organic and inorganic pollutants can become bound up or absorbed to suspended solids in runoff.

Some scrap and waste recycling facilities may also conduct vehicle maintenance on-site. Although many of these activities frequently occur indoors, there are specific activities which could contribute pollutants to storm water. This includes washdown of vehicle maintenance areas, leaks or spills of fuel, hydraulic fluids and oil and outdoor storage of lubricants, fluids, oils and oily rags. Fueling stations are also frequently conducted outdoors without any roof cover. Activities such as topping off fuel tanks, or overfilling storage tanks (without high-level alarms) are also activities that can cause contamination of runoff. One last activity of concern is vehicle washing which can result in accumulated residue material being discharged to a storm sewer system.

The following table highlights activities associated with vehicle maintenance and material handling that are potential sources of storm water contamination.

Table E-14.2
Other Potential Pollutant Source Activities

Activity: Material Handling Systems (forklifts, cranes, conveyors) Potential Sources: Spills and/or leaks from fueling tanks, spills/leaks from oil/hydraulic fuel reservoirs, faulty/leaking hose connections/fittings, leaking gaskets Pollutants of Concern: Accumulated particulate matter (ferrous and non-ferrous metals, plastics, rubber, other), oil/lubricants, PCBs (electrical equipment), mercury (electrical controls), lead/battery acids
Activity: Vehicle Maintenance Potential Sources: Parts cleaning, waste disposal of rags, oil filters, air filters, batteries, hydraulic fluids, transmission fluids, brake fluids, coolants, lubricants, degreasers, spent solvents Pollutants of Concern: Fuel (gas/diesel), fuel additives, oil/lubricants, heavy metals, brake fluids, transmission fluids, chlorinated solvents, arsenic
Activity: Fueling stations Potential Sources: spills and leaks during fuel transfer, spills due to "topping off" tanks, runoff from fueling areas, washdown of fueling areas, leaking storage tanks, spills of oils, brake fluids, transmission fluids, engine coolants, Pollutants of Concern: gas/diesel fuel, fuel additives, oil, lubricants, heavy metals
Activity: Vehicle & Equipment cleaning & washing Potential Sources: Washing and steam cleaning Pollutants of Concern: solvent cleaners, oil/lubricants/additives, antifreeze (ethylene glycol)

b. Waste Recycling Facilities (SIC 5093) - (Liquid Recyclable Wastes)

This sub-section applies to those facilities engaged in the reclaiming and recycling of liquid wastes such as "spent solvents", "used oil", and "used ethylene glycol" typically identified under SIC 5093. This sub-section is particularly applicable to those facilities that participated in EPA group application number 195. EPA received a single group application in this category of waste recycling facilities. The following is a profile of industrial activities and the types of significant materials associated with facilities participating in this group activity.

Group application number 195 included 220 facilities of which 214 were classified as service centers. Service centers accumulate spent solvent, used oil and antifreeze, filter cartridges and still bottoms contaminated with dry cleaning solvents (typically perchloroethylene), and used lacquer thinner from paint gun cleaning machines. The typical service center has a total storage capacity limited to approximately 10,000 gallons in individual containers and tanks with a maximum storage capacity of 20,000 gallons each. Service centers are typically limited to a maximum of 6 tanks (a total of 120,000 gallons). Twenty (20) of the service centers also function as accumulation centers where they have a maximum storage capacity of 70,000 gallons of liquid materials in containers. None of the containers are opened except under conditions where a container begins to leak or is damaged.

The group application also included four (4) facilities that operated only as container transfer stations and do not operate storage tanks. These facilities are largely enclosed warehouses that provide secondarily-contained storage areas. Three (3) facilities were identified as used oil depots where only oily water and/or used oil are accumulated in storage tanks. Storage tanks are limited to a maximum capacity of 20,000 gallons each. Used oil is transported to the facility in tanker trucks (3,500 gallons) and shipped out in tanker trucks (7,500 gallons). The used oil is ultimately transported to a processing or re-refining facility (not covered under this permit). The following table summarizes the percentage of facilities with significant materials stored.

Table E-14.3
Significant Materials Reported in Group Application Number 195

Significant Materials	Percent of Facilities
Mineral Spirits	98%
Immersion Cleaner	98%
Dry Cleaner Solvents	98%
Paint Solvents	83%
Industrial Solvents	81%
Spent Antifreeze	59%
Used Oil	57%
Allied Products	98%

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The types of materials identified in Table E-14.3 are potential sources of storm water runoff contamination. Since these materials are stored and transported in individual drums and bulk storage tanks, the potential exists for spills and/or leaks during all phases of waste transport, waste transfer, container/drum handling and shipping.

There are a number of operations at these facilities that have significant potential to release pollutants to the environment if recyclable waste materials are not managed properly. However, in response to other Federal and State environmental regulations, such as RCRA and 40 CFR 112 (Oil Pollution Prevention), facilities in this group application currently employ a range of the best management practices and structural controls that also benefit storm water quality.

(1) Pollutants Found in Storm Water Discharges. Based on data provided in the group application number 195, pollutants that were most frequently reported included total suspended solids (TSS), BOD, COD, nitrite plus nitrate, oil & grease. The following table provides a statistical summary of data provided in group application number 195.

Table E-14.4
Summary Statistics for Waste Recycling Facilities in Group Application Number 195 (SIC 5093) - (Recyclable Liquid Wastes). All values in mg/l.

Paragraph	# of Samples		Mean		Min		Max		Median		99th Percentile	
Sample Type	Grab	Comp	Grab	Comp	Grab	Comp	Grab	Comp	Grab	Comp	Grab	Comp
BOD5	22	17	18	9	2	2	94	48	5	5	79	38
COD	22	17	133	83	12	5	660	400	45	45	449	320
TSS	21	16	51	28	5	5	500	84	28	20	68	59
Nitrite + Nitrate	22	17	0.90	0.78	0.05	0.05	3.70	3.50	0.61	0.38	3.45	3.29
TKN	22	17	3.1	2.0	1.0	1.0	11.0	6.0	1.5	1.0	9.9	5.7
Oil & Grease	22	17	1.8	1.5	1.0	1.0	5.0	3.0	1.5	1.0	4.0	3.0

Table E-14.4 indicates that, with the exception of BOD and COD, average concentrations in grab and composite samples were comparable with average values reported in the NURP study (NURP did not measure oil & grease). The data also indicates that pollutants such as industrial solvents were all below detection limits (without values). In the case of oil & grease, all concentration values were below the reportable concentration of 10 mg/l (see 40 CFR 110.10 and 117.21).

(2) Waste Material Handling and Storage. Given the nature and type of materials stored and handled at these facilities, the potential exists for accidental spills and leaks. Consequently, the types of activities that occur at these facilities which could potentially result in contamination of storm water runoff is also of concern to EPA. The following table is a list of activities which may result in a release of pollutants.

Table E-14.5
Types of Potential Pollutant-Causing Activities at Waste Recycling Facilities that Handle Liquid Recyclable Wastes

Activity: Drum/Individual Container Storage and Handling Potential Sources of Pollutants: Leaks or spills due to faulty container/drum integrity, e.g., leaking seals or ports. Container materials incompatible with waste material. Improper stacking and storage of containers. Pollutants of Concern: Mineral spirits, industrial solvents, immersion cleaners, dry cleaner solvents, paint solvents, spent antifreeze.
Activity: Return and Fill Stations Potential Sources of Pollutants: Leaks, spills, or overflows from tanker truck transfer of wastes and hose drainage. Leaking pipes, valves, pumps, worn or deteriorated gaskets or seals Pollutants of Concern: Mineral spirits, industrial solvents, immersion cleaners, dry cleaner solvents, paint solvents, spent antifreeze.
Activity: Individual Container/Drum Storage Potential Sources of Pollutants: Leaks or spills due to faulty container/drum integrity, e.g., leaking seals or ports. Improper stacking and storage of containers. Pollutants of Concern: Mineral spirits, industrial solvents, immersion cleaners, dry cleaner solvents, paint solvents, spent antifreeze.

Table E-14.5
Types of Potential Pollutant-Causing Activities at Waste Recycling Facilities that Handle Liquid Recyclable Wastes (continued)

Activity: Storage Tank Operations Potential Sources of Pollutants: Overfill of storage tanks, leaking pipes, valves, worn or deteriorated pumps seals. Leaking underground storage tanks Pollutants of Concern: Mineral spirits, industrial solvents, immersion cleaners, dry cleaner solvents, paint solvents, spent antifreeze.
Activity: Material Handling Equipment Potential Sources of Pollutants: Leaking fuel lines, worn gaskets, leaking hydraulic lines and connections. Pollutants of Concern: Fuel, hydraulic fluid, oil and grease.

3. **Other Activities of Concern:**

The following table highlights other types of activities that are potential sources of storm water contamination.

Table E-14.6
Other Potential Sources of Storm Water Contamination

Activity: Vehicle and Equipment Maintenance (if applicable) Potential Sources of Pollutants: Replacement of fluids such as transmission and brake fluids, antifreeze, oil and other lubricants, washdown of maintenance areas, dumping fluids down floor drains connected to storm sewer system, outside storage of fluids and oily rags and waste material. Pollutants of Concern: Oil and grease, fuel, accumulated particulate matter, antifreeze.
Activity: Vehicle or Equipment Washing (if applicable) Potential Sources of Pollutants: Wash water or steam cleaning Pollutants of Concern: Oil, detergents, chlorinated solvents, suspended solids and accumulated particulate matter.

Table E-14.7
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 14

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	[illegible]	23.49	9.00	89.00	[illegible]	24.00	9.00	88.00	12.00	9.00	15.00
COD	130	253.33	120.00	1100.00	117	203.71	110.00	700.00	82.00	65.00	140.00
Copper	102	0.77	0.26	3.00	95	0.63	0.22	2.50	0.04	0.04	0.09
Lead	103	0.85	0.21	4.00	96	0.88	0.22	3.40	0.18	0.14	0.35
NO_3+NO_2-N	129	1.78	0.62	3.30	117	5.88	0.80	12.00	0.86	0.68	1.75
Oil & Grease	135	8.95	5.00	32.00					NR	NR	NR
P, Total	127	0.81	0.30	2.20	114	0.77	0.29	1.80	0.42	0.33	0.70
pH	136	7.52	7.47	9.10					NR	NR	NR
TKN	127	3.44	2.05	11.10	114	3.38	2.20	9.20	1.90	1.50	3.30
TSS	130	437.11	148.00	2096.00	116	375.84	84.50	1700.00	180.00	100.00	300.00
Zinc	97	3.16	1.40	12.00	90	3.20	1.40	10.00	0.20	0.16	0.50

Sector 15: Steam Electric Power Generating Facilities, Including Coal Handling Areas.

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (vii) steam electric power generating facilities." The steam electric power generating category includes facilities which are coal, oil, gas, or nuclear fired. Heat captured co-generation facilities are not covered under the definition of storm water discharge associated with industrial activity, however, dual fuel co-generation facilities are included in the definition. Ancillary facilities such as fleet centers, gas turbine stations, and substations that are not contiguous to a steam electric power generation facility are not included in this classification.

Pollutants of concern include fuel, oil, heavy metals, ammonia, chlorine, sulfuric acid, sodium hydroxide, ethylene glycol, arsenic, and solvents.

Table E-15
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 15

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	76	5.71	4.25	20.00	78	5.69	4.00	20.00	12.00	9.00	15.00
COD	76	104.02	32.50	360.00	77	69.47	39.50	280.00	82.00	65.00	140.00
Copper	70	0.08	0.00	0.21	75	0.03	0.02	0.13	0.04	0.04	0.09
Lead	28	0.02	0.00	0.08	23	0.02	0.01	0.07	0.18	0.14	0.35
NO_2+NO_3-N	76	5.62	0.36	3.70	77	0.75	0.45	3.20	0.86	0.68	1.75
Oil & Grease	88	1.38	0.00	6.00					NR	NR	NR
P, Total	75	0.79	0.29	3.09	78	0.63	0.27	3.10	0.42	0.33	0.70
pH	70	7.32	7.42	8.28					NR	NR	NR
TKN	76	2.41	1.25	8.55	78	1.95	1.00	10.00	1.90	1.50	3.30
TSS	76	516.25	44.00	1200.00	77	212.35	40.00	810.00	180.00	100.00	300.00
Zinc	35	0.32	0.05	0.66	39	0.27	0.06	0.92	0.20	0.16	0.50

Sector 16: Motor Freight Transportation Facilities, Passenger Transportation Facilities, Rail Transportation Facilities, and United States Postal Service Transportation Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (viii) facilities classified as Standard Industrial Classification (SIC) codes 40, 41, 42 (except 4221-25), 43, 44, and 5171 that have vehicle and equipment maintenance shops, or equipment cleaning operations." The category further states that only those portions of the facility that are either involved in vehicle and equipment maintenance (including vehicle and equipment rehabilitation, mechanical repairs, painting, fueling, and lubrication) or equipment cleaning operations are associated with industrial activity.

Vehicle and equipment maintenance is a broad term used to include the following activities: vehicle and equipment fluid changes, mechanical repairs, parts cleaning, sanding, refinishing, painting, fueling, locomotive sanding (loading sand for traction), storage of vehicles and equipment waiting for repair or maintenance, and storage of the related materials and waste materials, such as oil, fuel, batteries, tires, or oil filters. Equipment cleaning operations include areas where the following types of activities take place: vehicle exterior wash down, interior trailer washouts, tank washouts, and rinsing of transfer equipment.

SIC code 40 includes facilities primarily engaged in furnishing transportation by line-haul railroad, and switching and terminal establishments. The following types of facilities are examples of those covered under SIC code 40: electric railroad line-haul operation, railroad line-haul operation, interurban railways, beltline railroads, logging railroads, railroad terminals, and stations operated by railroad terminal companies.

SIC code 41 includes facilities primarily engaged in furnishing local and suburban transportation, such as those providing transportation in and around a municipality by bus, rail, or subway. The following types of facilities are examples of those covered under SIC code 41: bus line operations, airport transportation services (road or rail), cable car operations, subway operations, ambulance services, sightseeing buses, van pool operations, limousine rental with drivers, taxicab operations, and school buses not operated by the educational institution.

SIC code 42 includes facilities providing local or long-distance trucking, transfer, and/or storage services. The following types of facilities are examples of those covered under SIC code 42: hauling by dump truck, trucking timber, contract mail carriers, furniture moving, garbage collection without disposal, over-the-road trucking, long distance trucking, and freight trucking terminal.

SIC code 43 includes all establishments of the United States Postal Service.

SIC code 5171 includes establishments engaged in the wholesale distribution of crude petroleum and petroleum products from bulk liquid storage facilities.

Significant materials include oily rags, air filters, batteries, hydraulic fluids, paints, and vehicles awaiting service.

Pollutants include fuel, oil, heavy metals, chlorinated solvents, acid/alkaline wastes, ethylene glycol, arsenic, heavy metals, organics, hydraulic fluids, dust, paint solids, sediment, detergents, phosphorus, salts, suspended solids, and biochemical oxygen demand (BOD).

Table E-16
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 16

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	116	11.29	6.00	34.00	105	9.27	6.00	28.00	12.00	9.00	15.00
COD	117	318.10	118.00	781.00	102	189.46	89.00	489.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead									0.18	0.14	0.35
NO_2+NO_3-N	118	1.59	0.92	6.07	102	1.41	0.78	4.26	0.86	0.68	1.75
Oil & Grease	118	9.56	0.00	27.00					NR	NR	NR
P, Total	118	1.47	0.54	8.10	102	0.92	0.45	3.05	0.42	0.33	0.70
pH	114	7.30	7.40	8.80					NR	NR	NR
TKN	118	3.75	1.50	13.40	102	2.48	1.40	8.80	1.90	1.50	3.30
TSS	118	517.01	171.50	2800.00	102	248.51	89.50	917.00	180.00	100.00	300.00
Zinc	1	0.14	0.14	0.14	1	0.28	0.28	0.28	0.20	0.16	0.50

Sector 17: Vehicle and Equipment Maintenance and Cleaning Operations

The definition of storm water discharge associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (viii) transportation facilities classified as Standard Industrial Classification (SIC) codes 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 that have vehicle and equipment maintenance shops, equipment cleaning operations, or airport deicing operations."

SIC code 41 includes facilities primarily engaged in furnishing local and suburban transportation, such as those providing transportation in and around a municipality by bus, rail, or subway. The following types of facilities are examples of those covered under SIC code 41: bus line operation, airport transportation service (road or rail), cable car operation, subway operation, ambulance service, sightseeing buses, van pool operation, limousine rental with drivers, taxicab operation, and school buses not operated by the educational institution.

SIC code 42 includes facilities providing local or long-distance trucking, transfer, and/or storage services. The following types of facilities are examples of those covered under SIC code 42: hauling by dump truck, trucking timber, contract mail carriers, furniture moving, garbage collection without disposal, over-the-road trucking, long distance trucking, and freight trucking terminal.

SIC code 43 includes all establishments of the United States Postal Service.

SIC code 5171 includes establishments engaged in the wholesale distribution of crude petroleum and petroleum products from bulk liquid storage facilities.

Vehicle and equipment maintenance is a broad term used to include the following activities: vehicle and equipment fluid changes, mechanical repairs, parts cleaning, sanding, refinishing, painting, fueling, storage of vehicles and equipment waiting for repair or maintenance, and storage of the related materials and waste materials, such as oil, fuel, batteries, or oil filters. Equipment cleaning operations include areas where the following types of activities take place: vehicle exterior wash down, interior trailer washouts, tank washouts, and rinsing of transfer equipment.

Significant materials include oils, washing equipment, used equipment, vehicle parts, vehicles, fuels, paint, waste rags, oil filters, storage tanks, and detergents. Pollutants from these facilities include fuel, oil, heavy metals, organics, solvents, suspended solids, phosphorus, salts, acid/alkaline wastes and arsenic.

Table E-17
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 17

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	95%
BOD5	400	17.11	8.00	60.50	376	11.07	6.00	41.00	12.00	9.00	15.00
COD	408	135.16	63.95	498.00	374	85.64	48.00	250.00	82.00	65.00	140.00
Copper	19	0.02	0.01	0.06	20	0.02	0.01	0.08	0.04	0.04	0.09
Lead	32	0.03	0.01	0.11	31	0.01	0.00	0.06	0.18	0.14	0.35
NO_3+NO_2-N	399	2.99	0.61	9.00	372	1.99	0.52	5.10	0.86	0.68	1.75
Oil & Grease	418	16.38	2.80	41.00					NR	NR	NR
P, Total	405	1.12	0.33	3.90	373	0.73	0.29	2.91	0.42	0.33	0.70
pH	380	7.13	7.26	8.89					NR	NR	NR
TKN	405	2.69	1.40	7.70	373	2.04	1.13	6.30	1.90	1.50	3.30
TSS	406	503.15	104.00	1890.00	375	454.20	67.00	1100.00	180.00	100.00	300.00
Zinc	30	0.23	0.13	1.10	28	1.34	0.11	0.66	0.20	0.16	0.50

Sector 18: Water Transportation Facilities, Vehicle Maintenance/Equipment Cleaning Operations

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: ...category (viii) water transportation facilities classified as Standard Industrial Classification (SIC) code 44 that have vehicle maintenance shops and/or equipment cleaning operations. The category further states that only those portions of the facility that are either involved in vehicle and equipment maintenance (including vehicle and equipment rehabilitation, mechanical repairs, painting, fueling, and lubrication), or equipment cleaning operations are associated with industrial activity. Vehicle and equipment maintenance is a broad term used to include the following activities: vessel and equipment fluid changes, mechanical repairs, parts cleaning, sanding, blasting, welding, refinishing, painting, fueling, storage of the related materials and waste materials, such as oil, fuel, batteries, or oil filters. Equipment cleaning operations include areas where vessel and vehicle exterior washdown occurs.

SIC code 44 includes facilities primarily engaged in furnishing water transportation services. The following types of facilities are examples of those covered under SIC code 44:

- Deep Sea Foreign Transportation of Freight (SIC 4412)
- Deep Sea Domestic Transportation of Freight (SIC 4424)
- Freight Transportation on the Great Lakes - St. Lawrence Seaway (SIC 4432)
- Water Transportation of Freight, Not Elsewhere Classified (SIC 4449)
- Deep Sea Transportation of Passengers, Except by Ferry (SIC 4481)
- Ferries (SIC 4482)
- Marine Cargo Handling (SIC 4491)
- Towing and Tugboat Services (SIC 4492)
- Marinas (SIC 4493)
- Water Transportation Services, Not Elsewhere Classified (SIC 4499)

Pollutants of concern include paint solids, heavy metals, suspended solids, spent abrasives, solvents, dust, paint, paint thinner, spent solvents, dust, oil, ethylene glycol, acid/alkaline wastes, detergents, fuel, trash, petroleum products, sanitary waste bilge & ballast water, biochemical oxygen demand (BOD), and bacteria.

Table E-18
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 18

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	15	8.60	7.00	39.00	14	6.00	6.00	11.00	12.00	9.00	15.00
COD	15	130.93	93.00	500.00	14	75.79	50.50	203.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead	4	0.20	0.05	0.70	3	0.10	0.10	0.10	0.18	0.14	0.35
NO_2+NO_3-N	15	4.23	0.60	54.00	14	0.66	0.65	1.61	0.86	0.68	1.75
Oil & Grease	15	11.93	2.00	96.00					NR	NR	NR
P, Total	15	0.27	0.10	1.20	14	0.15	0.17	0.32	0.42	0.33	0.70
pH	15	7.14	7.00	8.80					NR	NR	NR
TKN	15	2.64	1.60	16.00	14	9.41	0.75	118.00	1.90	1.50	3.30
TSS	15	633.80	135.00	4330.00	14	224.14	67.50	944.00	180.00	100.00	300.00
Zinc	4	0.68	0.22	2.20	3	0.42	0.21	0.87	0.20	0.16	0.50

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Sector 19: Ship Building & Repairing and Boat Building & Repairing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (ii) facilities classified as Standard Industrial Classification (SIC) code 373." SIC code 373 includes facilities primarily engaged in ship and boat building and repairing services, and include the following:

- **Ship Building and Repairing (SIC code 3731).** These are establishments primarily engaged in building and repairing ships, barges, and lighters, whether self-propelled or towed by other crafts. The industry also includes the conversion and alteration of ships and the manufacture of off-shore oil and gas well drilling and production platforms (whether of not self-propelled). Examples include building and repairing of barges, cargo vessels, combat ships, crew boats, dredges, ferryboats, fishing vessels, lighthouse tenders, naval ships, offshore supply boats, passenger-cargo vessels, patrol boats, sailing vessels, towboats, trawlers, and tugboats.

- **Boat Building and Repairing (SIC code 3732).** These facilities are primary engaged in building and repairing boats. Examples include building and repairing of fiberglass boats, motor-boats, sailboats, rowboats, canoes, dinghies, dories, small fishing boats, houseboats, kayaks, lifeboats, pontoons, and skiffs.

Pollutants of concern include spent abrasives, solvents, dust, oil, ethylene glycol, acid/alkaline wastes, detergents, paint solids, heavy metals, spent solvents, biochemical oxygen demand (BOD), bacteria, suspended solids.

Table E-19
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 19

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	44	5.00	2.80	15.00	37	7.40	0.90	23.00	12.00	9.00	15.00
COD	51	73.22	53.00	260.00	43	68.80	28.00	240.00	82.00	65.00	140.00
Copper	5	0.16	0.15	0.32	5	0.08	0.09	0.13	0.04	0.04	0.09
Lead	6	0.75	0.04	4.24	5	11.00	0.06	0.33	0.18	0.14	0.35
NO_2+NO_3-N	51	0.79	0.72	1.60	45	0.85	0.72	1.80	0.86	0.68	1.75
Oil & Grease	52	0.98	0.00	5.00					NR	NR	NR
P, Total	51	0.21	0.00	0.91	45	0.88	0.00	0.76	0.42	0.33	0.70
pH	43	7.20	7.30	8.11					NR	NR	NR
TKN	51	1.19	1.00	2.40	43	2.20	0.97	3.90	1.90	1.50	3.30
TSS	51	92.33	17.00	505.00	45	2.36	8.00	200.00	180.00	100.00	300.00
Zinc	2	0.31	0.31	0.36	1	39.00	0.33	0.33	0.20	0.16	0.50

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Sector 20: Vehicle Maintenance Areas, Equipment Cleaning Areas, or Deicing Areas Located at Air Transportation Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... category (viii) facilities classified as Standard Industrial Classification (SIC) 45 that have vehicle and equipment maintenance shops, equipment cleaning operations, or airport deicing operations." Only those portions of the facility that are either involved in vehicle and equipment maintenance (including vehicle and equipment rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, or airport deicing operations are considered associated with industrial activity. SIC code 45 generally applies to airports, airport terminals and flying fields. Industrial activities include the following:

Aircraft Deicing includes both deicing to remove frost, snow or ice, and anti-icing which prevents the accumulation of frost, snow or ice. Deicing of an airplane is accomplished through the application of a freezing point depressant fluid, commonly ethylene glycol or propylene glycol, to the exterior surface of an airplane. Both ethylene and propylene glycol have high biochemical oxygen demands (BOD) when discharged to receiving waters. Environmental impacts on surface waters due to glycol discharges includes glycol odors and glycol contaminated surface water and ground water systems, diminished dissolved oxygen levels and fish kills.

Runway Deicing/Anti-icing activities include deicing/anti-icing operations conducted on runways, taxiways and ramps. Runway deicing/anti-icing commonly involves either the application of chemical fluids such as ethylene glycol or propylene glycol, or solid constituents such as pelletized urea. Urea has a high nitrogen content, therefore degradation of urea in a receiving water causes an increase in nutrient loadings resulting in an accelerated growth of algae and eutrophic conditions. Under certain ambient conditions, the degradation of urea in receiving waters can also result in ammonia concentrations toxic to aquatic life.

Aircraft, Ground Vehicle and Equipment Maintenance and Washing. Maintenance activities included in this section include both minor and major operations conducted either on the apron adjacent to the passenger terminal, or at dedicated maintenance facilities. Potential pollutant sources from all types of maintenance activities includes spills and leaks of engine oils, hydraulic fluids, transmission oil, radiator fluids, and chemical solvents used for parts cleaning. In addition, the disposal of waste parts, batteries, oil and fuel filters, and oily rags also have a potential for contaminating storm water runoff from maintenance areas unless proper management practices and operating procedures are implemented. The spent wash water from aircraft and ground vehicle washing activities could potentially be contaminated with surface dirt, metals, and fluids (fuel, hydraulic fluid, oil, lavatory waste).

Runway Maintenance. Over time, materials such as tire rubber, oil and grease, paint chips, and jet fuel can buildup on the surface of a runway causing a reduction in the friction of the pavement surface. When the friction level of the runway falls below a specific level, then maintenance on the runway must be performed. The Federal Aviation Administration (FAA)

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recommends several methods for removing rubber deposits and other contaminants from a runway surface including high pressure water, chemical solvents, high velocity particle impact, and mechanical grinding. If not properly managed, the materials removed from the runway surface could be discharged into nearby surface waters. Similarly, if chemical solvents are used in the maintenance operation, improper management practices could result in discharges of the chemical solvents in the storm water runoff from runway areas to nearby surface waters.

Table E-20
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 20

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	96	23.95	7.50	42.00	89	21.34	5.30	41.40	12.00	9.00	15.00
COD	95	81.49	44.00	286.00	88	75.63	36.00	182.00	82.00	65.00	140.00
Copper	2	0.03	0.03	0.04	3	0.01	0.01	0.02	0.04	0.04	0.09
Lead	2	0.02	0.02	0.03	3	0.00	0.00	0.00	0.18	0.14	0.35
NO_3+NO_2-N	75	1.27	0.41	7.90	65	1.29	0.43	7.70	0.86	0.68	1.75
Oil & Grease	98	4.66	1.85	20.00					NR	NR	NR
P, Total	86	0.44	0.20	1.84	79	0.29	0.20	0.88	0.42	0.33	0.70
pH	94	7.23	7.60	8.30					NR	NR	NR
TKN	95	19.79	1.58	27.00	88	16.00	1.40	18.80	1.90	1.50	3.30
TSS	96	184.73	29.00	1080.00	87	79.59	22.00	258.00	180.00	100.00	300.00
Zinc	8	0.14	0.08	0.58	3	0.35	0.04	1.00	0.20	0.16	0.50

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Sector 22: Domestic Wastewater Treatment Plants

The definition of storm water discharge associated with industrial activity includes point source discharges from eleven major categories of facilities, including: "...category (ix) treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more or required to have an approved pretreatment program under 40 CFR part 403." This category does not includes farm lands, domestic gardens or lands used for sludge management where beneficially reused which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the CWA.

Pollutants of concern include diesel, gasoline, petroleum products other than fuels: numerous grades of motor oils, gear and chassis lubricants, turbine oils, grease and hydraulic fluids, acid/alkaline wastes, arsenic, organics, chlorinated ethylene glycol, acids and bases for pH adjustments, disinfectants, polymers and coagulants, alum, ferric chloride, soda ash, lime, methanol, sodium aluminate, sodium hypochlorite, sodium hydrochloride mineral spirits, acetone, paint thinner, and lacquer thinner, toluene, TCE, isopropandlamine, and methyl-ethyl-ketone, dust, paint solids, paint, spent chlorinated solvents, commercial brands of balance fertilizers (6-6-6, 8-8-8 or 12-12-12), commercial sludge based products, fuel, process chemicals, diazanon, malathion, amdro, dimethylphthalate, diethyl phthalate, dichlorvos, carbaryl, skeetal, batex, liquid copper, bacteria, biochemical oxygen demand (BOD), suspended solids, oil, heavy metals, chlorinated solvents, ethylene glycol, detergents, metals, phosphorous.

Table E-22
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 22

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	90	33.26	11.50	53.40	89	46.11	8.00	200.00	12.00	9.00	15.00
COD	84	133.03	68.65	410.00	84	157.95	61.59	880.00	82.00	65.00	140.00
Copper	28	0.07	0.01	0.22	27	0.05	0.02	0.11	0.04	0.04	0.09
Lead	27	0.03	0.00	0.15	26	0.01	0.00	0.09	0.18	0.14	0.35
NO_3+NO_2-N	84	20.86	1.09	136.00	83	20.50	0.87	131.27	0.86	0.68	1.75
Oil & Grease	89	24.24	0.90	26.00					NR	NR	NR
P, Total	86	0.95	0.50	3.17	84	0.68	0.45	1.89	0.42	0.33	0.70
pH	82	6.80	6.98	7.83					NR	NR	NR
TKN	79	8.10	1.52	18.00	78	4.74	1.33	11.00	1.90	1.50	3.30
TSS	90	160.17	68.10	575.00	88	114.44	55.50	414.00	180.00	100.00	300.00
Zinc	23	0.23	0.06	0.75	22	0.12	0.06	0.43	0.20	0.16	0.50

Sector 23: Food and Kindred Products Manufacturing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (xi) facilities under Standard Industrial Classification (SIC) codes 20, 21 ..."

- Meat Products (SIC Codes 2011, 2013, and 2015)
- Dairy Products (SIC Codes 2021, 2022, 2023, 2024, and 2026)
- Canned, Frozen, and Preserved Fruits, Vegetables, and Food Specialties (SIC Codes 2032, 2033, 2034, 2035, 2037, and 2038)
- Grain Mill Products (SIC Codes 2041, 2043, 2044, 2045, 2046, 2047, and 2048)
- Bakery Products (SIC Codes 2051, 2052, and 2053)
- Sugar and Confectionery Products (SIC Codes 2061, 2062, 2063, 2064, 2066, 2067, and 2068)
- Fats and Oils (SIC Codes 2074, 2075, 2076, 2077, and 2079)
- Beverages (SIC Codes 2082, 2083, 2084, 2085, 2086, and 2087)
- Miscellaneous Food Preparations and Kindred Products (SIC Codes 2091, 2092, 2095, 2096, 2097, 2098, and 2099)
- Tobacco Products (SIC Codes 2111, 2121, 2131, and 2141).

Meat Products (SIC Code 201X) - Production related activities include stockyards, slaughtering (killing, blood processing, viscera handling, and hide processing), cutting and deboning, meat processing, rendering, and materials recovery.

Dairy Products (SIC Code 202X) - Typical operations may include: culturing, churning, pressing, curing, blending, condensing, sweetening, drying, milling, and packaging.

Canned, Frozen, and Preserved Fruits, Vegetables, and Frozen Specialties (SIC Code 203X) -Fruits and vegetables are washed, cut, blanched, and cooked prior to being classified as finished product. Additional operations may include drying, dehydrating, and freezing.

Grain Mills (SIC Code 204X) - Process operations performed in the grain mill subsector include: washing, milling, debranning, heat treatment (i.e., steeping, parboiling, drying and cooking), screening, shaping (i.e., extruding, grinding, molding, and flaking), and vitamin and mineral supplementing.

Bakery Products (SIC Code 205X) - Process operations in this subsector include mixing, shaping of dough, cooling, and decorating.

Sugar and Confectionery (SIC Code 206X) - Typical processes include mixing, cooking, and then forming using various techniques. The manufacture of chocolate products requires shelling, roasting, and grinding of the cocoa beans followed by the typical processing operations.

Fats and Oils (SIC Code 207X) Typical process operations at an animal and marine fats and oils facility include cooking of inedible fats and oils. Operations at an edible oils manufacturer include refining, bleaching, hydrogenation, fractionation, emulsification, deodorization, filtration, and blending of the crude oils into edible products.

Beverages (SIC Code 208X) - Process operations may include brewing, distilling, fermentation, blending, and packaging (i.e., bottling, canning, or bulk packaging).

Miscellaneous Food Preparation and Kindred Products (SIC Code 209X) - Process operations may include shelling, washing, drying, shaping, baking, frying, and seasoning.

Tobacco Products (SIC Code 21XX) - Typical process operations may include drying, blending, shaping, cutting and rolling.

Significant materials exposed to storm water at food and kindred products manufacturing facilities consist mostly of food products or byproducts and include acids (phosphoric, sulfuric), activated carbon, ammonia, animal cages, bleach, blood, bone meal, brewing residuals, calcium oxide, carbon dioxide, caustic soda, chlorine, cheese, coke oven tar, detergent, eggs, ethyl alcohol, fats (greases, shortening, oils), feathers, feed, ferric chloride, fruits, vegetables, coffee beans, gel bone, grain (flour, oats, wheat), hides, lard, manure, milk, salts (brine), skim powder, starch, sugar (sweetener, honey, fructose, syrup), tallow, wastes (off-spec product, sludge), whey, and yeast.

The pollutants of concern are biological oxygen demand (BOD_5), total suspended solids (TSS), oil and grease, pH, and chemicals from applications of pesticides.

Table E-23
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 23

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	298	51.15	13.90	206.00	287	42.54	11.00	180.00	12.00	9.00	15.00
COD	296	192.46	77.00	745.00	286	141.65	63.00	463.00	82.00	65.00	140.00
Copper	17	0.08	0.04	0.27	17	0.05	0.03	0.24	0.04	0.04	0.09
Lead	12	0.01	0.01	0.03	10	0.01	0.01	0.04	0.18	0.14	0.35
NO_2+NO_3-N	301	1.17	0.56	3.70	289	0.98	0.55	3.60	0.86	0.68	1.75
Oil & Grease	300	5.35	1.05	20.95					NR	NR	NR
P, Total	298	5.13	0.56	9.06	287	1.32	0.48	5.96	0.42	0.33	0.70
pH	286	7.06	7.10	8.40					NR	NR	NR
TKN	300	4.95	2.35	18.00	290	4.07	2.00	17.00	1.90	1.50	3.30
TSS	298	252.39	72.50	1320.00	286	200.06	53.50	900.00	180.00	100.00	300.00
Zinc	33	0.78	0.21	2.10	31	0.79	0.24	5.83	0.20	0.16	0.50

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Sector 24: Textile Mills, Apparel and other Fabric Product Manufacturing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (xi) facilities under Standard Industrial Classification (SIC) code 22." Storm water discharges from the following activities are covered: Textile Mill Products, of and regarding facilities and establishments engaged in the preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and cordage, the manufacturing of broadwoven fabrics, narrow woven fabrics, knit fabrics, and carpets and rugs from yarn; processes involved in the dyeing and finishing of fibers, yarn fabrics, and knit apparel; the integrated manufacturing of knit apparel and other finished articles of yarn; the manufacturing of felt goods (wool), lace goods, nonwoven fabrics, and miscellaneous textiles.

Pollutants of concern include biochemical oxygen demand (BOD5), total suspended solids (TSS), pH, total chromium, total aluminum, total copper, total lead, total zinc, COD, phenols, sulfides, oil and grease, and benzene.

Table E-24
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 24

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	110	11.41	7.75	38.00	107	9.82	7.00	29.00	12.00	9.00	15.00
COD	110	69.19	44.00	228.00	107	48.05	37.00	111.00	82.00	65.00	140.00
Copper	16	0.03	0.01	0.15	14	0.07	0.01	0.61	0.04	0.04	0.09
Lead	8	0.07	0.02	0.28	7	0.04	0.03	0.11	0.18	0.14	0.35
NO_3+NO_2-N	110	1.33	0.39	2.50	107	1.14	0.39	1.87	0.86	0.68	1.75
Oil & Grease	111	2.94	0.00	14.00					NR	NR	NR
P, Total	110	0.35	0.14	0.66	107	0.31	0.11	0.60	0.42	0.33	0.70
pH	105	6.72	6.85	8.60					NR	NR	NR
TKN	110	2.72	1.70	6.50	107	1.92	1.50	5.40	1.90	1.50	3.30
TSS	110	126.22	35.50	410.00	107	80.04	22.00	380.00	180.00	100.00	300.00
Zinc	6	0.33	0.19	1.06	14	0.30	0.21	0.88	0.20	0.16	0.50

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Sector 25: Wood and Metal Furniture and Fixture Manufacturing Facilities

The definition of storm water discharges associated with an industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (xi) facilities classified as Standard Industrial Classification (SIC) codes 2434 and 25." Furniture and fixture manufacturing facilities eligible for coverage include facilities identified by the following SIC codes:

- Wood Kitchen Cabinets (SIC Code 2434)
- Household Furniture (SIC Code 251)
- Office Furniture (SIC Code 252)
- Public Buildings and Related Furniture (SIC Code 253)
- Partitions, Shelving, Lockers, and Office and Store Fixtures (SIC Code 254)
- Miscellaneous Furniture and Fixtures (SIC Code 259).

The process of manufacturing wood furniture begins with the delivery and storage of wood. There are three different raw wood materials, lumber, veneer, and particle board. Once delivered, raw lumber is allowed to air dry up to one year. After the lumber is sufficiently air dried it is then transported to a dry kiln for further drying. Once the lumber has been dried to a desired moisture content, the dried lumber is taken to the processing area. The remaining furniture manufacturing processes are all completed indoors, including cutting, planing, sanding, finishing, and lathing.

Veneer is another raw material used in the production of furniture. In this process logs are placed in a steam vat to increase moisture content. The logs are turned on a lathe to peel off the veneer. The resulting veneer sheets are layered into stacks or "hacks." Moisture is removed from the hacks by kiln drying. After a desired moisture content has been achieved the hacks are disassembled.

Particle board is the third raw material incorporated into the manufacturing of wood furniture. The board is received, cut to size, and banded on all four edges with solid wood. The banding is accomplished in continuous, steam heated units utilizing adhesives. The panels are allowed to cool and then they are sanded.

The significant materials identified as exposed to storm water at wood furniture and fixture manufacturing facilities include raw wood, sawdust, coal, kiln ash, solvent-based finishing materials and waste products, used rags, raw glue and waste materials, and petroleum-based products.

Metal furniture manufacturing facilities may purchase wood pieces ready for assembly or they may have all the industrial activities of wood manufacturing facilities in addition to the metal manufacturing facilities. Facilities that manufacture metal household furniture maintain all operations including: machining and assembly, finishing, and temporary storage of finished products within an enclosed building. Cold roll steel is initially received and temporarily stored within the manufacturing building. However, steel may be stored outside

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prior to use. The steel is cut to size, bent, and welded to design specifications to fabricate raw metal household furniture. Final grinding, sanding, finishing, spot welding, and painting are then completed.

The significant materials identified as exposed to storm water at metal furniture and fixture facilities include metals, sawdust, solvent-based finishing materials and waste products, electroplating solutions and sludges, used rags, raw glue and waste materials, and petroleum-based products.

Pollutants at wood and metal furniture manufacturing facilities include TSS, pH, cadmium, arsenic, COD, BOD_5, lead, solvents, oil & grease, diesel fuel, and gasoline.

Table E-25
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 25

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	25	12.22	9.00	44.00	24	8.80	5.95	26.00	12.00	9.00	15.00
COD	25	95.96	83.00	230.00	24	76.33	72.50	180.00	82.00	65.00	140.00
Copper	4	0.04	0.04	0.07	4	0.00	0.00	0.02	0.04	0.04	0.09
Lead	3	0.08	0.06	0.16	3	0.01	0.01	0.02	0.18	0.14	0.35
NO_3+NO_2-N	25	1.73	0.90	6.20	24	1.51	0.68	5.60	0.86	0.68	1.75
Oil & Grease	25	3.84	0.00	14.00					NR	NR	NR
P, Total	25	0.27	0.20	0.89	24	0.26	0.19	0.71	0.42	0.33	0.70
pH	23	7.54	7.50	8.90					NR	NR	NR
TKN	25	4.37	1.70	15.00	24	4.40	1.35	13.00	1.90	1.50	3.30
TSS	25	187.83	130.00	440.00	24	142.88	90.50	550.00	180.00	100.00	300.00
Zinc	4	2.97	0.78	10.00	4	0.59	0.40	1.50	0.20	0.16	0.50

Sector 26: Printing and Publishing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (xi) facilities classified as Standard Industrial Classification (SIC) Code 27 which includes facilities primarily engaged in printing and publishing services. The following facilities are covered under SIC code 27:

- **Book Printing (SIC Code 2732)**: Establishments primarily engaged in printing, or in printing and binding, books and pamphlets, but not engaged in publishing.
- **Commercial Printing, Lithographic (SIC Code 2752)**: Establishments primarily engaged in printing by the lithographic process. Offset printing, photo-offset printing, and photolithographing are also included in this industry.
- **Commercial Printing, Gravure (SIC Code 2754)**: Establishments primarily engaged in gravure printing.
- **Commercial Printing, Not Elsewhere Classified (SIC Code 2759)**: Establishments primarily engaged in commercial or job printing. This industry includes general printing shops, as well as shops specializing in printing newspapers and periodicals for others.
- **Platemaking and Related Services (SIC Code 2796)**: Establishments primarily engaged in making plates for printing purposes and in related services. Also included are establishments primarily engaged in making positive or negatives from which offset lithographic plates are made.

Pollutants of concern include toxic waste ink with solvents chromium, lead, dust, sludge, ink - sludges with chromium or lead, solvents, photographic processing wastes, fuel, oil, heavy metals, trash, and petroleum products.

Table E-26
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 26

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	27	10.99	9.00	49.00	27	6.95	6.40	22.20	12.00	[illegible]	15.00
COD	27	57.19	49.00	176.00	27	42.37	39.00	119.00	82.00	65.00	140.00
Copper	7	0.03	0.03	0.08	6	0.02	0.03	0.04	0.04	0.04	0.09
Lead	1	0.03	0.03	0.03	0				0.18	0.14	0.35
$NO_3 + NO_3 - N$	20	1.27	0.82	4.00	20	1.35	1.05	4.49	0.86	0.68	1.75
Oil & Grease	27	12.58	2.50	56.00					NR	NR	NR
P. Total	27	0.37	0.14	1.50	27	0.35	0.13	1.30	0.42	0.33	0.70
pH	20	7.07	7.03	8.46					NR	NR	NR
TKN	27	3.13	1.50	10.00	27	1.57	0.84	4.60	1.90	1.50	3.30
TSS	27	91.52	30.00	433.00	27	30.83	28.00	82.00	180.00	100.00	300.00
Zinc	4	0.48	0.37	1.00	3	0.47	0.52	0.65	0.20	0.16	0.50

Sector 27: Rubber, Miscellaneous Plastic Products, and Miscellaneous Manufacturing Industries

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... (xi) facilities classified as Standard Industrial Classification (SIC) major groups 30 and 39." Storm water discharges from category (xi) facilities are only regulated where precipitation and storm water runon come into contact with areas associated with industrial activities and significant materials. Sector 27 covers all storm water discharges from facilities classified as SIC 30 and 39, except for those facilities classified as SIC code 391 - Jeweler, Silverware, and Plated ware. Facilities classified as SIC code 391 are subject to Sector 29 permitting requirements.

Major SIC group 30 includes rubber and miscellaneous plastic products. Specifically, this SIC group includes manufacturers of tires and inner tubes, rubber and plastic footwear, rubber and plastic hose and belting, gaskets, packing and sealing devices, and miscellaneous fabricated rubber products. This SIC group also includes miscellaneous plastic products such as unsupported plastic film, sheet, rods and tubes, laminated plastic plate, sheet and profile shapes, plastic pipe and bottles, plastic foam products such as cups, ice chests and packaging materials, plastic plumbing fixtures, and miscellaneous plastic products.

Major SIC group 39 (except 391) includes miscellaneous manufacturing industries. Specifically, this group includes manufacturers of musical instruments, games, toys and athletic goods, pens, pencils and artists' supplies, buttons, and pins and needles.

Pollutants found in storm water discharges from rubber and miscellaneous plastic products manufacturers may include total suspended solids (TSS), oil and grease, zinc, and acids.

Table E-27
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 27

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	90	13.92	7.15	51.00	89	11.21	7.00	34.00	12.00	9.00	15.00
COD	90	100.00	53.00	330.00	87	72.08	43.00	240.00	82.00	65.00	140.00
Copper	5	0.00	0.00	0.01	5	0.03	0.05	0.05	0.04	0.04	0.09
Lead	1	0.00	0.00	0.00	1	0.01	0.01	0.01	0.18	0.14	0.35
NO_3+NO_2-N	89	0.86	0.58	2.93	86	1.26	0.67	3.56	0.86	0.68	1.75
Oil & Grease	94	4.26	0.50	18.00					NR	NR	NR
P. Total	89	0.41	0.19	1.61	85	0.34	0.16	0.83	0.42	0.33	0.70
pH	86	7.17	7.10	8.40					NR	NR	NR
TKN	89	2.34	1.36	6.00	86	1.63	1.25	4.70	1.90	1.50	3.30
TSS	90	188.55	44.00	893.00	87	119.32	30.00	476.00	180.00	100.00	300.00
Zinc	34	0.98	0.19	4.90	34	0.80	0.25	2.86	0.20	0.16	0.50

Sector 28: Leather Tanning and Finishing Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (ii) facilities classified as Standard Industrial Classification (SIC) code 3111." Storm water discharges covered include those from leather tanning facilities and facilities which make fertilizer solely from leather scraps and leather dust where precipitation and storm water runon come into contact with significant materials including, but not limited to, raw materials, waste products, by-products, stored materials, and fuels.

Leather tanning or finishing is the conversion of animal hides or skins into leather. Leather is made from the inner layer of the animal skin, which consists primarily of the protein collagen. Tanning is the reaction of the collagen fibers with tannins, chromium, alum or other tanning agents. Tanning processes use sodium dichromate, sulfuric acid and detergents and a variety of raw and intermediate materials.

There are three major processes required to make finished leather. These are beamhouse operations, tanyard processes and retanning and finishing processes.

- Beamhouse Operations—These consist of four activities: side and trim; soak and wash; fleshing and unhairing. Side and trim is the cutting of the hide into two sides and trimming of areas which do not produce good leather. In soak and wash processes, the hides are soaked in water to restore moisture lost during curing. Washing removes dirt, salt, blood, manure, and nonfibrous proteins. Fleshing is a mechanical operation which removes excess flesh. The removed matter is normally recovered and sold for conversion to glue. Unhairing involves using calcium hydroxide, sodium sulfhydrate, and sodium sulfide to destroy the hair (hair pulp process) or remove hair roots.

- Tanyard Processes—These consist of bating, pickling, tanning, wringing, splitting, and shaving. Bating involves the addition of salts of ammonium sulfate or ammonium chloride used to convert the residual alkaline chemicals present from the unhairing process into soluble compounds which can be washed from the hides or skins. "Pickling" the hide with sulfuric acid provides the acid environment necessary for chromium tanning. In the tanning process, tanning agents such as trivalent chromium and vegetable tannins convert the hide into a stable product which resists decomposition. Wringing of the "blue hides" (hides tanned with chromium) removes excess moisture with a machine similar to a clothes wringer. Splitting adjusts the thickness of the tanned hide to the requirements of the finished product and produces a "split" from the flesh side of the hide. The hide is then shaved to remove any remaining fleshy matter.

- Retanning and Wet Finishing Processes—These include retanning, bleaching, coloring, fatliquoring, and finishing. The most common retanning agents are chromium, vegetable extracts and syntans (based upon naphthalene and phenol). Sodium bicarbonate and sulfuric acid are sometimes used to bleach leather. Coloring involves the use of dyes (usually aniline based) on the tanned skin. Animal or vegetable fatliquors are added to replace the natural oils lost in the beamhouse and tanyard processes. Finishing includes all operations performed on the hide after fatliquoring, and includes finishing to enhance color and resistance to stains and abrasions, smoothing and stretching of the skin, drying, conditioning, staking, dry milling, buffing and plating.

Significant materials include raw materials, brine or salt cured hides and skins, fuels, materials such as solvents, detergents, finished materials, fertilizers, pesticides, waste products, leather shavings and dust, leather scrap, blue hides and splits, empty chemical containers, spent solvents, and emissions from spray booths.

Pollutants include aluminum, manganese, Total Kjeldahl Nitrogen (TKN), nitrate + nitrite as N, and Biochemical Oxygen Demand (BOD_5).

Table E-28
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 28

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	31	33.07	11.00	140.00	31	22.32	10.00	77.00	12.00	9.00	15.00
COD	31	205.45	82.00	900.00	31	91.94	50.00	340.00	82.00	65.00	140.00
Copper									0.04	0.04	0.09
Lead	2	0.02	0.02	0.04	2	0.02	0.02	0.04	0.18	0.14	0.35
NO_3+NO_2-N	31	1.86	1.20	4.70	31	1.88	0.90	9.10	0.86	0.68	1.75
Oil & Grease	31	13.87	0.00	120.00					NR	NR	NR
P, Total	31	0.36	0.16	1.60	31	0.83	0.18	1.30	0.42	0.33	0.70
pH	31	7.21	7.40	8.60					NR	NR	NR
TKN	31	7.70	4.30	22.00	31	6.22	3.50	15.00	1.90	1.50	3.30
TSS	31	309.84	49.00	1300.00	31	114.81	86.00	460.00	180.00	100.00	300.00
Zinc									0.20	0.16	0.50

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Sector 29: Fabricated Metal Products Facilities

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "...category (xi) facilities classified as Standard Industrial Classification (SIC) codes 34 and 391." Storm water discharges from fabricated metal and processing facilities eligible for coverage include the following types of operations:

- Fabricated Metal Products, Except Machinery and Transportation Equipment, SIC code 34 (3429, 3441, 3442, 3443, 3444, 3451, 3452, 3462, 3465, 3471, 3479, 3494, 3496, 3499)

- Jewelry, Silverware, and Plated Ware, SIC code 391.

This section covers establishments engaged in fabricating ferrous and nonferrous metal products, such as metal cans, tinware, general hardware, automotive parts, tanks, road mesh, structural metal products, nonelectrical equipment, and a variety of metal and wire products made from purchased iron or steel rods, bars, or wire materials.

These facilities are engaged in the manufacturing of a variety of products that are constructed primarily by using metals. The operations performed usually begin with materials in the form of raw rods, bars, sheet, castings, forgings, and other related materials and can progress to the most sophisticated surface finishing operations. There are typically several operations that take place at a fabrication facility: machining operations, grinding, cleaning and stripping, surface treatment and plating, painting, and assembly. The machining operation involves turning, drilling, milling, reaming threading, broaching, grinding, polishing, cutting and shaping, and planing. Grinding is the process using abrasive grains such as aluminum oxide, silicon carbide, and diamond to remove stock from a workpiece. Cleaning and stripping is a preparatory process involving solvents for the removal of oil, grease and dirt. Both alkaline and acid cleaning are employed. Surface treatment and plating is a major component that involves batch operations to increase corrosion or abrasion resistance. This is generally in the form of galvanizing. Painting is generally practiced at most facilities to provide decoration and protection to the product. Assembly is the fitting together of previously manufactured parts into a complete unit or structure.

Areas with significant materials include those with waste storage, outside product storage, used for pickling acids, storage of cutoff scrap metal, aluminum scraps, hazardous materials, galvanized steel components, solvent storage, waste paper storage, and machinery storage.

Pollutants at these facilities include aluminum, copper, manganese, nitrate + nitrite as N, iron, and zinc.

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Table E-29
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 29

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	115	28.31	7.60	81.00	[illegible]	10.04	7.00	40.00	12.00	9.00	15.00
COD	115	118.16	56.00	440.00	114	86.17	47.50	249.00	82.00	65.00	140.00
Copper	36	0.63	0.03	4.30	33	0.46	0.02	0.64	0.04	0.04	0.09
Lead	32	0.11	0.00	0.89	30	0.06	0.00	0.22	0.18	0.14	0.35
NO_2+NO_3-N	115	1.48	0.74	7.00	114	1.27	0.77	3.50	0.86	0.68	1.75
Oil & Grease	114	6.11	2.00	21.00					NR	NR	NR
P, Total	113	1.03	0.22	9.80	114	0.84	0.21	4.80	0.42	0.33	0.70
pH	103	7.06	7.05	8.70					NR	NR	NR
TKN	115	2.61	1.37	7.20	114	1.78	1.20	5.75	1.90	1.50	3.30
TSS	115	186.58	76.00	758.00	114	125.39	32.00	423.00	180.00	100.00	300.00
Zinc	60	4.20	0.36	9.77	58	2.17	0.21	10.50	0.20	0.16	0.50

Sector 30: Transportation Equipment, Industrial or Commercial Machinery Manufacturing Facilities

The definition of storm water discharge associated with industrial activity includes point source discharges of storm water from eleven categories of facilities, including: "...category (xi) facilities classified as Standard Industrial Classification (SIC) codes ... 34 (except 3441), 35, 37 (except 373),..." Under these SIC codes, the facilities subject to storm water regulations include:

- Fabricated Structural Metal Products, (SIC Code 344)
- Metal Forgings and Stampings, (SIC Code 346)
- Miscellaneous Fabricated Metal Products (SIC Code 349)
- Engines and Turbines (SIC Code 351)
- Farm and Garden Machinery and Equipment (SIC Code 352)
- Construction, Mining, and Materials Handling Machinery and Equipment (SIC Code 353)
- Metalworking Machinery and Equipment (SIC Code 354)
- Special Industry Machinery, Except Metalworking Machinery (SIC Code 355)
- General Industrial Machinery and Equipment (SIC Code 356)
- Refrigeration and Service Industry Machinery (SIC Code 358)
- Miscellaneous Industrial and Commercial Machinery and Equipment (SIC Code 359)
- Motor Vehicles and Motor Vehicle Equipment (SIC Code 371)
- Aircraft and Parts (SIC Code 372)
- Motorcycles, Bicycles, and Parts (SIC Code 375)
- Guided Missiles and Space Vehicles and Parts (SIC Code 376)
- Miscellaneous Transportation Equipment (SIC Code 379)

The general manufacturing process is conducted indoors, and includes activities such as cutting, shaping, grinding, cleaning, coating, forming, and finishing. Specific processes are referred to as "unit operations." These operations occur predominately indoors, so contamination of storm water discharges from manufacturing processes is unlikely.

Significant materials include ferrous and nonferrous metals, such as aluminum, copper, iron, steel and alloys of these metals; either in raw form or as intermediate products, paints, solvents (e.g., paint thinners, degreasers), chemicals (e.g., acids, bases, liquid gases), fuels (e.g., gasoline and diesel fuel), lubricating and cutting oils, and plastics.

Pollutants of concern at these facilities include total suspended solids (TSS), turbidity, fugitive dust, oil and grease, organics, heavy metals, and chemical oxygen demand (COD).

Table E-30
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 30

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	182	13.01	6.00	32.00	179	7.34	5.00	19.00	12.00	9.00	15.00
COD	174	66.89	36.00	310.00	169	46.55	29.00	149.20	82.00	65.00	140.00
Copper	79	0.20	0.01	0.84	74	0.06	0.01	0.36	0.04	0.04	0.09
Lead	76	0.22	0.00	0.97	75	0.18	0.00	0.94	0.18	0.14	0.35
NO_2+NO_3-N	184	1.20	0.58	5.00	174	1.28	0.45	4.50	0.86	0.68	1.75
Oil & Grease	189	7.84	0.00	34.00					NR	NR	NR
P, Total	176	0.29	0.14	1.00	179	0.40	0.13	1.12	0.42	0.33	0.70
pH	179	6.93	7.09	8.34					NR	NR	NR
TKN	170	2.47	1.30	5.80	165	1.81	1.10	4.75	1.90	1.50	3.30
TSS	173	162.81	30.00	576.00	169	100.41	17.00	319.00	180.00	100.00	300.00
Zinc	88	0.58	0.20	2.55	85	0.39	0.14	1.40	0.20	0.16	0.50

Sector 31: Electronic and Electrical Equipment and Components, Photographic and Optical Goods

The definition of storm water discharges associated with industrial activity includes point source discharges of storm water from eleven major categories of facilities, including: "... category (xi) facilities classified as Standard Industrial Classification (SIC) codes 36, 38, and 357."

Major SIC group 36 includes manufacturers of a broad range of electronic and electrical equipment and components, not including computer equipment. Specifically, this group includes manufacturers of electricity distribution equipment such as transformers and switch-gear, electrical industrial equipment such as motors and generators, household appliances, electric lighting and wiring equipment such as light bulbs and lighting fixtures, and audio and video equipment including phonograph records and audio tapes and disks. Also included are manufacturers of communication equipment including telephone and telegraph equipment, radio and television equipment, electronic components such as printed circuit boards and semiconductors and related devices, and miscellaneous electrical items such as batteries and electrical equipment for automobiles. Storm water discharges from facilities in this category are only regulated where precipitation and storm water runon come into contact with areas associated with industrial activities and significant materials.

Major SIC group 38 includes manufacturers of measuring, analyzing, and controlling instruments, photographic, medical and optical goods, and watches and clocks. Specifically, this group includes facilities which manufacture search, detection, navigation, or guidance systems such as radar and sonar equipment, measurement and control instruments and laboratory apparatus, surgical, medical and dental instruments and supplies, photographic equipment and supplies, and watches and clocks.

Computer and office equipment is included in industrial SIC group 357. This group includes manufacturers of computers, computer storage devices, and peripheral equipment for computers such as printers and plotters. Manufacturers of miscellaneous office machines are also included in this group.

Pollutants found in storm water discharges from Electronic and Electrical Equipment and Components, Photographic and Optical Goods manufacturers may include total suspended solids (TSS), heavy metals, organics, oil and grease, and acids.

Table E-31
Summary Statistics From (Part 2) Sampling Results by Industrial Sector
Industrial Sector 31

Pollutant	Grab Samples (mg/l)				Composite Samples (mg/l)				NURP Results (mg/l)		
	No.	Mean	Median	95%	No.	Mean	Median	95%	Mean	Median	90%
BOD5	64	8.81	5.50	32.00	56	7.48	5.10	14.00	12.00	9.00	15.00
COD	65	59.19	46.00	170.00	56	36.32	24.00	200.00	82.00	65.00	140.00
Copper	54	0.04	0.00	0.11	50	0.01	0.00	0.05	0.04	0.04	0.09
Lead	60	0.02	0.00	0.08	56	0.01	0.00	0.04	0.18	0.14	0.35
$NO_3 + NO_2 - N$	64	0.83	0.51	2.80	57	0.66	0.51	1.43	0.86	0.68	1.75
Oil & Grease	69	0.58	0.00	4.10					NR	NR	NR
P, Total	64	1.50	0.13	1.10	57	1.02	0.16	1.20	0.42	0.33	0.70
pH	69	7.43	7.54	8.60					NR	NR	NR
TKN	62	1.46	1.05	4.09	56	1.36	1.01	3.70	1.90	1.50	3.30
TSS	63	89.21	29.00	348.00	56	67.12	14.00	370.00	180.00	100.00	300.00
Zinc	51	0.16	0.09	0.53	48	0.15	0.09	0.47	0.20	0.16	0.50

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APPENDIX F

GROUP APPLICATION PART 2 SAMPLING DATA

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APPENDIX F

GROUP APPLICATION PART 2 SAMPLING DATA

ORGANIZED BY POLLUTANT

This appendix contains tabular and graphical descriptions of the sampling data for the 31 industrial sectors that were identified in the group application portion of the Phase I permitting process (four of the sectors were consolidated into two sectors for permit development purposes, only tablular data is presented for copper, lead, and zinc). This appendix summarizes the sampling data on a pollutant by pollutant basis. The tables and figures display the mean values, median values, 95th percentile values, for the grab and composite samples and the mean, median and 90th percentile values for NURP data for a portion of the pollutants sampled within each sector.

INDUSTRIAL SECTORS GROUP APPLICATIONS (TABLE 1)	
SECTOR	ACTIVITIES REPRESENTED
1	Lumber and Wood Products
2	Paper and Allied Products
3	Chemicals and Allied Products
4	Asphalt and Lubricant Manufacturers
5	Stone, Clay, Glass and Concrete Products
6	Primary Metal Industries
7	Metal Mining
8	Coal and Lignite Mining
9	Oil and Gas Extraction
10	Mining and Quarrying of Nonmetallic Minerals
11	Hazardous Waste Treatment Storage or Disposal Facilities
12	Industrial Landfills, Land Application Sites and Open Dumps
13	Used Motor Vehicle Parts
14	Scrap and Waste Materials
15	Steam Electric Power Generating Facilities
16	Railroad Transportation
17	Local and Suburban Transit and Interurban Highway Passenger Transportation Motor Freight Transportation United States Postal Service Petroleum Bulk Stations
18	Water Transportation
19	Ship Building and Repairing Boat Building and Repairing
20	Transportation By Air
22	Domestic Wastewater Treatment Plants
23	Food and Kindred Products Tobacco Products
24	Textile Mill Products Apparel and Other Finished Products Made From Fabrics and Similar Materials
25	Furniture and Fixtures Manufacturing
26	Printing Publishing and Allied Industries
27	Rubber and Misc. Plastic Products
28	Leather and Leather Products
29	Fabricated Metal Products, Except Machinery and Transportation Equipment Jewelry, Silverware, and Plated Ware
30	Industrial and Commercial Machinery (Except Computer and Office Equipment) Transportation Equipment
31	Electronic and other Electrical Equipment and Components Measuring, Analyzing, and Controlling Instruments; Photographic and Optical Goods; Watches and Clocks

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Table F-1
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Data) for BOD_5 (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	BOD5				BOD5			
NURP	Median Urban Site *						12	9	15
USGS	Commercial Site *						16	8	NR
01	Lumber & Wood Products	198	39.63	13.00	193.00	200	45.37	17.00	135.50
02	Paper & Allied Products	121	34.72	8.00	115.00	111	24.25	8.00	93.00
03	Chemicals & Allied Products	165	36.42	7.00	67.00	156	11.74	6.00	45.00
04	Petrol Refining & Related Ind.	61	39.99	7.00	47.00	51	10.87	4.00	22.00
05	Stone, Clay, Glass Products	310	14.30	5.00	32.00	300	7.32	4.20	26.00
06	Primary Metal Ind.	163	32.15	11.00	83.00	140	34.08	8.30	61.50
07	Metal Mining	18	10.02	9.00	27.00	12	10.63	6.00	44.00
08	Coal & Lignite Mining	7	3.63	1.80	9.00	4	6.55	3.90	17.40
09	Oil & Gas Extraction	35	13.79	9.71	44.00	33	10.59	7.00	21.80
10	Nonmetallic Mineral Mining	55	7.09	5.00	24.00	51	6.89	5.00	17.00
11	Hazardous Waste TSDFs	8	17.75	11.50	45.00	9	9.44	7.00	45.00
12	Industrial Landfills & Dumps	51	13.66	7.00	59.00	48	9.04	4.40	34.00
13	Used Motor Vehicle Parts	13	7.15	6.00	16.00	30	12.61	6.50	48.00
14	Scrap & Waste Materials	130	23.49	9.00	89.00	120	24.00	9.00	88.00
15	Steam Electric Power Plants	76	5.71	4.25	20.00	78	5.69	4.00	20.00
16	Railroad Transport	116	11.29	6.00	34.00	105	9.27	6.00	28.00
17	Transport: Trucks, Freight, etc.	400	17.11	8.00	60.50	376	11.07	6.00	41.00
18	Water Transport	15	8.60	7.00	39.00	14	6.00	6.00	11.00
19	Ship & Boat Building, Repair	44	5.00	2.80	15.00	37	7.40	0.90	23.00
20	Air Transport	96	23.95	7.50	42.00	89	21.34	5.30	41.40
22	Wastewater Treatment	90	33.26	11.50	53.40	89	46.11	8.00	200.00
23	Food, Tobacco Manufact.	298	51.15	13.90	206.00	287	42.54	11.00	180.00
24	Textile & Apparel Manufact.	110	11.41	7.75	38.00	107	9.82	7.00	29.00
25	Furniture & Fixtures	25	12.22	9.00	44.00	24	8.80	5.95	26.00
26	Printing & Publishing	27	10.99	9.00	49.00	27	6.95	6.40	22.20
27	Rubber & Plastic Products	90	13.92	7.15	51.00	89	11.21	7.00	34.00
28	Leather/Products	31	33.07	11.00	140.00	31	22.32	10.00	77.00
29	Fabricated Metal Products, Jewelry	115	28.31	7.60	81.00	111	10.04	7.00	40.00
30	Ind. & Comm. & Transport Equip.	182	13.01	6.00	32.00	179	7.32	5.00	19.00
31	Electronic Equip. & Instruments	64	8.81	5.50	32.00	56	7.48	5.10	14.00

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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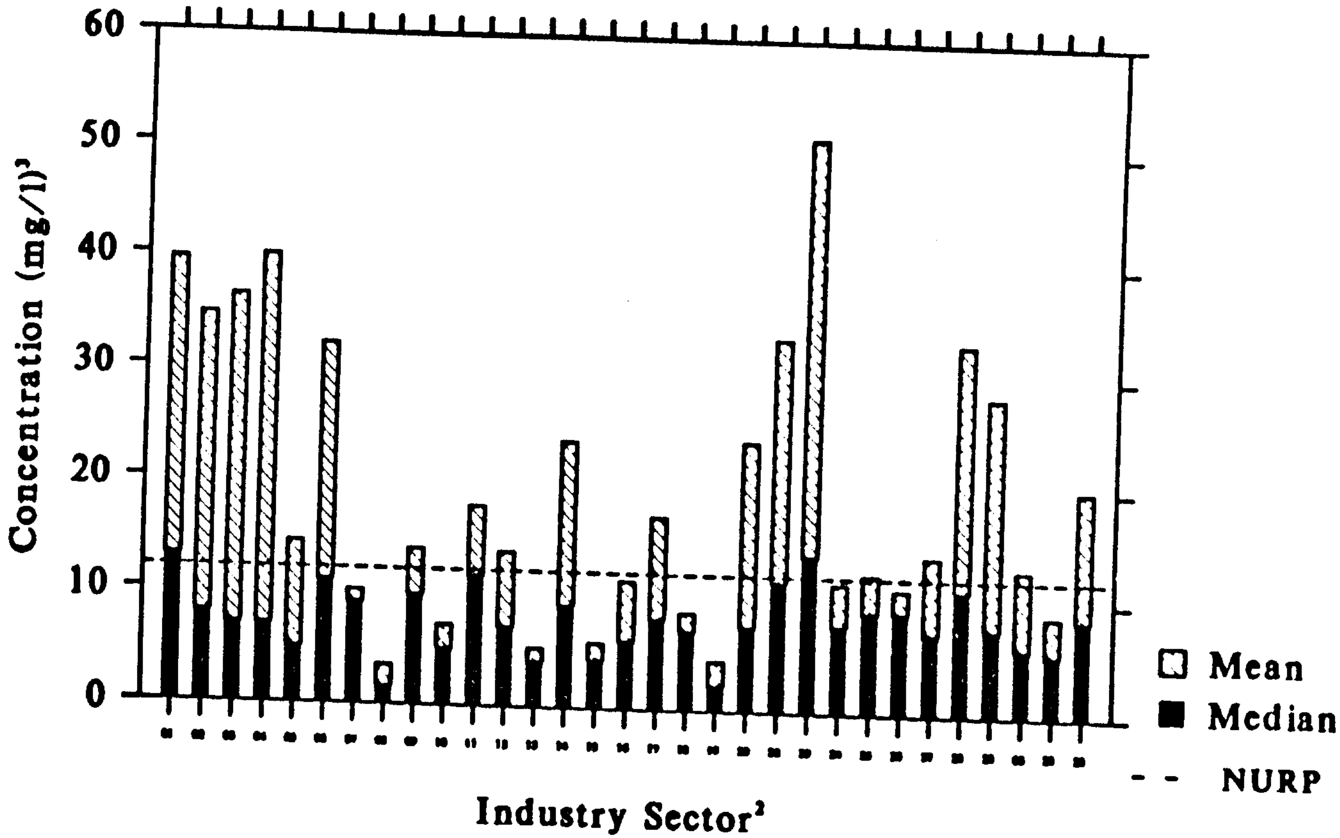
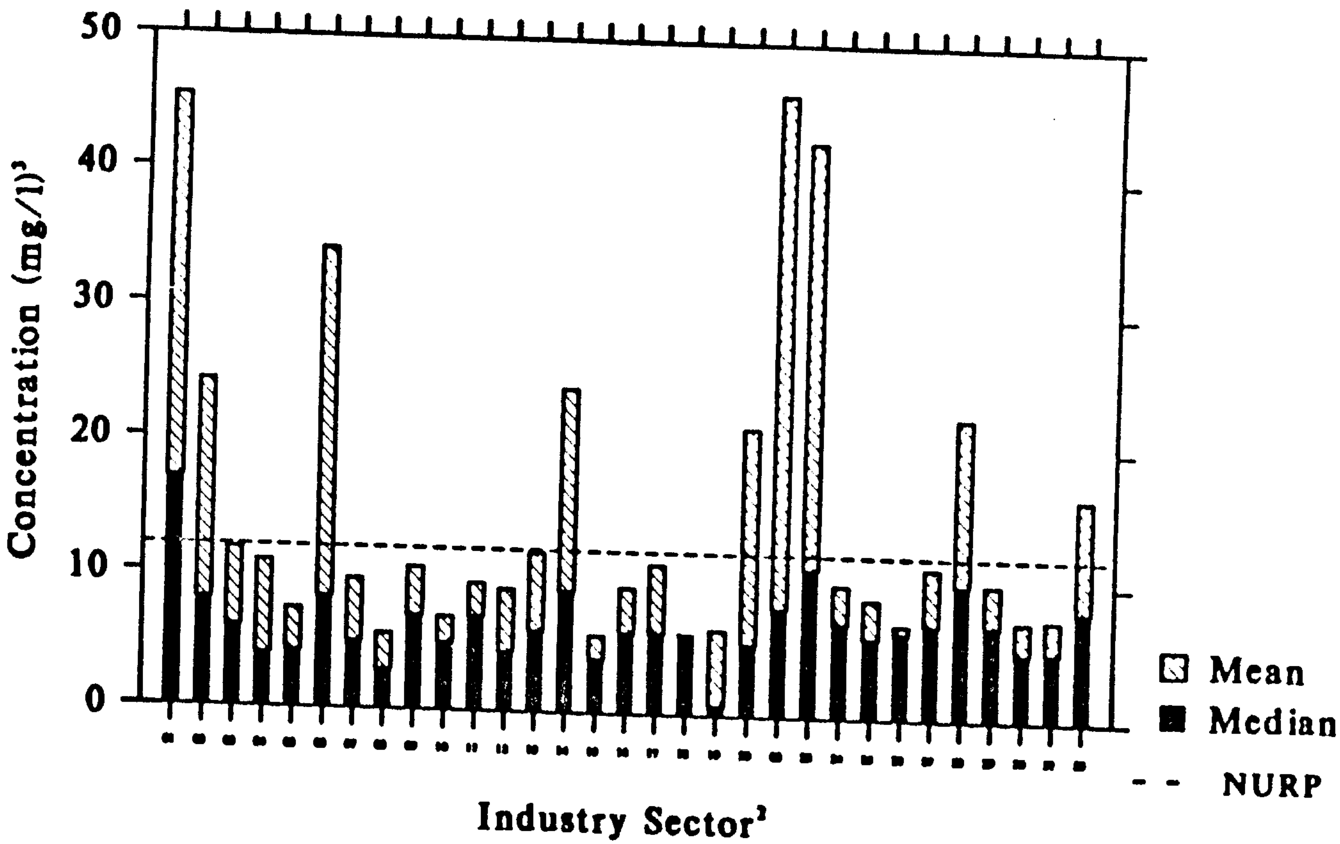


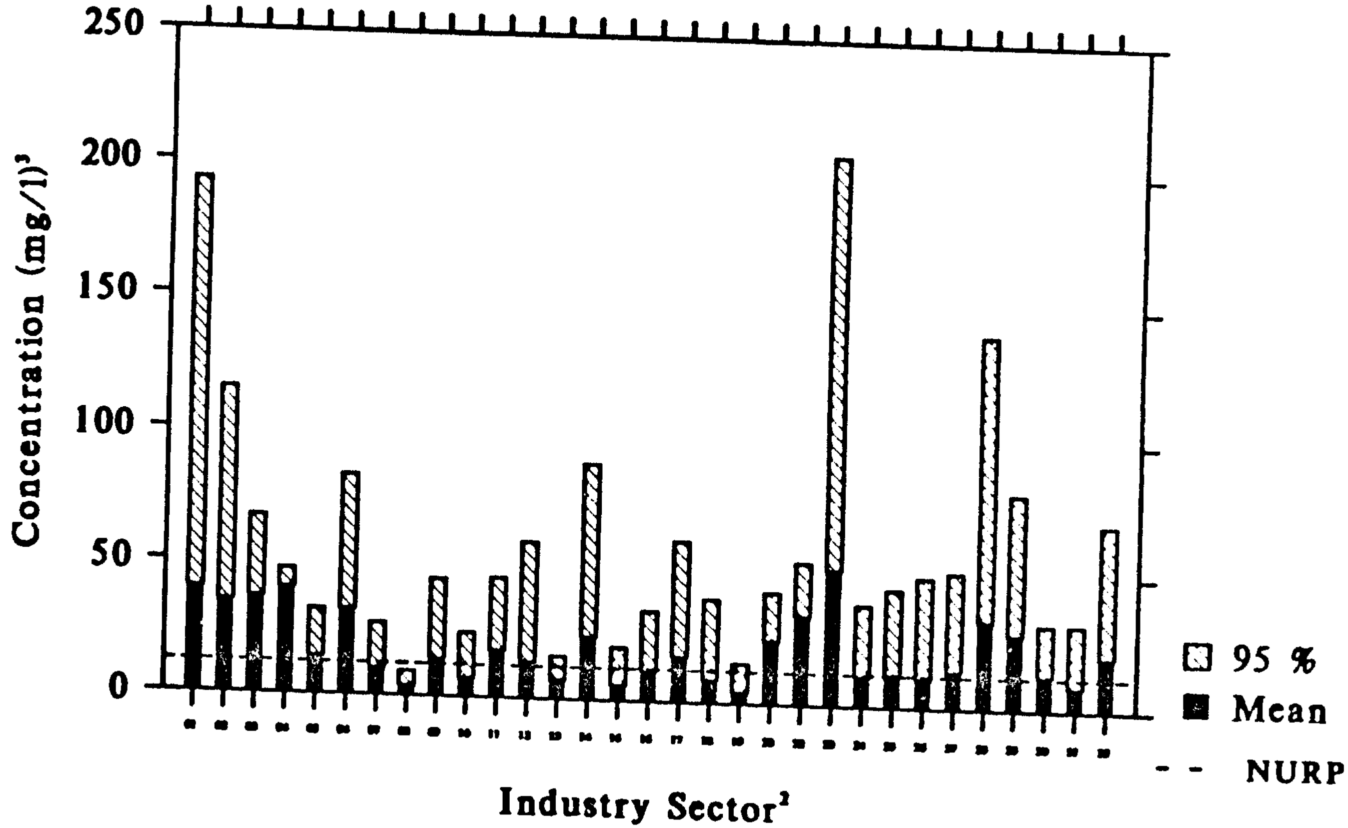
1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-1. BOD$_5$ Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector



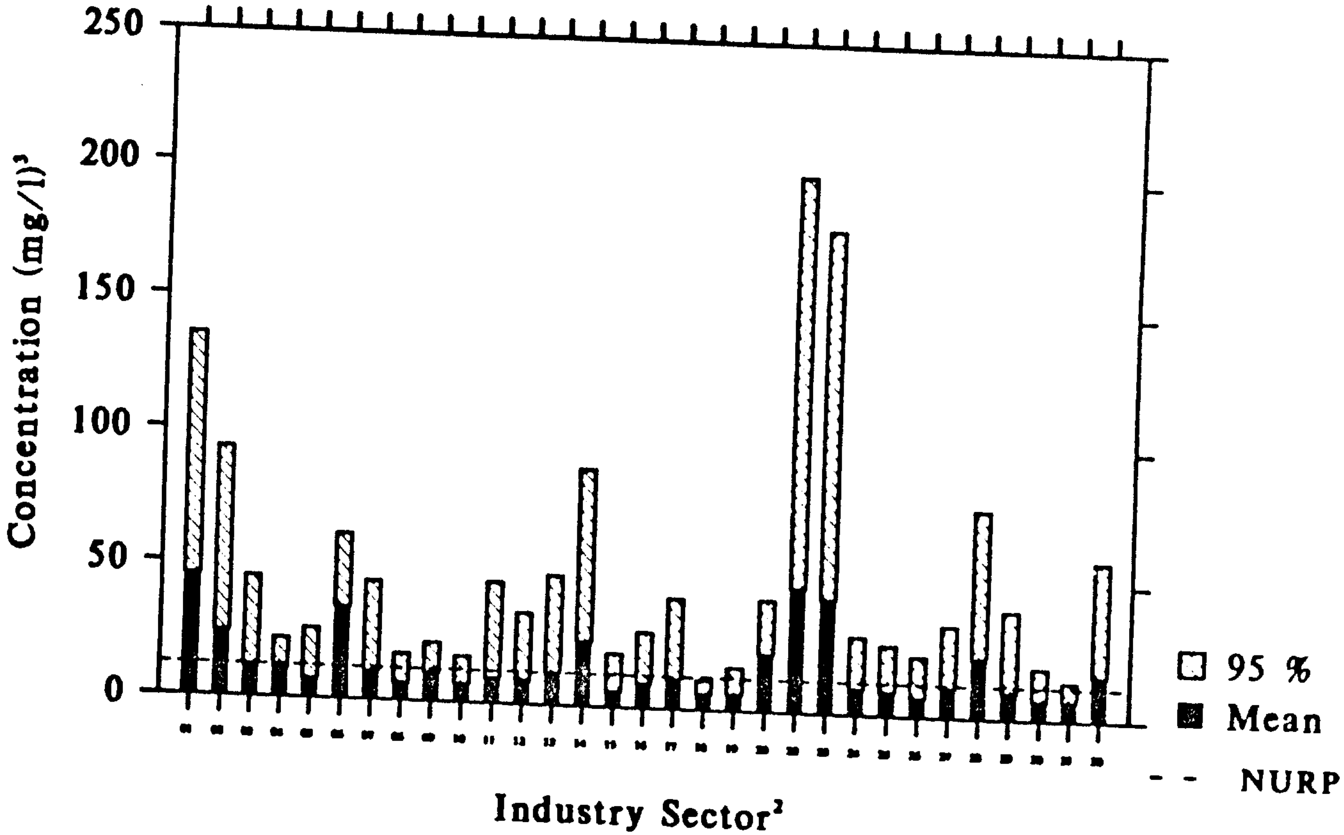
1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-2. BOD_5 Concentration Storm Water Discharges[1] Composite Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-3. BOD_5 Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-4. BOD_5 Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

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Table F-2
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for COD (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	COD				COD			
NURP	Median Urban Site *						82	65	140
USGS	Commercial Site *						NR	NR	NR
01	Lumber & Wood Products	198	297.64	131.00	1500.00	198	242.50	122.50	1080.00
02	Paper & Allied Prod.	121	191.69	61.00	740.00	113	133.90	51.00	530.00
03	Chemicals & Allied Products	168	96.14	57.50	290.00	159	77.24	41.00	320.00
04	Petrol Refining & Related Ind.	64	151.55	48.00	485.00	53	86.93	50.00	375.00
05	Stone, Clay, Glass Products	313	107.47	51.30	317.00	302	77.53	43.15	240.00
06	Primary Metal Ind.	162	221.34	70.50	870.00	151	109.84	60.00	420.00
07	Metal Mining	18	144.54	71.10	630.00	15	195.07	160.00	740.00
08	Coal & Lignite Mining	13	16.45	6.00	83.90	8	26.86	13.50	115.00
09	Oil & Gas Extraction	36	140.12	82.00	352.00	31	115.94	92.00	445.00
10	Nonmetallic Mineral Mining	56	58.79	33.00	247.00	51	66.20	37.00	185.00
11	Hazardous Waste TSDFs	8	117.40	41.00	500.00	9	48.90	34.00	131.00
12	Industrial Landfills & Dumps	51	114.46	31.00	825.00	48	102.02	27.50	548.00
13	Used Motor Vehicle Parts	30	135.00	61.00	250.00	13	66.23	60.00	155.00
14	Scrap & Waste Materials	130	253.33	120.00	1100.00	117	203.71	110.00	700.00
15	Steam Electric Power Plants	76	104.02	32.50	360.00	77	69.47	39.50	280.00
16	Railroad Transport	117	318.10	118.00	781.00	102	189.46	89.00	489.00
17	Transport: Trucks, Freight, etc.	408	135.16	63.95	498.00	374	85.64	48.00	250.00
18	Water Transport	15	130.93	93.00	500.00	14	75.79	50.50	203.00
19	Ship & Boat Building, Repair	51	73.22	53.00	260.00	43	68.80	28.00	240.00
20	Air Transport	95	81.49	44.00	286.00	88	75.63	36.00	182.00
22	Wastewater Treatment	84	133.03	68.65	410.00	84	157.95	61.59	880.00
23	Food, Tobacco Manufact.	296	192.46	77.00	745.00	286	141.65	63.00	463.00
24	Textile & Apparel Manufact.	110	69.19	44.00	228.00	107	48.05	37.00	111.00
25	Furniture & Fixtures	25	95.96	83.00	230.00	24	76.33	72.50	180.00
26	Printing & Publishing	27	57.19	49.00	176.00	27	42.37	39.00	119.00
27	Rubber & Plastic Products	90	100.00	53.00	330.00	87	72.08	43.00	240.00
28	Leather/Products	31	205.45	82.00	900.00	31	91.94	50.00	340.00
29	Fabricated Metal Products, Jewelry	115	118.16	56.00	440.00	114	86.17	47.50	249.00
30	Ind. & Comm. & Transport Equip.	174	66.89	36.00	310.00	169	46.55	29.00	149.20
31	Electronic Equip. & Instruments	65	59.19	46.00	170.00	56	36.32	24.00	200.00

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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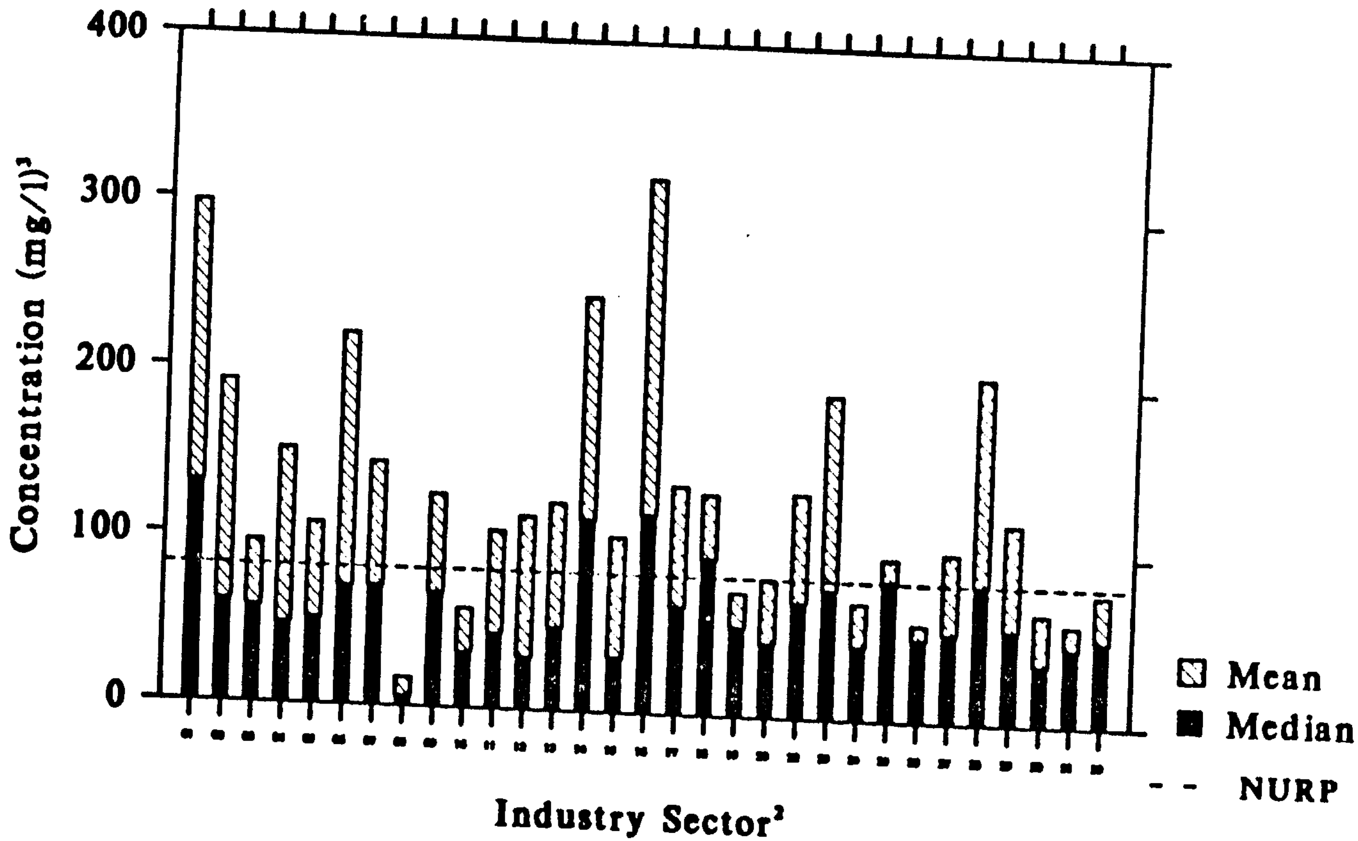
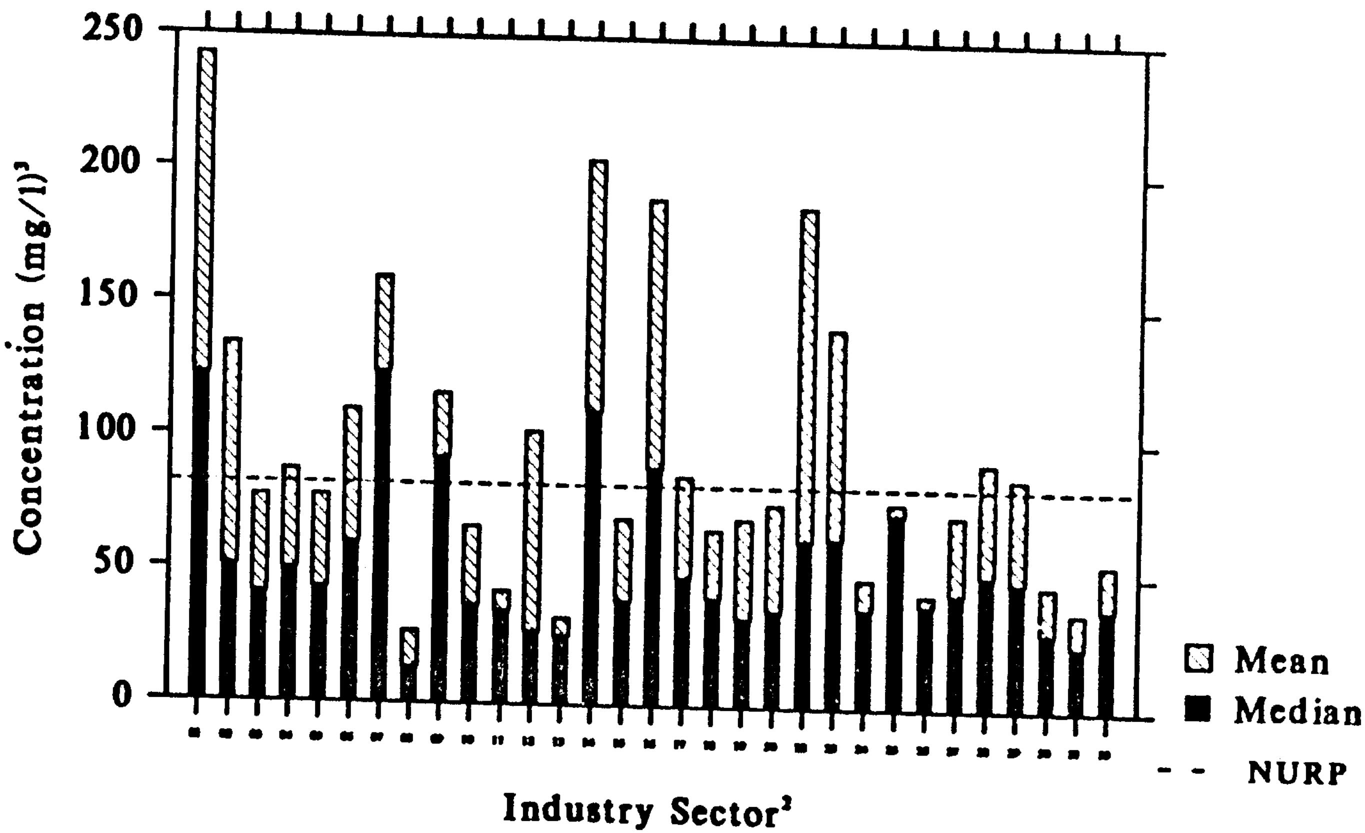


1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-5. COD Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-6. COD Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

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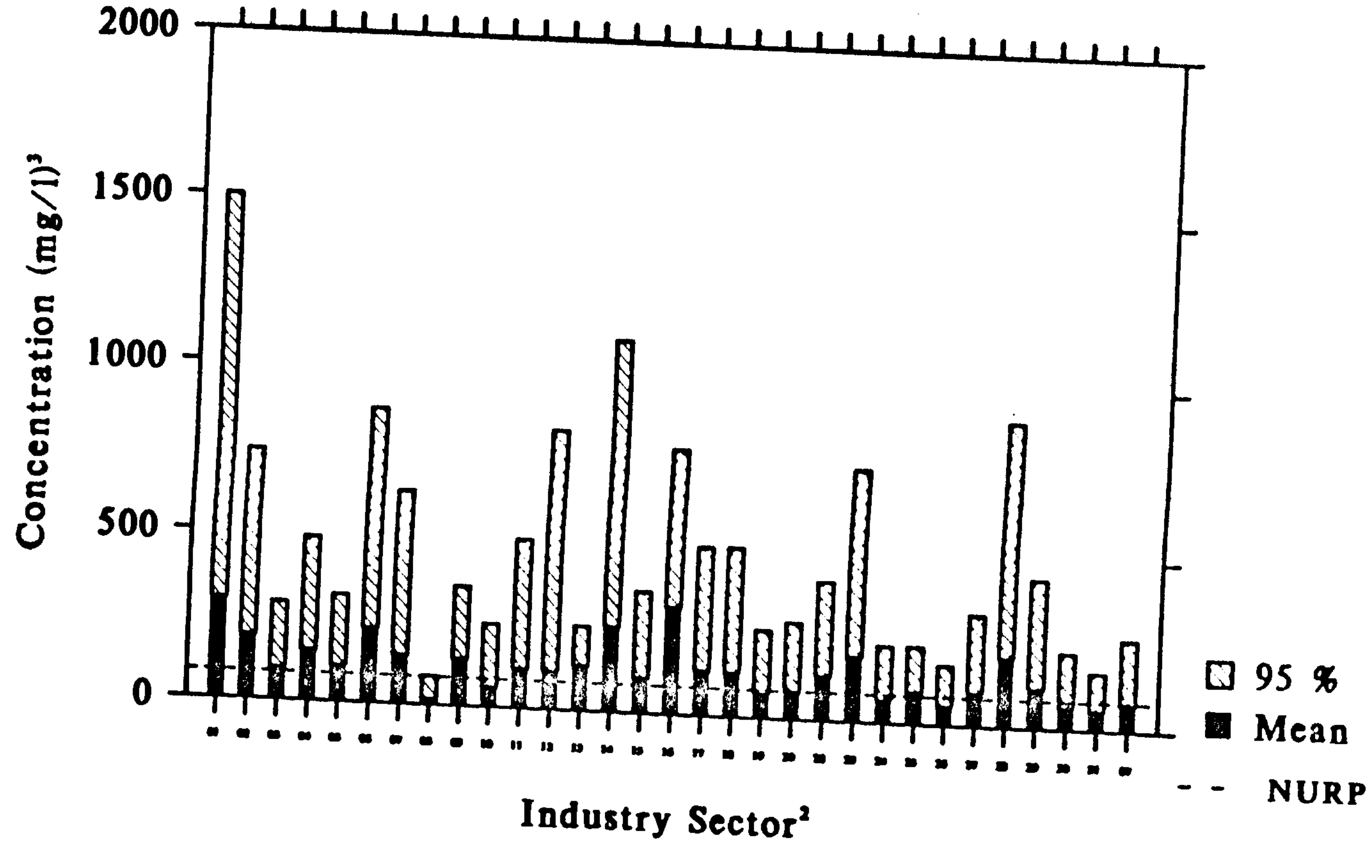
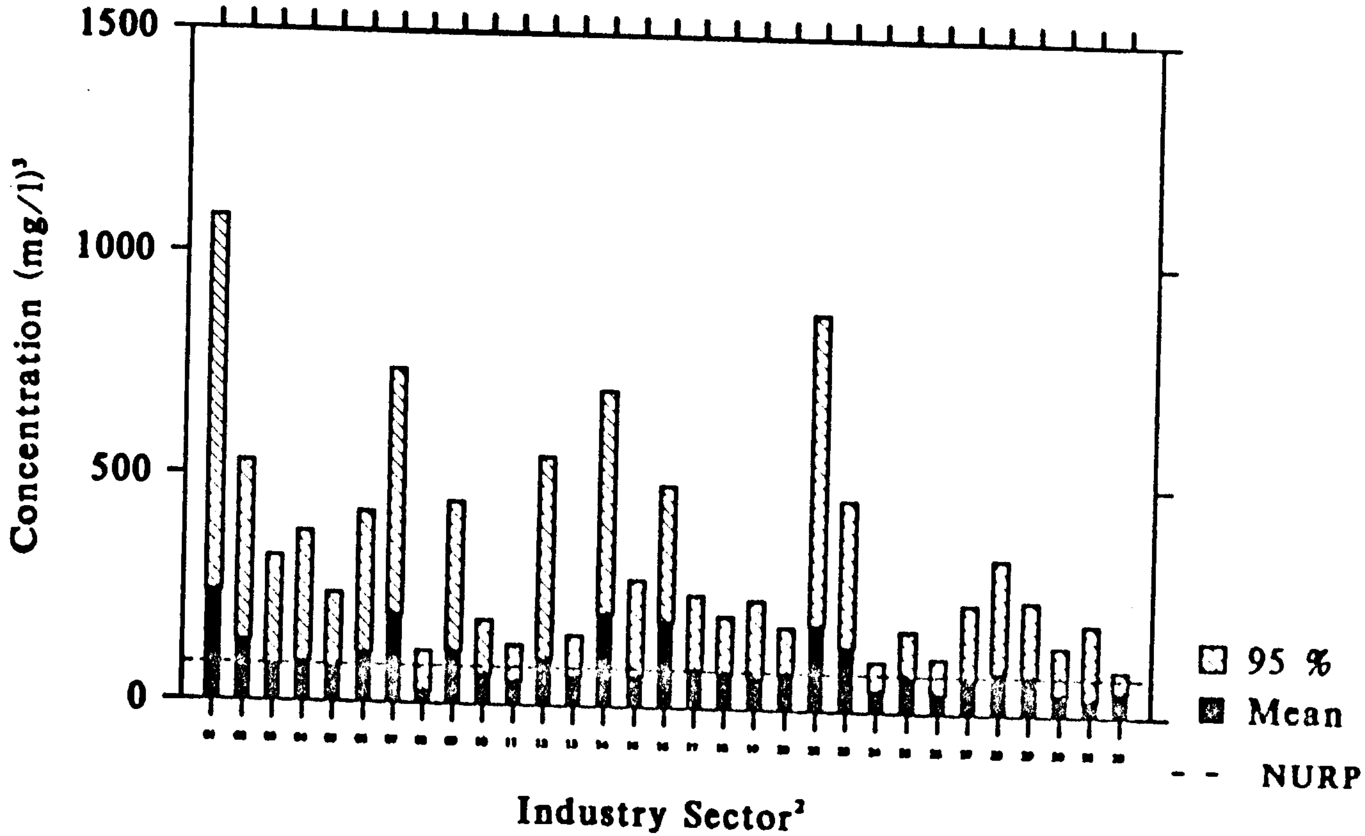


1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-7. COD Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-8. COD Concentration Storm Water Discharges[1]
Composite Samples by Industry Sector

Table F-3
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Data) for $NO_2 + NO^3$ - N (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	NO_2+NO_3-N				NO_2+NO_3-N			
NURP	Median Urban Site *						0.86	0.68	1.75
USGS	Commercial Site *						0.38	0.25	NR
01	Lumber & Wood Products	189	0.95	0.32	2.20	188	0.75	0.34	1.79
02	Paper & Allied Prod.	121	0.95	0.50	3.93	111	0.76	0.47	2.44
03	Chemicals & Allied Products	164	5.83	0.80	16.00	154	4.29	0.82	17.00
04	Petrol Refining & Related Ind.	62	0.97	0.31	2.63	52	0.82	0.30	2.43
05	Stone, Clay, Glass Products	303	1.99	0.60	3.03	292	1.40	0.55	3.03
06	Primary Metal Ind.	148	1.17	0.68	3.60	135	1.38	0.77	4.30
07	Metal Mining	16	1.10	0.75	5.30	13	0.90	0.86	2.10
08	Coal & Lignite Mining	8	0.77	0.40	3.12	6	1.00	0.61	3.12
09	Oil & Gas Extraction	35	0.52	0.15	4.10	31	0.60	0.12	3.30
10	Nonmetallic Mineral Mining	50	0.98	0.65	3.00	45	1.27	0.76	4.17
11	Hazardous Waste TSDFs	9	0.46	0.47	0.79	9	0.39	0.34	0.67
12	Industrial Landfills & Dumps	50	1.57	0.55	4.10	47	1.38	0.50	6.02
13	Used Motor Vehicle Parts	13	1.70	0.83	5.65	30	1.62	1.32	4.87
14	Scrap & Waste Materials	129	1.78	0.62	3.30	117	5.88	0.80	12.00
15	Steam Electric Power Plants	76	5.62	0.36	3.70	77	0.75	0.45	3.20
16	Railroad Transport	118	1.59	0.92	6.07	102	1.41	0.78	4.26
17	Transport: Trucks, Freight, etc.	399	2.99	0.61	9.00	372	1.99	0.52	5.10
18	Water Transport	15	4.23	0.60	54.00	14	0.66	0.65	1.61
19	Ship & Boat Building, Repair	51	0.79	0.72	1.60	45	0.85	0.72	1.80
20	Air Transport	75	1.27	0.41	7.90	65	1.29	0.43	7.70
22	Wastewater Treatment	84	20.86	1.09	136.00	83	20.50	0.87	131.27
23	Food, Tobacco Manufact.	301	1.17	0.56	3.70	289	0.98	0.55	3.60
24	Textile & Apparel Manufact.	110	1.33	0.39	2.50	107	1.14	0.39	1.87
25	Furniture & Fixtures	25	1.73	0.90	6.20	24	1.51	0.68	5.60
26	Printing & Publishing	20	1.27	0.82	4.00	20	1.35	1.05	4.49
27	Rubber & Plastic Products	89	0.86	0.58	2.93	86	1.26	0.67	3.56
28	Leather/Products	31	1.86	1.20	4.70	31	1.88	0.90	9.10
29	Fabricated Metal Products, Jewelry	115	1.48	0.74	7.00	114	1.27	0.77	3.50
30	Ind. & Comm. & Transport Equip.	184	1.20	0.58	5.00	174	1.28	0.45	4.50
31	Electronic Equip. & Instruments	64	0.83	0.51	2.80	57	0.66	0.51	1.43

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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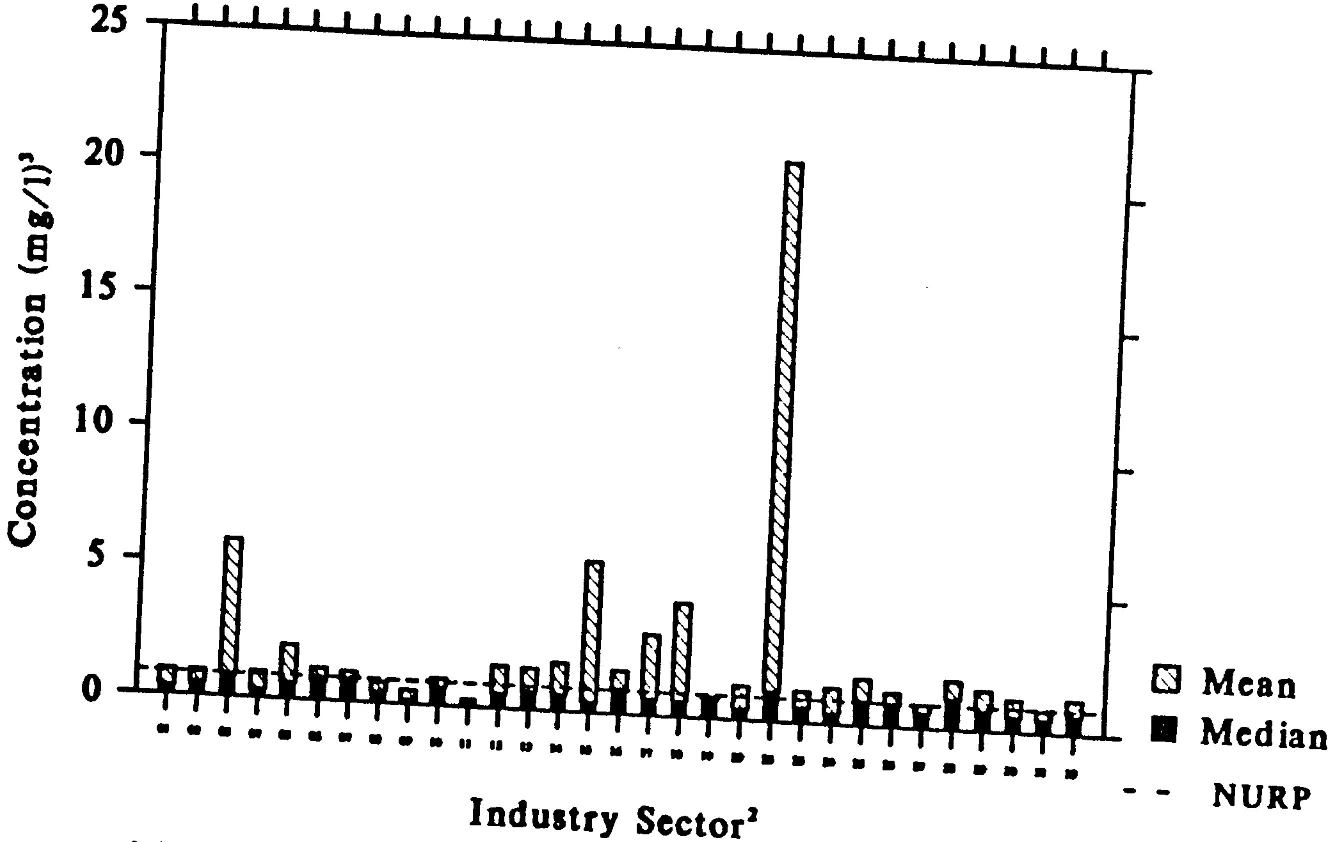
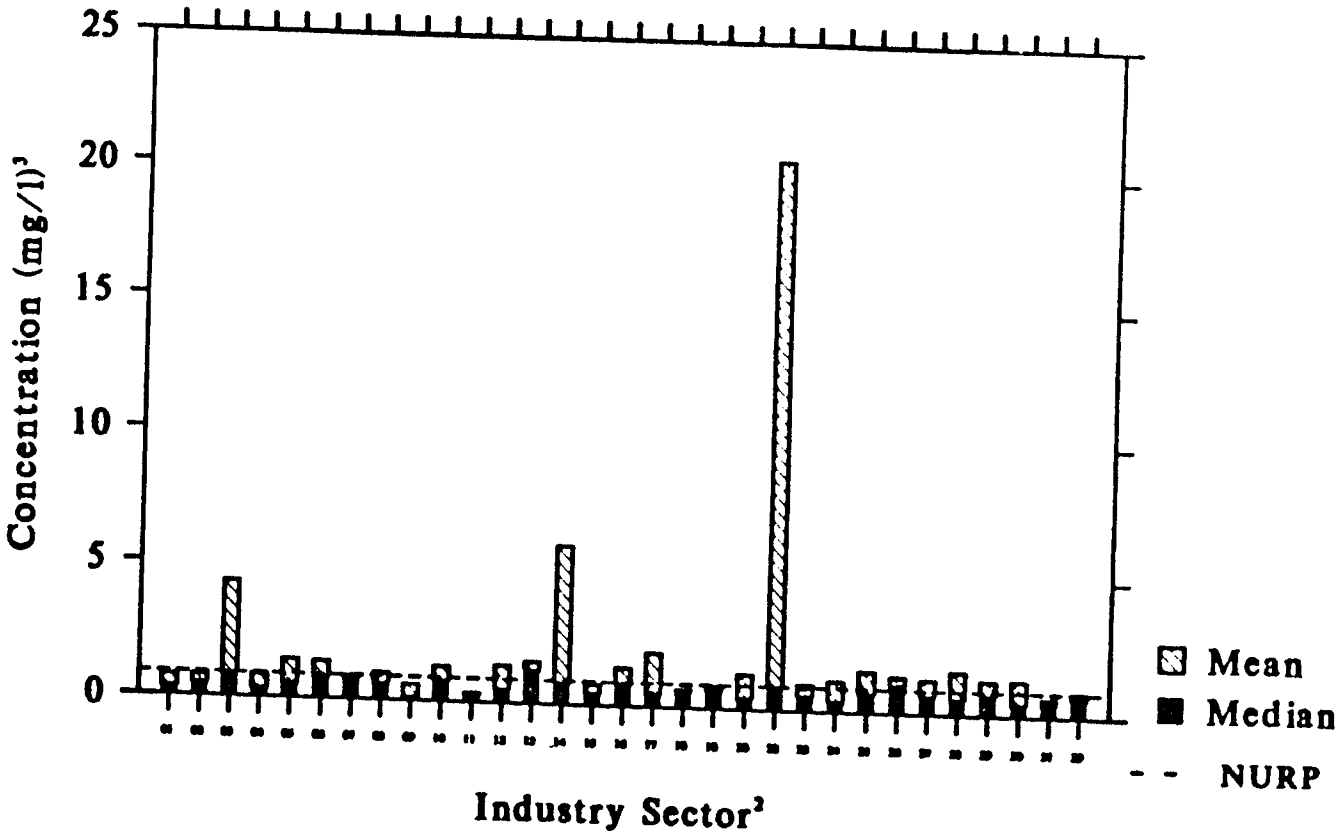


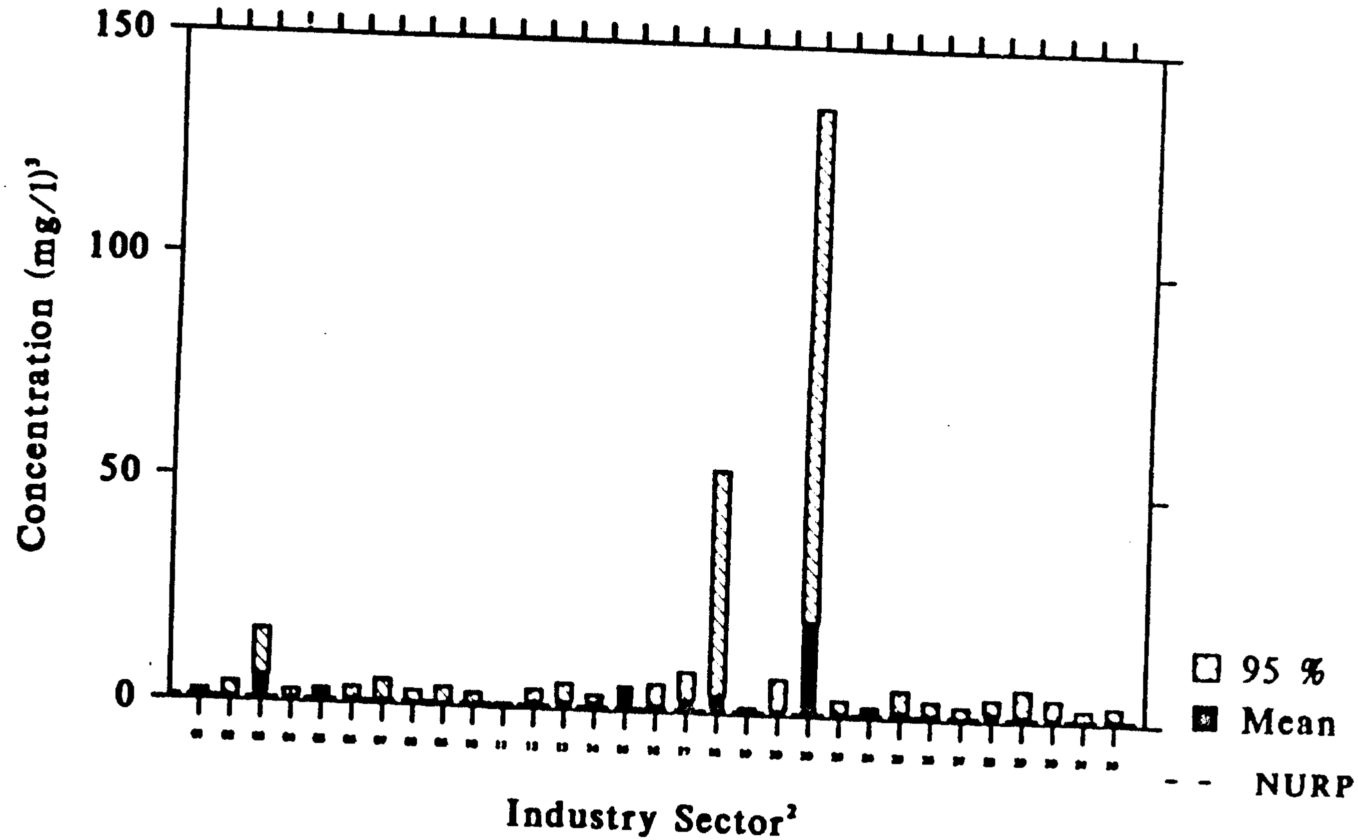
1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-9. Nitrate Plus Nitrite Nitrogen Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-10. Nitrate Plus Nitrite Nitrogen Concentration Storm Water Discharges[1] Composite Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-11. Nitrate Plus Nitrite Nitrogen Concentration Storm Water Discharges[1] Grab Samples by Industry Sector

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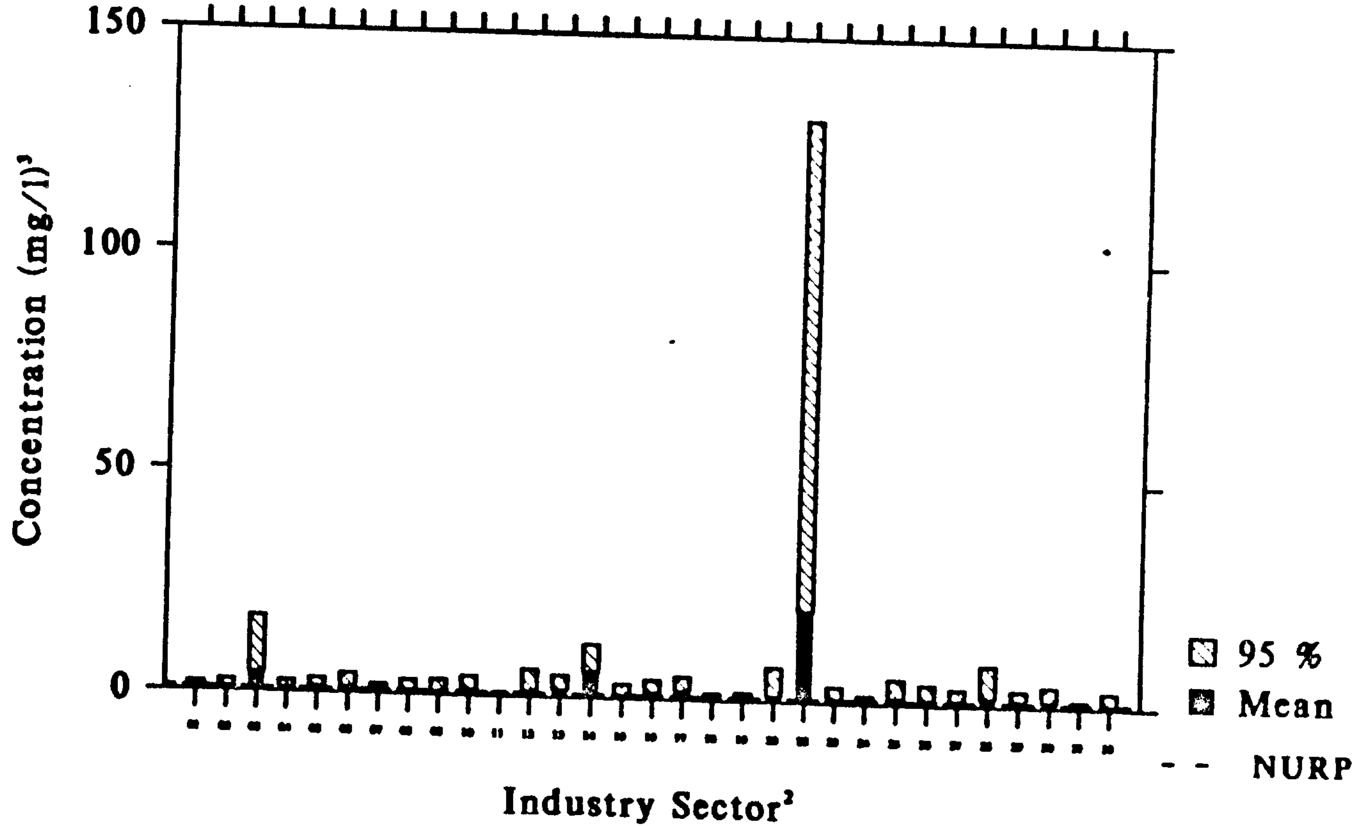

1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-12. Nitrate Plus Nitrite Nitrogen Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

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Table F-4
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for TKN (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	TKN				TKN			
NURP	Median Urban Site *						1.90	1.50	3.30
USGS	Commercial Site *						NR	NR	NR
01	Lumber & Wood Products	188	2.57	1.62	9.26	188	2.32	1.50	7.50
02	Paper & Allied Prod.	121	3.83	1.76	10.20	112	3.17	1.77	10.10
03	Chemicals & Allied Products	171	15.50	1.90	27.00	159	18.30	1.70	23.70
04	Petrol Refining & Related Ind.	63	2.13	1.13	7.16	51	1.63	0.99	6.28
05	Stone, Clay, Glass Products	304	3.82	1.16	7.00	292	2.37	1.00	5.00
06	Primary Metal Ind.	160	3.56	1.98	13.00	149	3.05	1.60	9.70
07	Metal Mining	15	3.27	2.60	9.40	13	3.39	3.20	11.80
08	Coal & Lignite Mining	9	2.56	2.60	5.20	8	2.65	1.46	7.40
09	Oil & Gas Extraction	36	1.39	0.76	5.20	30	1.69	0.93	5.67
10	Nonmetallic Mineral Mining	55	1.81	1.05	8.00	50	2.41	0.84	6.89
11	Hazardous Waste TSDFs	9	1.43	1.30	3.00	9	1.07	0.92	3.92
12	Industrial Landfills & Dumps	51	3.36	1.10	12.00	48	3.03	1.04	14.20
13	Used Motor Vehicle Parts	13	2.17	1.90	4.87	30	2.27	1.77	6.63
14	Scrap & Waste Materials	127	3.44	2.05	11.10	114	3.38	2.20	9.20
15	Steam Electric Power Plants	76	2.41	1.25	8.55	78	1.95	1.00	10.00
16	Railroad Transport	118	3.75	1.50	13.40	102	2.48	1.40	8.80
17	Transport: Trucks, Freight, etc.	405	2.69	1.40	7.70	373	2.04	1.13	6.30
18	Water Transport	15	2.64	1.60	16.00	14	9.41	0.75	118.00
19	Ship & Boat Building, Repair	51	1.19	1.00	2.40	43	2.20	0.97	3.90
20	Air Transport	95	19.79	1.58	27.00	88	16.00	1.40	18.80
22	Wastewater Treatment	79	8.10	1.52	18.00	78	4.74	1.33	11.00
23	Food, Tobacco Manufact.	300	4.95	2.35	18.00	290	4.07	2.00	17.00
24	Textile & Apparel Manufact.	110	2.72	1.70	6.50	107	1.92	1.50	5.40
25	Furniture & Fixtures	25	4.37	1.70	15.00	24	4.40	1.35	13.00
26	Printing & Publishing	27	3.13	1.50	10.00	27	1.57	0.84	4.60
27	Rubber & Plastic Products	89	2.34	1.36	6.00	86	1.63	1.25	4.70
28	Leather/Products	31	7.70	4.30	22.00	31	6.22	3.50	15.00
29	Fabricated Metal Products, Jewelry	115	2.61	1.37	7.20	114	1.78	1.20	5.75
30	Ind. & Comm. & Transport Equip.	170	2.47	1.30	5.80	165	1.81	1.10	4.75
31	Electronic Equip. & Instruments	62	1.46	1.05	4.09	56	1.36	1.01	3.70

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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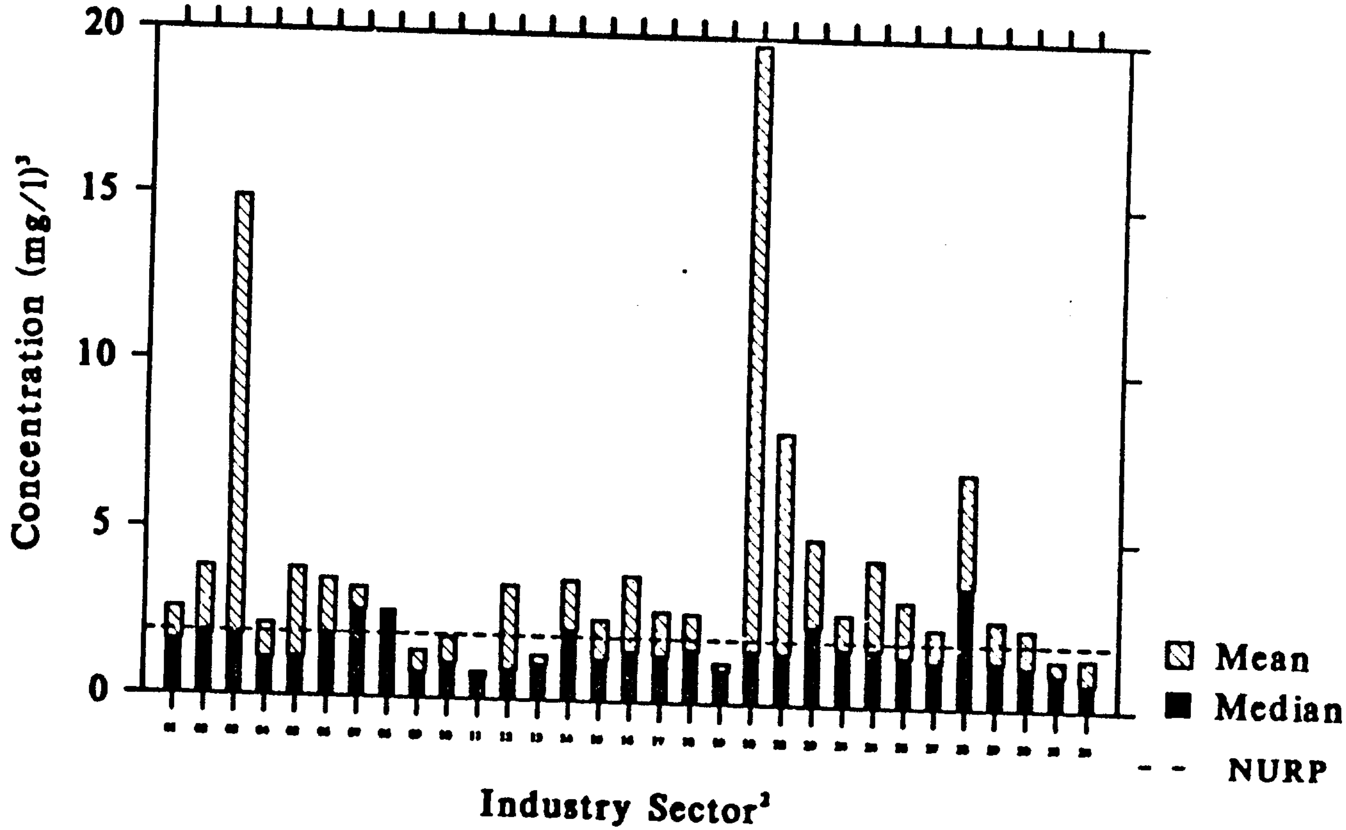
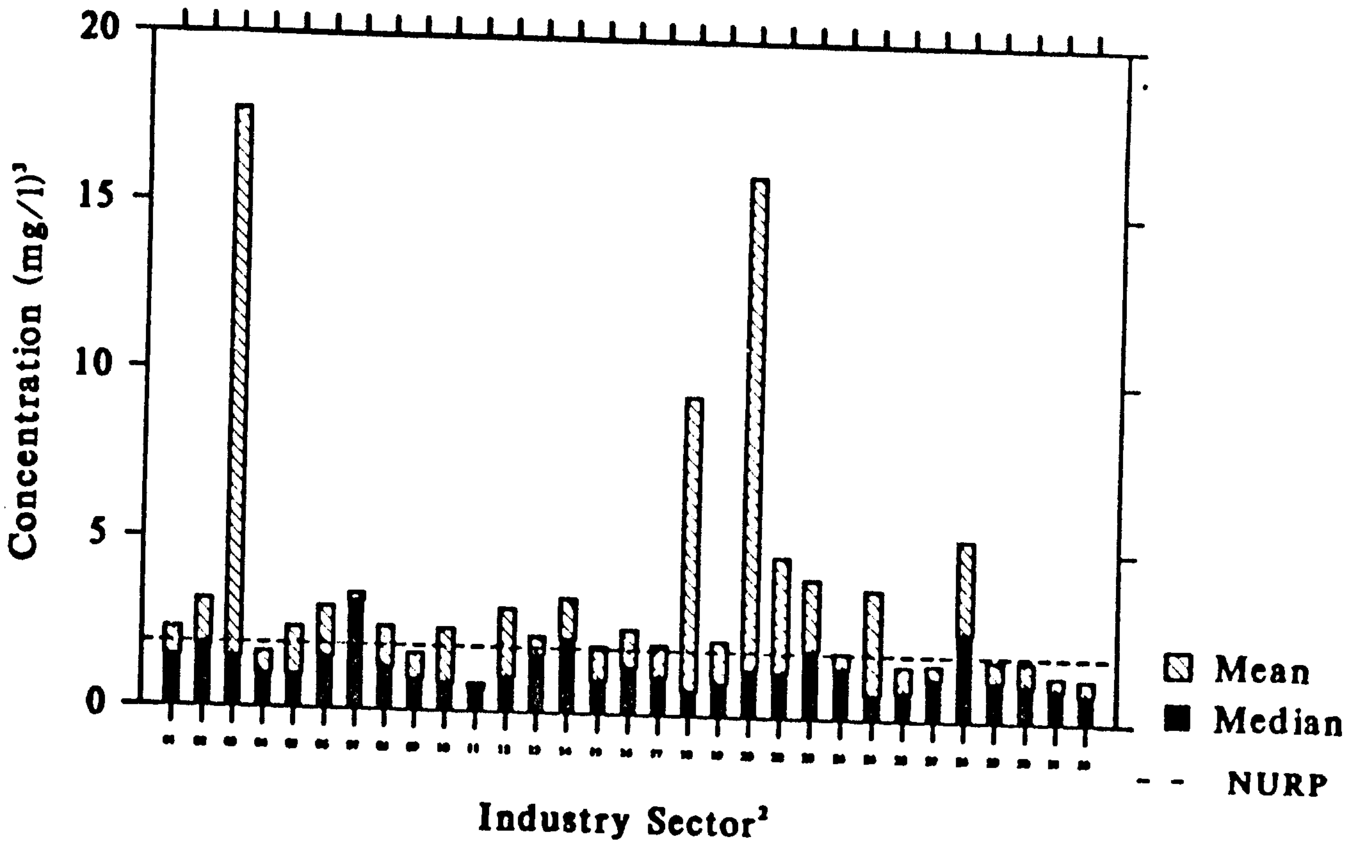


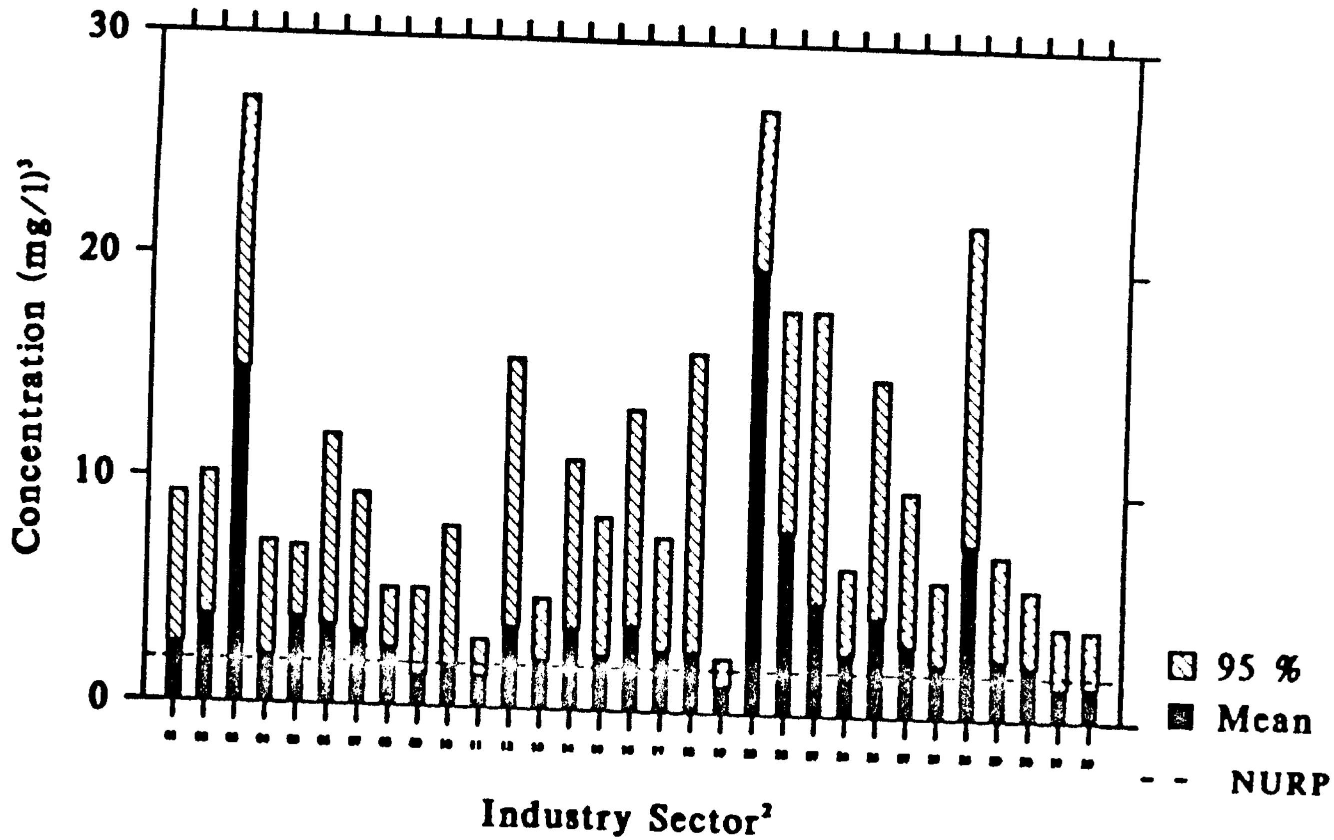
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-13. TKN Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



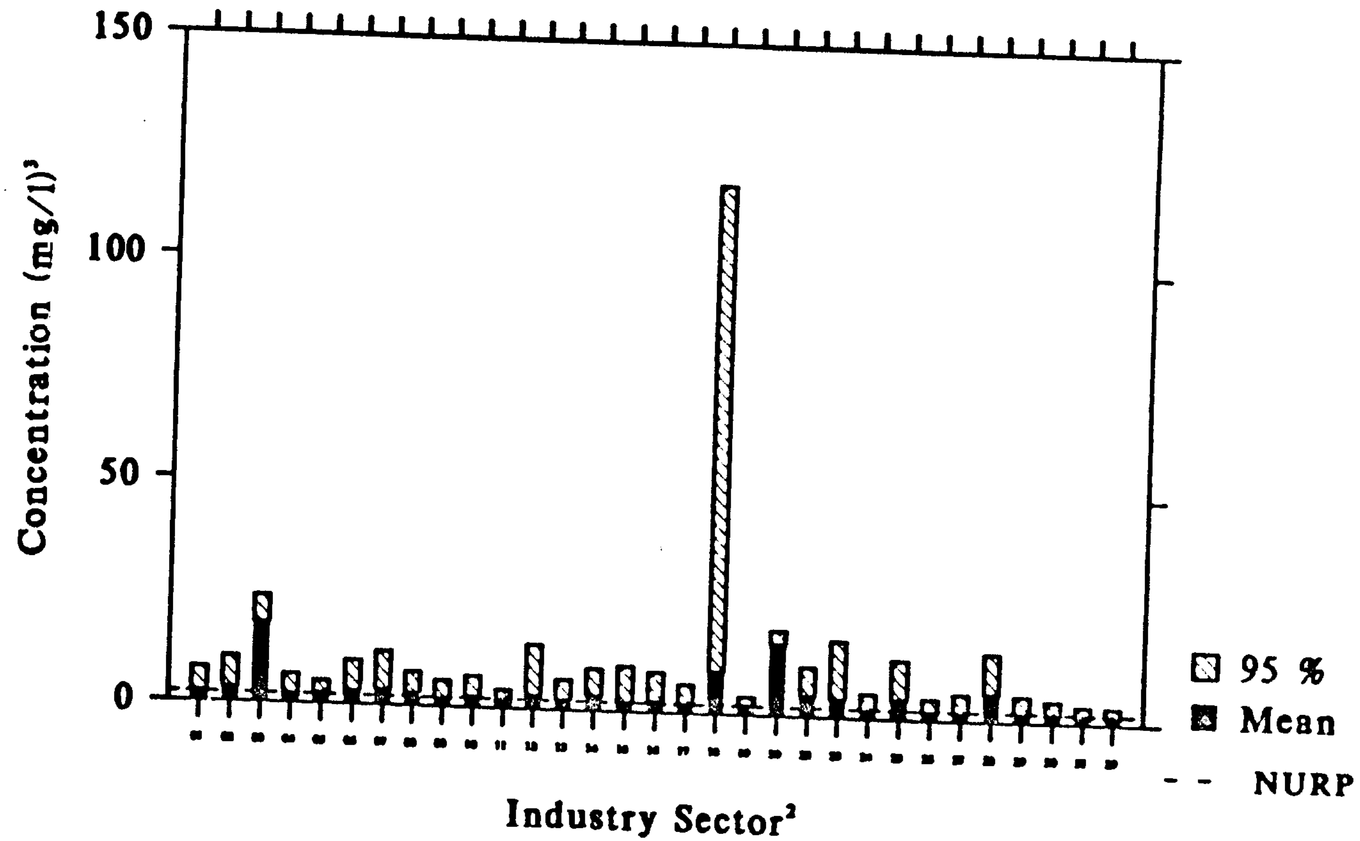
1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-14. TKN Concentration Storm Water Discharges[1] Composite Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-15. TKN Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-16. TKN Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

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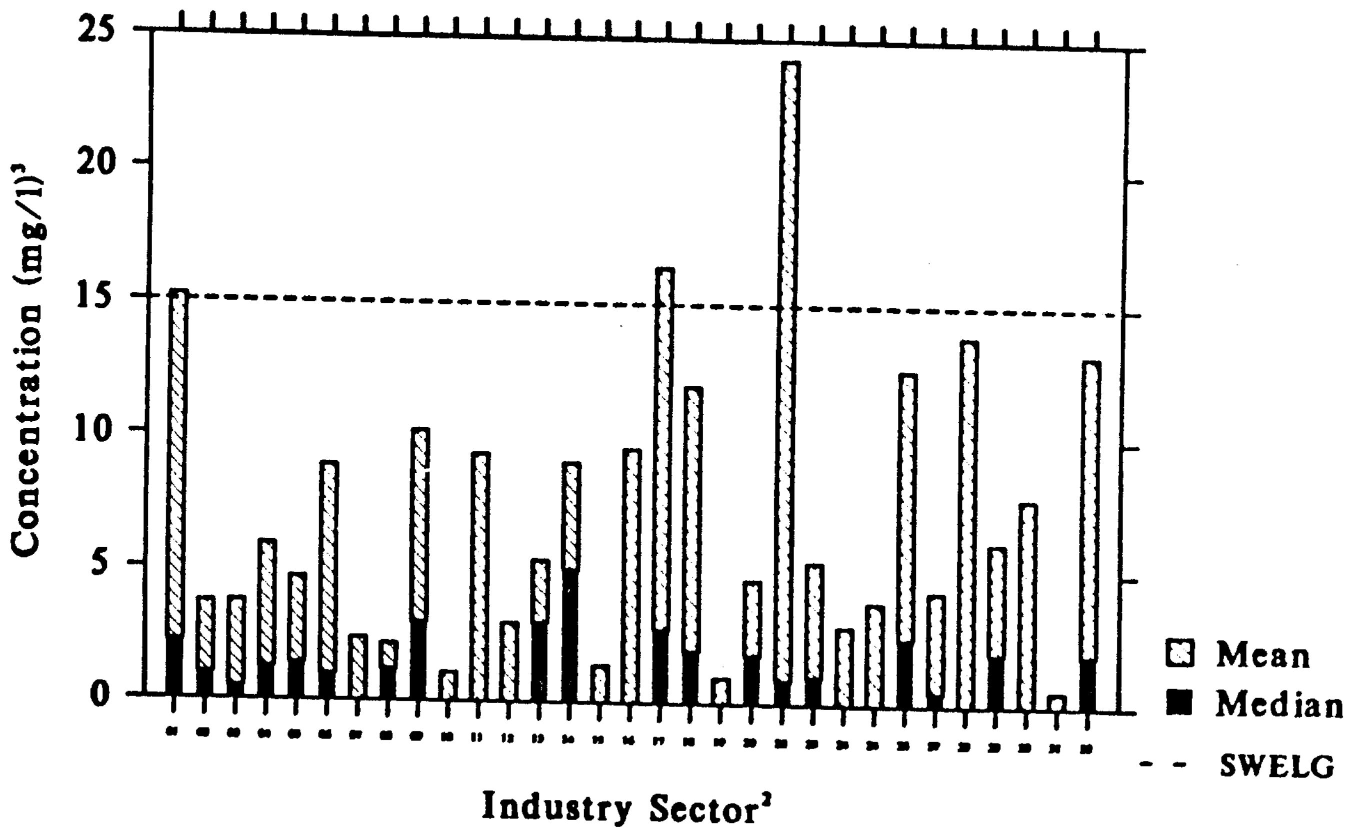
Table F-5
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Data) for Oil and Grease (mg/l)

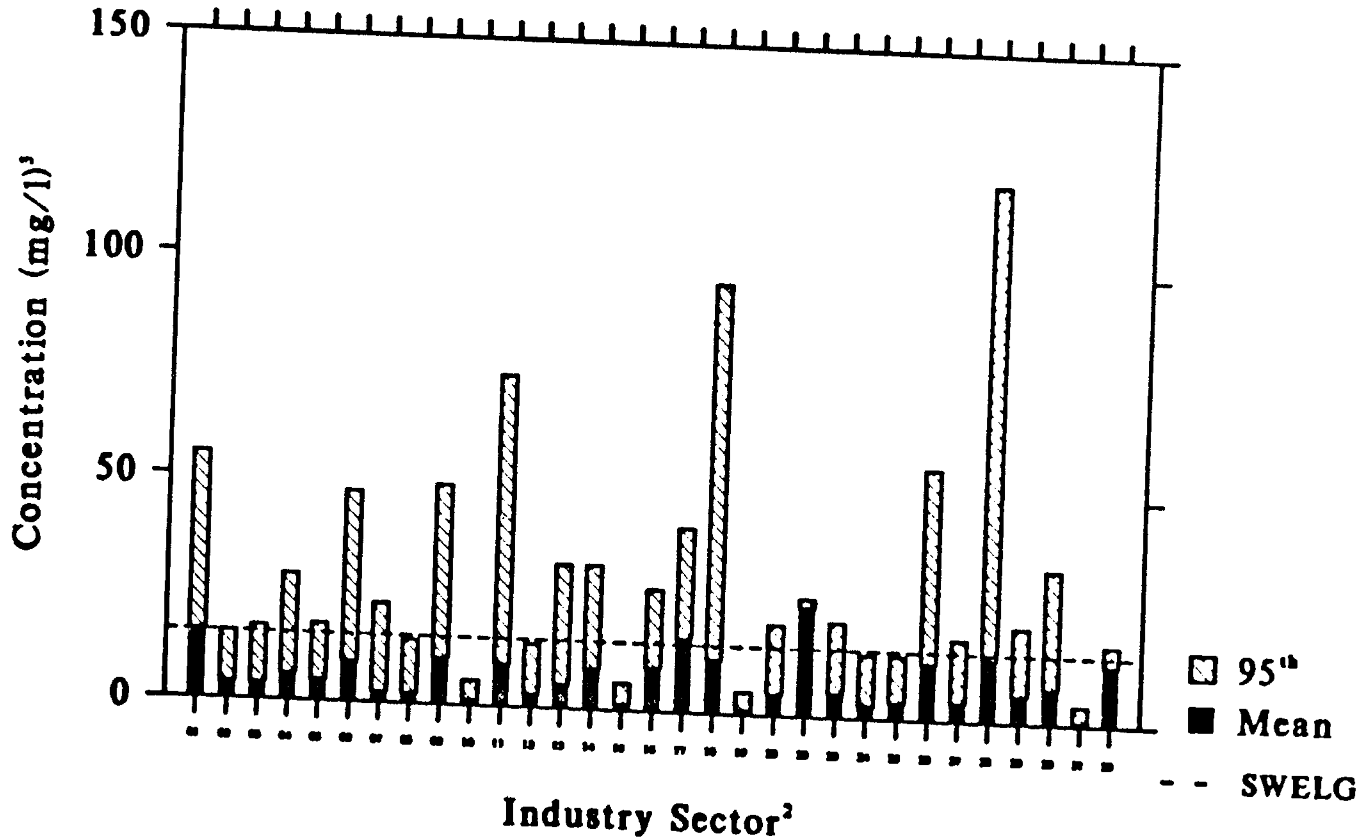
Sector	DESCRIPTION	Grab Samples				Composite Samples			
		No.	Mean	Median	95 %	No.	Mean	Median	95 %
	FOR POLLUTANT	Oil & Grease				Oil & Grease			
NURP	Median Urban Site *						NR	NR	NR
USGS	Commercial Site *						NR	NR	NR
01	Lumber & Wood Products	207	15.21	2.20	55.00				
02	Paper & Allied Prod.	122	3.69	1.00	15.00				
03	Chemicals & Allied Products	169	3.75	0.50	16.30				
04	Petrol Refining & Related Ind.	64	5.89	1.25	28.00				
05	Stone, Clay, Glass Products	315	4.67	1.40	17.10				
06	Primary Metal Ind.	163	8.88	1.00	47.00				
07	Metal Mining	16	2.36	0.00	22.00				
08	Coal & Lignite Mining	19	2.17	1.20	13.90				
09	Oil & Gas Extraction	36	10.18	3.00	49.00				
10	Nonmetallic Mineral Mining	60	1.08	0.00	5.45				
11	Hazardous Waste TSDFs	9	9.33	0.00	74.00				
12	Industrial Landfills & Dumps	53	2.97	0.00	14.00				
13	Used Motor Vehicle Parts	30	5.35	3.00	32.00				
14	Scrap & Waste Materials	135	8.95	5.00	32.00				
15	Steam Electric Power Plants	88	1.38	0.00	6.00				
16	Railroad Transport	118	9.56	0.00	27.00				
17	Transport: Trucks, Freight, etc.	418	16.38	2.80	41.00				
18	Water Transport	15	11.93	2.00	96.00				
19	Ship & Boat Building, Repair	52	0.98	0.00	5.00				
20	Air Transport	98	4.66	1.85	20.00				
22	Wastewater Treatment	89	24.24	0.90	26.00				
23	Food, Tobacco Manufact.	300	5.35	1.05	20.95				
24	Textile & Apparel Manufact.	111	2.94	0.00	14.00				
25	Furniture & Fixtures	25	3.84	0.00	14.00				
26	Printing & Publishing	27	12.58	2.50	56.00				
27	Rubber & Plastic Products	94	4.26	0.50	18.00				
28	Leather/Products	31	13.87	0.00	120.00				
29	Fabricated Metal Products, Jewelry	114	6.11	2.00	21.00				
30	Ind. & Comm. & Transport Equip.	189	7.84	0.00	34.00				
31	Electronic Equip. & Instruments	69	0.58	0.00	4.10				

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-17. Oil & Grease Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector



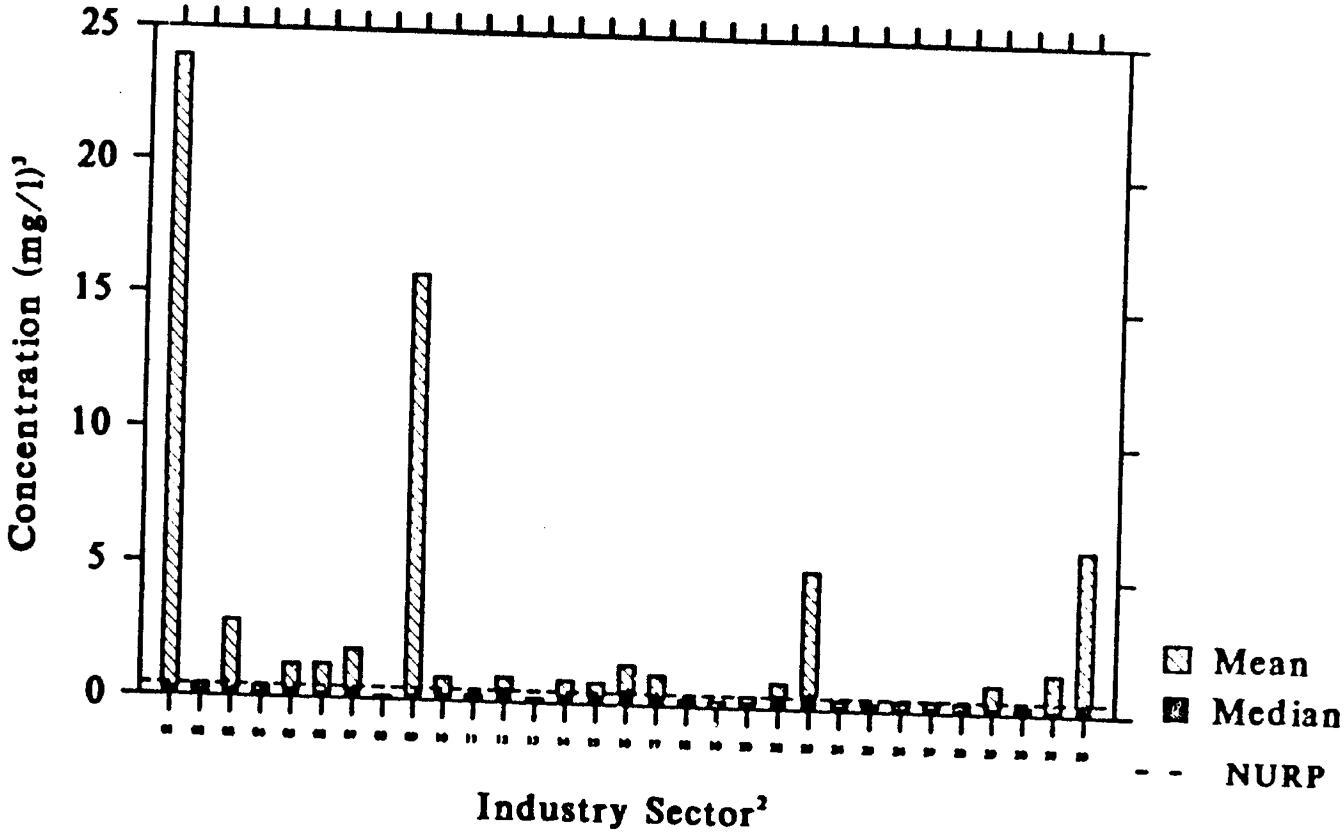
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-18. Oil & Grease Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector

Table F-6
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Data) for Total Phosphorus (mg/l)

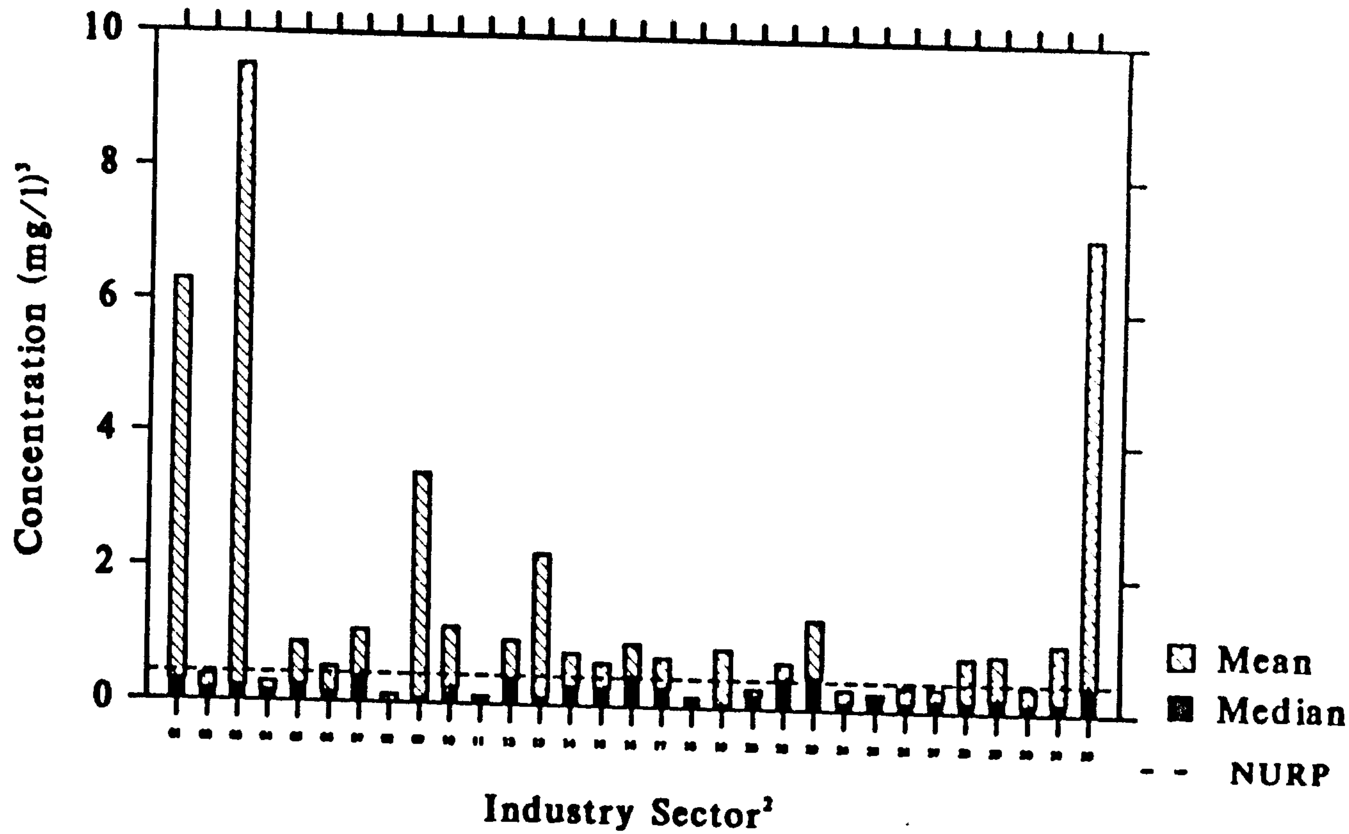
Sector	DESCRIPTION	Grab Samples No.	Mean	Median	95 %	Composite Samples No.	Mean	Median	95 %
	FOR POLLUTANT	P, Total				P, Total			
NURP	Median Urban Site *						0.42	0.33	0.70
USGS	Commercial Site *						0.31	0.18	NR
01	Lumber & Wood Products	198	23.91	0.29	2.66	199	6.29	0.30	1.72
02	Paper & Allied Prod.	120	0.39	0.18	1.06	111	0.36	0.16	0.91
03	Chemicals & Allied Products	170	2.82	0.24	12.10	158	9.51	0.23	16.40
04	Petrol Refining & Related Ind.	63	0.37	0.13	1.65	54	0.28	0.15	1.28
05	Stone, Clay, Glass Products	313	1.21	0.28	4.96	300	0.87	0.25	3.24
06	Primary Metal Ind.	163	1.25	0.17	1.80	149	0.52	0.14	0.96
07	Metal Mining	21	1.83	0.30	11.00	16	1.06	0.38	7.00
08	Coal & Lignite Mining	8	0.12	0.04	0.66	5	0.12	0.00	0.58
09	Oil & Gas Extraction	36	15.82	0.18	144.90	33	3.41	0.07	19.46
10	Nonmetallic Mineral Mining	55	0.84	0.20	4.69	51	1.13	0.24	2.61
11	Hazardous Waste TSDFs	9	0.24	0.07	1.60	9	0.11	0.09	0.32
12	Industrial Landfills & Dumps	50	0.91	0.50	3.35	47	0.95	0.38	4.08
13	Used Motor Vehicle Parts	13	0.19	0.05	1.08	30	3.05	0.26	15.70
14	Scrap & Waste Materials	127	0.81	0.30	2.20	114	0.77	0.29	1.80
15	Steam Electric Power Plants	75	0.79	0.29	3.09	78	0.63	0.27	3.10
16	Railroad Transport	118	1.47	0.54	8.10	102	0.92	0.45	3.05
17	Transport: Trucks, Freight, etc.	405	1.12	0.33	3.90	373	0.73	0.29	2.91
18	Water Transport	15	0.27	0.10	1.20	14	0.15	0.17	0.32
19	Ship & Boat Building, Repair	51	0.21	0.00	0.91	45	0.88	0.00	0.76
20	Air Transport	86	0.44	0.20	1.84	79	0.29	0.20	0.88
22	Wastewater Treatment	86	0.95	0.50	3.17	84	0.68	0.45	1.89
23	Food, Tobacco Manufact.	298	5.13	0.56	9.06	287	1.32	0.48	5.96
24	Textile & Apparel Manufact.	110	0.35	0.14	0.66	107	0.31	0.11	0.60
25	Furniture & Fixtures	25	0.27	0.20	0.89	24	0.26	0.19	0.71
26	Printing & Publishing	27	0.37	0.14	1.50	27	0.35	0.13	1.30
27	Rubber & Plastic Products	89	0.41	0.19	1.61	85	0.34	0.16	0.83
28	Leather/Products	31	0.36	0.16	1.60	31	0.83	0.18	1.30
29	Fabricated Metal Products, Jewelry	113	1.03	0.22	9.80	114	0.84	0.21	4.80
30	Ind. & Comm. & Transport Equip.	176	0.29	0.14	1.00	179	0.40	0.13	1.12
31	Electronic Equip. & Instruments	64	1.50	0.13	1.10	57	1.02	0.16	1.20

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported



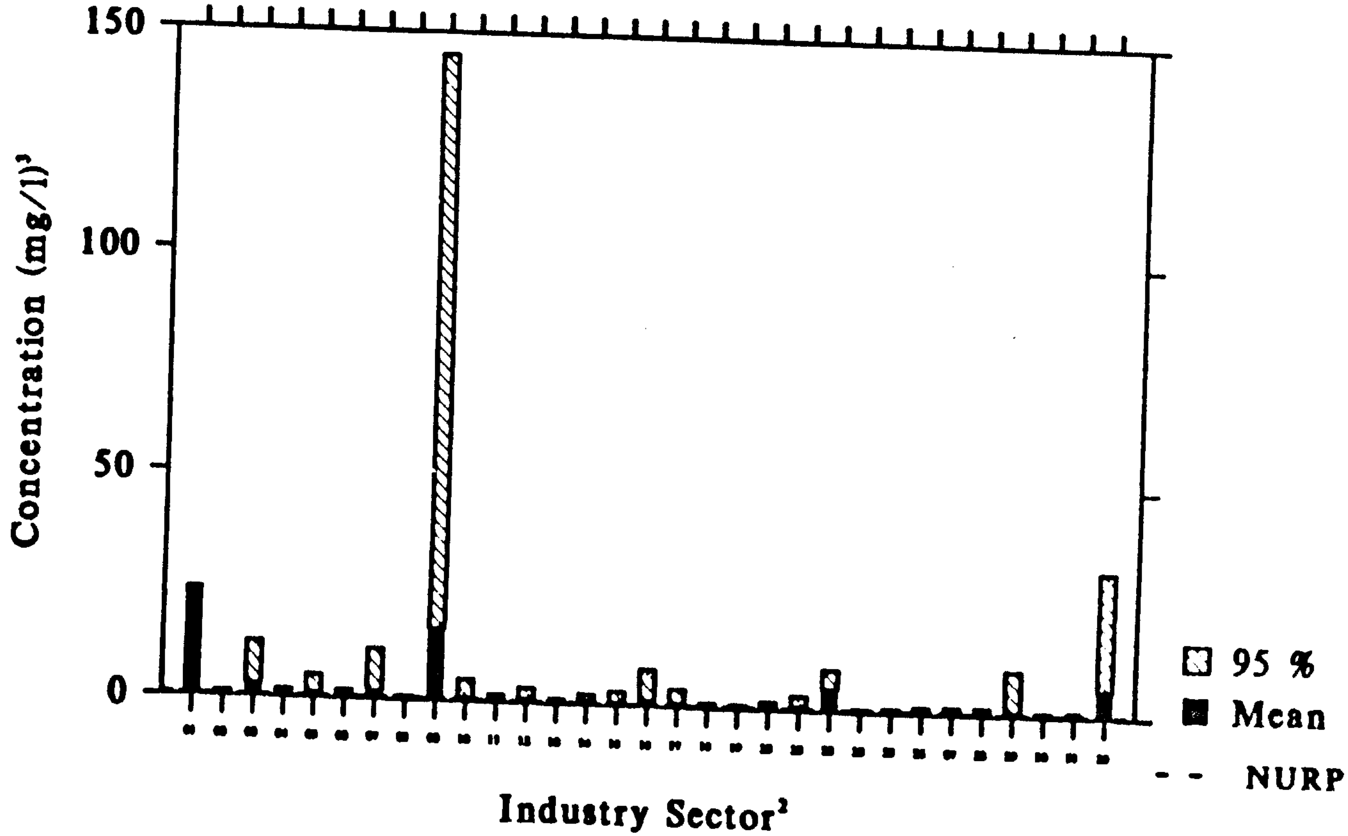
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-19. Phosphorus Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



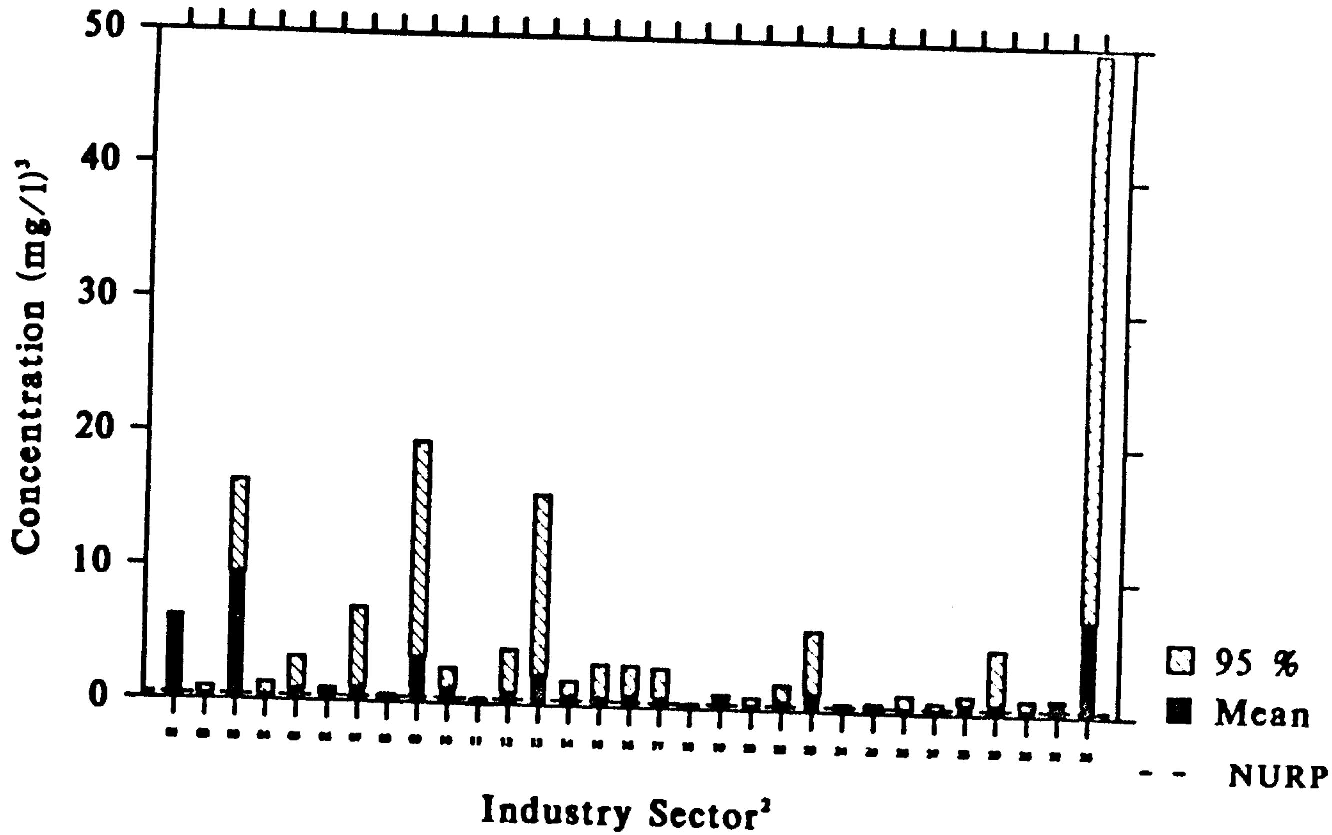
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-20. Phosphorus Concentration Storm Water Discharges[1]
Composite Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-21. Phosphorus Concentration Storm Water Discharges[1]
Grab Samples by Industry Sector



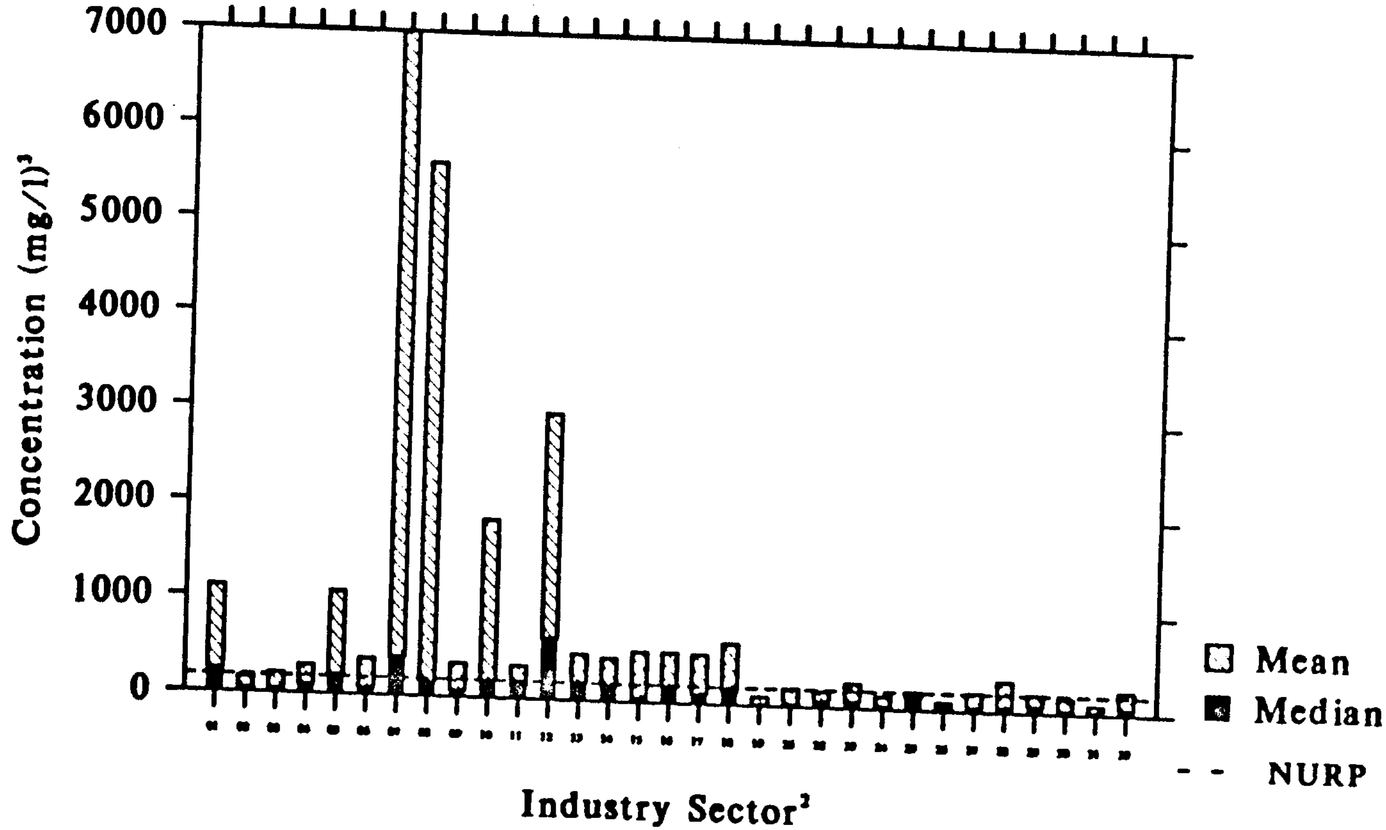
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-22. Phosphorus Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

Table F-7
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for TSS (mg/l)

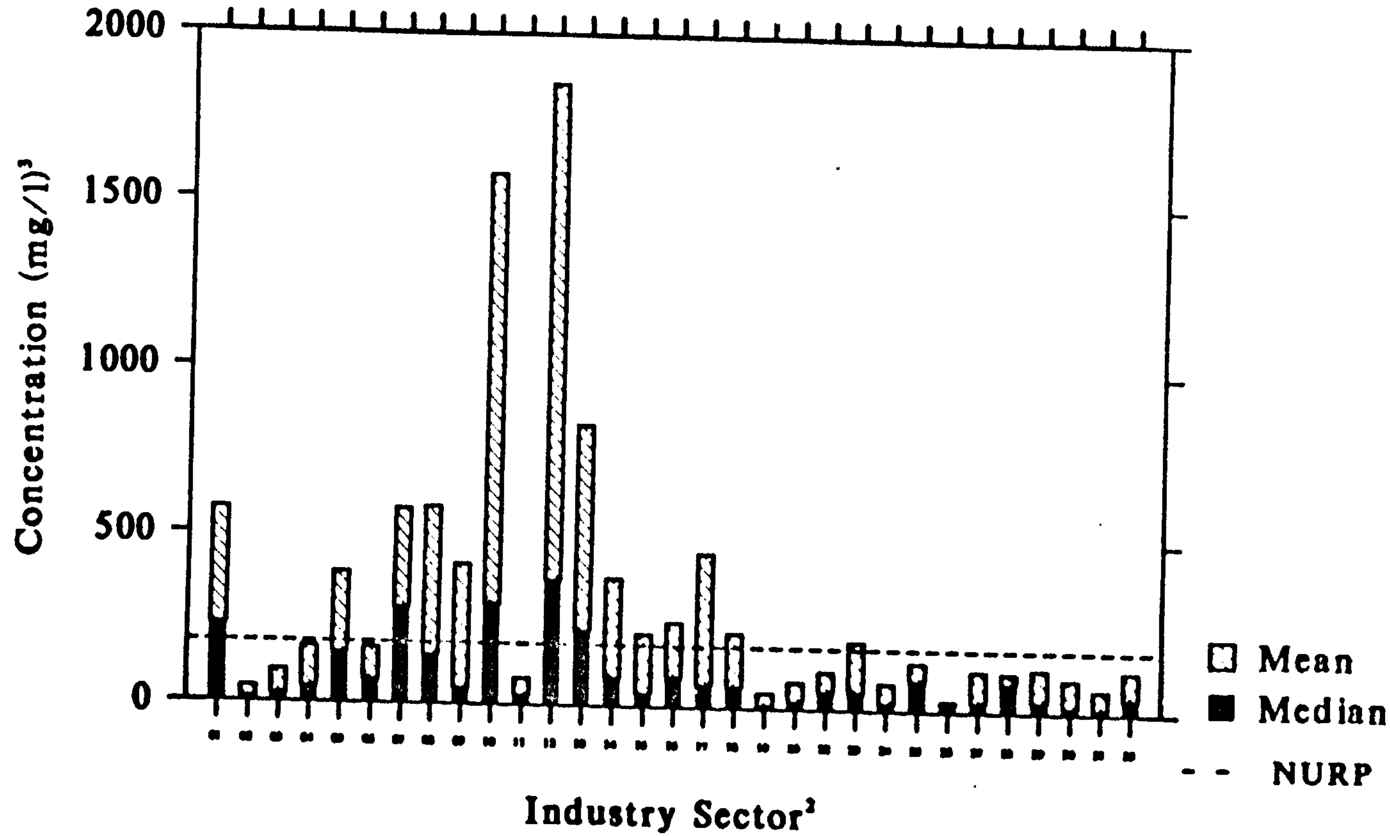
Sector	DESCRIPTION	Grab Samples				Composite Samples			
		No.	Mean	Median	95 %	No.	Mean	Median	95 %
	FOR POLLUTANT	TSS				TSS			
NURP	Median Urban Site *						180	100	300
USGS	Commercial Site *						248	109	NR
01	Lumber & Wood Products	198	1108	242	4800	198	575	230	2288
02	Paper & Allied Prod.	121	153	41	520	111	44	13	198
03	Chemicals & Allied Products	169	200	40	793	159	94	25	453
04	Petrol Refining & Related Ind.	63	287	93	1330	54	165	46	860
05	Stone, Clay, Glass Products	311	1067	200	2620	302	386	149	1440
06	Primary Metal Ind.	162	368	72	1700	149	162	69	717
07	Metal Mining	17	6996	403	100000	15	623	330	3050
08	Coal & Lignite Mining	10	5608	150	33420	8	690	251	3880
09	Oil & Gas Extraction	37	353	75	1520	30	413	48	2056
10	Nonmetallic Mineral Mining	55	1848	181	11120	51	1576	296	10080
11	Hazardous Waste TSDFs	8	338	128	1100	9	83	32	304
12	Industrial Landfills & Dumps	51	2979	633	19370	47	1850	370	9140
13	Used Motor Vehicle Parts	13	474	183	2300	30	839	226	5100
14	Scrap & Waste Materials	130	437	148	2096	116	376	85	1700
15	Steam Electric Power Plants	76	516	44	1200	77	212	40	810
16	Railroad Transport	118	517	172	2800	102	249	90	917
17	Transport: Trucks, Freight, etc.	406	503	104	1890	375	454	67	1100
18	Water Transport	15	634	135	4330	14	224	68	944
19	Ship & Boat Building, Repair	51	92	17	505	45	2	8	200
20	Air Transport	96	185	29	1080	87	80	22	258
22	Wastewater Treatment	90	160	68	575	88	114	56	414
23	Food, Tobacco Manufact.	298	252	73	1320	286	200	54	900
24	Textile & Apparel Manufact.	110	126	36	410	107	80	22	380
25	Furniture & Fixtures	25	188	130	440	24	143	91	550
26	Printing & Publishing	27	92	30	433	27	31	28	82
27	Rubber & Plastic Products	90	189	44	893	87	119	30	476
28	Leather/Products	31	310	49	1300	31	115	86	460
29	Fabricated Metal Products, Jewelry	115	187	76	758	114	125	32	423
30	Ind. & Comm. & Transport Equip.	173	163	30	576	169	100	17	319
31	Electronic Equip. & Instruments	63	89	29	348	56	67	14	370

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported



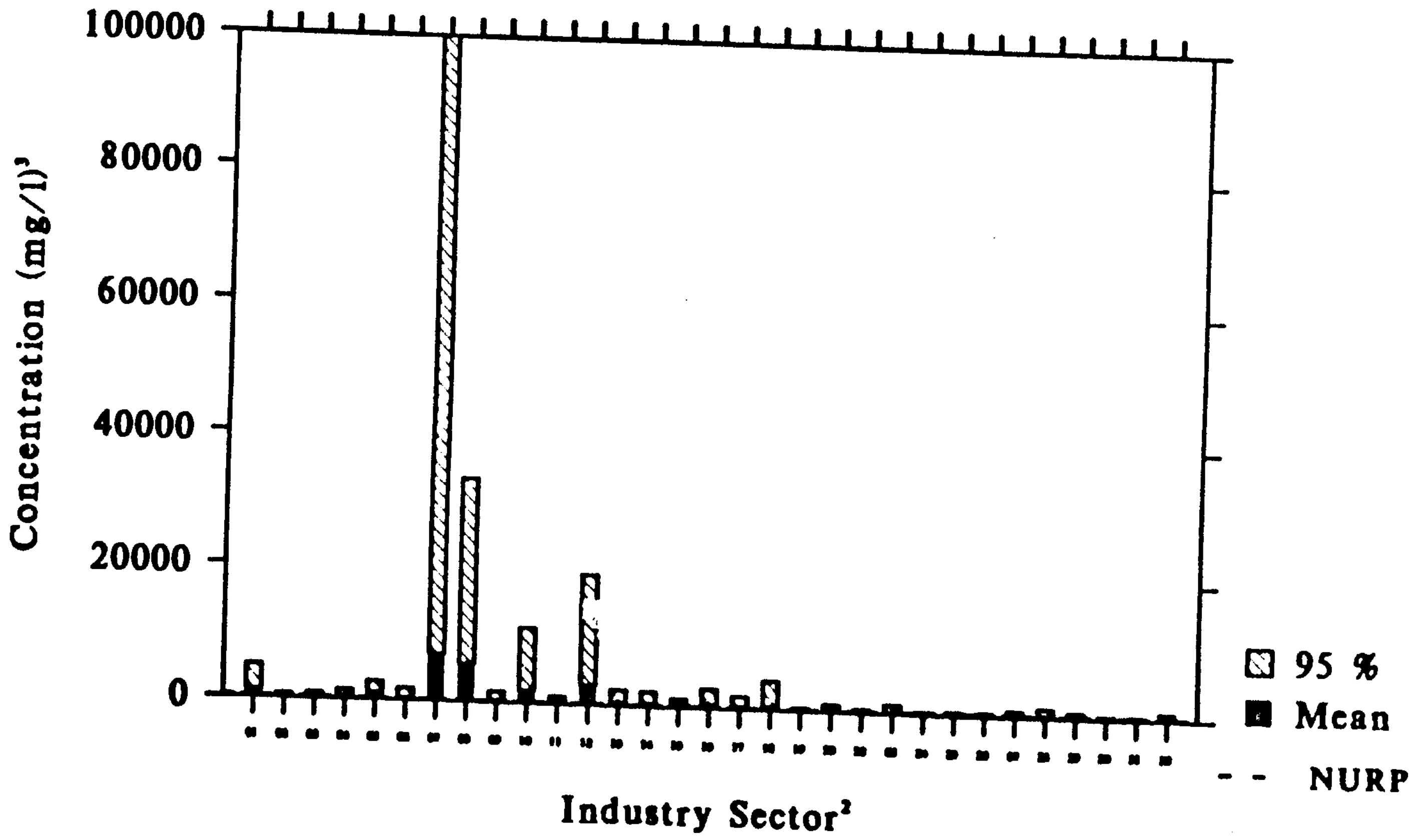
1. Based upon part 2 group application data submitted by Jan 1, 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-23. TSS Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



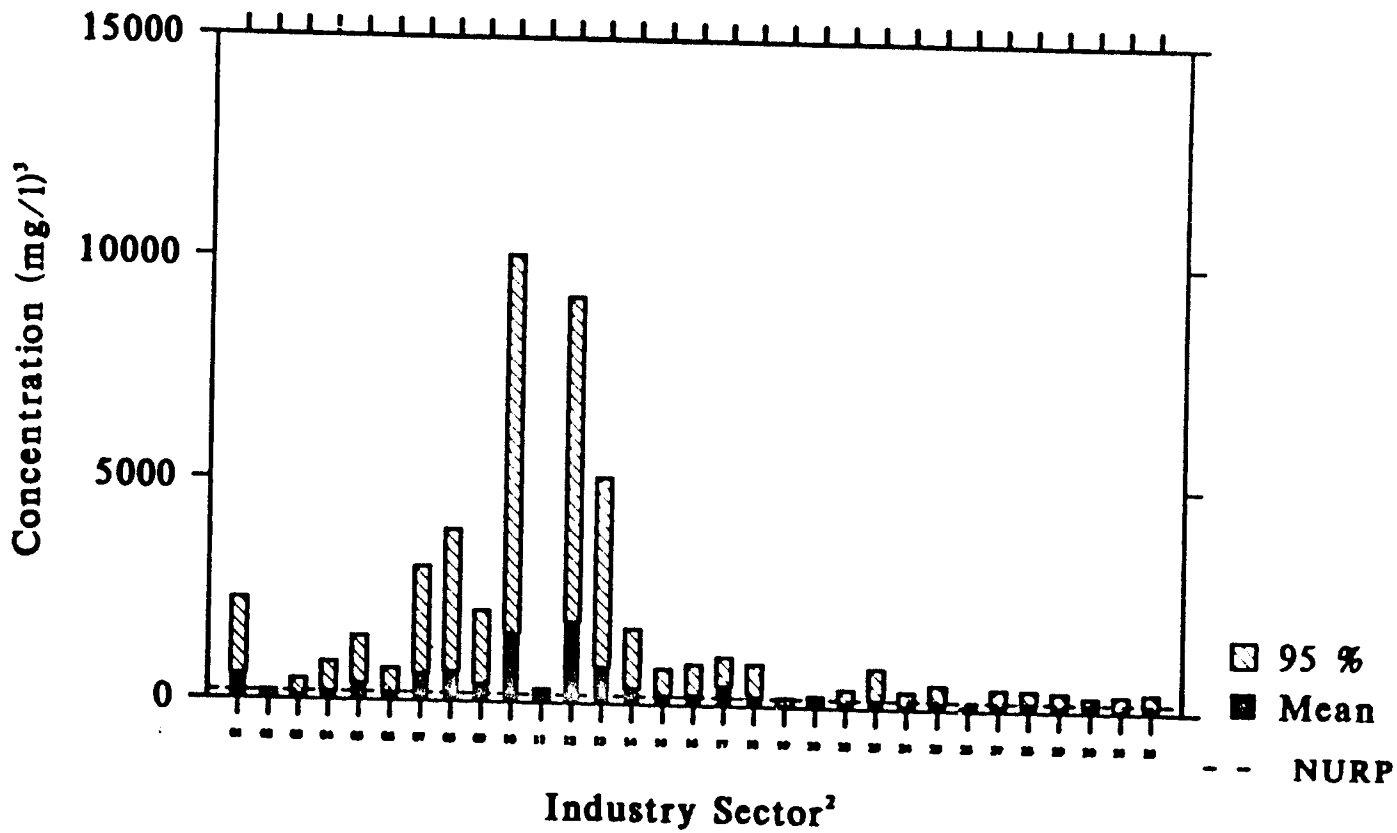
1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-24. TSS Concentration Storm Water Discharges[1] Composite Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-25. TSS Concentration Storm Water Discharges[1] Grab Samples by Industry Sector



1. Based upon part 2 group application data submitted by Jan 1. 1992
2. See Table 1 for List of Industry Sectors by number
3. Values reported as Nondetect were assumed to be 0.0 mg/l

Figure F-26. TSS Concentration Storm Water Discharges[1] Composite Samples by Industry Sector

Table F-8
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for Copper (mg/l)

Sector	DESCRIPTION	Grab Samples				Composite Samples			
		No.	Mean	Median	95 %	No.	Mean	Median	95 %
	FOR POLLUTANT	Copper				Copper			
NURP	Median Urban Site *						0.04	0.04	0.09
USGS	Commercial Site *						0.03	0.02	NR
01	Lumber & Wood Products	32	0.05	0.03	0.16	29	0.04	0.03	0.12
02	Paper & Allied Prod.	2	0.03	0.03	0.05	2	0.03	0.03	0.07
03	Chemicals & Allied Products	51	0.19	0.01	0.21	46	0.12	0.00	0.19
04	Petrol Refining & Related Ind.								
05	Stone, Clay, Glass Products	6	0.13	0.02	0.40	5	0.16	0.04	0.40
06	Primary Metal Ind.	143	3.46	0.10	3.40	131	2.25	0.07	3.10
07	Metal Mining	19	3.88	0.14	46.80	13	0.59	0.09	3.40
08	Coal & Lignite Mining	1	0.00	0.00	0.00	2	0.00	0.00	0.00
09	Oil & Gas Extraction								
10	Nonmetallic Mineral Mining	6	0.05	0.01	0.15	4	0.01	0.01	0.01
11	Hazardous Waste TSDFs								
12	Industrial Landfills & Dumps								
13	Used Motor Vehicle Parts								
14	Scrap & Waste Materials	102	0.77	0.26	3.00	95	0.63	0.22	2.50
15	Steam Electric Power Plants	70	0.08	0.00	0.21	75	0.03	0.02	0.13
16	Railroad Transport								
17	Transport: Trucks, Freight, etc.	19	0.02	0.01	0.06	20	0.02	0.01	0.08
18	Water Transport								
19	Ship & Boat Building, Repair	5	0.16	0.15	0.32	5	0.08	0.09	0.13
20	Air Transport	2	0.03	0.03	0.04	3	0.01	0.01	0.02
22	Wastewater Treatment	28	0.07	0.01	0.22	27	0.05	0.02	0.11
23	Food, Tobacco Manufact.	17	0.08	0.04	0.27	17	0.05	0.03	0.24
24	Textile & Apparel Manufact.	16	0.03	0.01	0.15	14	0.07	0.01	0.61
25	Furniture & Fixtures	4	0.04	0.04	0.07	4	0.00	0.00	0.02
26	Printing & Publishing	7	0.03	0.03	0.08	6	0.02	0.03	0.04
27	Rubber & Plastic Products	5	0.00	0.00	0.01	5	0.03	0.05	0.05
28	Leather/Products								
29	Fabricated Metal Products, Jewelry	36	0.63	0.03	4.30	33	0.46	0.02	0.64
30	Ind. & Comm. & Transport Equip.	79	0.20	0.01	0.84	74	0.06	0.01	0.36
31	Electronic Equip. & Instruments	54	0.04	0.00	0.11	50	0.01	0.00	0.05

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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Table F-9
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for Lead (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	Lead				Lead			
NURP	Median Urban Site *						0.18	0.14	0.35
USGS	Commercial Site *						0.22	0.07	NR
01	Lumber & Wood Products								
02	Paper & Allied Prod.	2	0.05	0.05	0.09	2	0.03	0.03	0.05
03	Chemicals & Allied Products	47	0.07	0.01	0.17	42	0.02	0.01	0.07
04	Petrol Refining & Related Ind.								
05	Stone, Clay, Glass Products	15	0.24	0.01	3.30	15	0.25	0.01	3.40
06	Primary Metal Ind.	136	0.78	0.02	1.41	123	0.19	0.02	1.00
07	Metal Mining	23	0.89	0.00	1.20	13	6.07	0.05	65.00
08	Coal & Lignite Mining	2	0.02	0.02	0.04	2	0.00	0.00	0.00
09	Oil & Gas Extraction								
10	Nonmetallic Mineral Mining	6	0.00	0.00	0.00	4	0.00	0.00	0.00
11	Hazardous Waste TSDFs								
12	Industrial Landfills & Dumps	9	9.62	0.08	83.70	7	20.64	0.18	143.00
13	Used Motor Vehicle Parts								
14	Scrap & Waste Materials	103	0.85	0.21	4.00	96	0.88	0.22	3.40
15	Steam Electric Power Plants	28	0.02	0.00	0.08	23	0.02	0.01	0.07
16	Railroad Transport								
17	Transport: Trucks, Freight, etc.	32	0.03	0.01	0.11	31	0.01	0.00	0.06
18	Water Transport	4	0.20	0.05	0.70	3	0.10	0.10	0.10
19	Ship & Boat Building, Repair	6	0.75	0.04	4.24	5	11.00	0.06	0.33
20	Air Transport	2	0.02	0.02	0.03	3	0.00	0.00	0.00
22	Wastewater Treatment	27	0.03	0.00	0.15	26	0.01	0.00	0.09
23	Food, Tobacco Manufact.	12	0.01	0.01	0.03	10	0.01	0.01	0.04
24	Textile & Apparel Manufact.	8	0.07	0.02	0.28	7	0.04	0.03	0.11
25	Furniture & Fixtures	3	0.08	0.06	0.16	3	0.01	0.01	0.32
26	Printing & Publishing	1	0.03	0.03	0.03	0			
27	Rubber & Plastic Products	1	0.00	0.00	0.00	1	0.01	0.01	0.01
28	Leather/Products	2	0.02	0.02	0.04	2	0.02	0.02	0.04
29	Fabricated Metal Products, Jewelry	32	0.11	0.00	0.89	30	0.06	0.00	0.22
30	Ind. & Comm. & Transport Equip.	76	0.22	0.00	0.97	75	0.18	0.00	0.94
31	Electronic Equip. & Instruments	60	0.02	0.00	0.08	56	0.01	0.00	0.04

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

Table F-10
Summary of Sampling Data From Phase I Part II Permit Applications (With Comparison to NURP and USGS Studies) for Zinc (mg/l)

Sector	DESCRIPTION	Grab Samples No.	Grab Samples Mean	Grab Samples Median	Grab Samples 95 %	Composite Samples No.	Composite Samples Mean	Composite Samples Median	Composite Samples 95 %
	FOR POLLUTANT	Zinc				Zinc			
NURP	Median Urban Site *						0.20	0.16	0.50
USGS	Commercial Site *						0.31	0.11	NR
01	Lumber & Wood Products	16	0.47	0.37	1.70	15	0.36	0.30	1.20
02	Paper & Allied Prod.	1	0.62	0.62	0.62	1	0.78	0.78	0.78
03	Chemicals & Allied Products	75	2.11	0.24	7.70	70	1.74	0.24	4.20
04	Petrol Refining & Related Ind.								
05	Stone, Clay, Glass Products	8	0.35	0.14	1.17	7	0.39	0.18	1.12
06	Primary Metal Ind.	144	8.85	0.46	11.80	132	6.55	0.43	9.67
07	Metal Mining	14	3.04	0.59	16.30	8	3.87	0.66	20.90
08	Coal & Lignite Mining	2	0.17	0.17	0.30	2	0.06	0.06	0.09
09	Oil & Gas Extraction								
10	Nonmetallic Mineral Mining	5	0.18	0.18	0.34	3	0.29	0.30	0.30
11	Hazardous Waste TSDFs								
12	Industrial Landfills & Dumps								
13	Used Motor Vehicle Parts								
14	Scrap & Waste Materials	97	3.16	1.40	12.00	90	3.20	1.40	10.00
15	Steam Electric Power Plants	35	0.32	0.05	0.66	39	0.27	0.06	0.92
16	Railroad Transport	1	0.14	0.14	0.14	1	0.28	0.28	0.28
17	Transport: Trucks, Freight, etc.	30	0.23	0.13	1.10	28	1.34	0.11	0.66
18	Water Transport	4	0.68	0.22	2.20	3	0.42	0.21	0.87
19	Ship & Boat Building, Repair	2	0.31	0.31	0.36	1	39.00	0.33	0.33
20	Air Transport	8	0.14	0.08	0.58	3	0.35	0.04	1.00
22	Wastewater Treatment	23	0.23	0.06	0.75	22	0.12	0.06	0.43
23	Food, Tobacco Manufact.	33	0.78	0.21	2.10	31	0.79	0.24	5.83
24	Textile & Apparel Manufact.	16	0.33	0.19	1.06	14	0.30	0.21	0.88
25	Furniture & Fixtures	4	2.97	0.78	10.00	4	0.59	0.40	1.50
26	Printing & Publishing	4	0.48	0.37	1.00	3	0.47	0.52	0.65
27	Rubber & Plastic Products	34	0.98	0.19	4.90	34	0.80	0.25	2.86
28	Leather/Products								
29	Fabricated Metal Products, Jewelry	60	4.20	0.36	9.77	58	2.17	0.21	10.50
30	Ind. & Comm. & Transport Equip.	88	0.58	0.20	2.55	85	0.39	0.14	1.40
31	Electronic Equip. & Instruments	51	0.16	0.09	0.53	48	0.15	0.09	0.47

*NURP and USGS results were reported only as composite samples, not grab.
NR = Not Reported

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APPENDIX G

GEOGRAPHIC ANALYSIS OF SIC CODES

4470

APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES

SIC	SIC NAME	COUNT	% Pls I	Pls I+UAs	All UAs	UA > 250	UA > 100	UA > 50	Inc > 50k	Inc > 25k	Inc > 10k	Inc > 5k	Coastal Areas percent UAs	Coastal Areas percent All	Growing Areas percent UAs	Growing Areas percent All
			PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)							
	ALL FACILITIES	7,736,471	32	45	61	49	57	61	45	61	79	88	37	48	18	25
	AG & SILVICULTURE CAT	310,086	14	20	31	21	26	31	23	36	57	72	16	28	10	17
	MANUFACTURING CAT	1,554,013	30	44	61	49	56	61	45	61	80	89	37	49	18	25
	COMMERCIAL/RETAIL CAT	5,872,372	33	46	63	51	59	63	47	63	80	89	38	49	19	25
	ALL POTENTIAL PHASE II	1,015,239	28	40	56	44	51	56	41	57	76	86	32	44	16	23
	PHASE II GROUP B "SECTORS"															
	Automotive Service	369,870	27	38	55	43	50	55	41	57	77	87	32	44	16	22
	Transport, Rail and other	14,808	47	64	81	72	78	81	57	72	87	94	57	63	23	27
	Petrol. Pipelines & Distributors	35,319	16	25	39	27	34	39	30	45	66	79	23	37	8	15
	Various Utilities	22,242	24	36	53	40	48	53	39	55	75	86	30	42	16	23
	National Security	2,414	34	43	60	45	53	60	44	62	81	90	36	48	16	23
	Munic. Services, Vehicle Maint.	4,611	25	35	51	38	46	51	39	55	76	86	30	46	13	21
	Wholesale, Wood Products	48,593	26	36	53	39	47	53	39	55	76	86	30	43	15	22
	Wholesale, Coal & Ores	1,384	23	31	48	35	45	48	38	57	79	87	18	23	7	12
	Wholesale, Metal Products	14,303	36	54	75	65	72	75	54	69	85	93	45	53	19	23
	Wholesale, Machinery	77,562	32	47	65	53	61	65	47	62	80	89	35	45	16	20
	Livestock, Feedlots	43,421	8	11	20	11	15	20	16	29	53	69	8	21	6	13
	Intensive Ag. Chemical Use	121,861	26	38	54	41	49	54	39	54	74	85	31	44	18	25
	Extensive Ag. Chemical Use	18,992	31	42	62	47	56	62	47	64	81	90	34	46	17	23
	Wholesale, Food	11,372	36	49	67	56	63	67	48	64	82	90	50	67	19	25
	Photographic Activities	30,684	40	53	70	57	65	70	52	68	84	91	42	51	23	29
	Machinery & Electrical Repair	135,744	29	40	56	43	51	56	42	58	77	87	32	44	18	25
	Laboratories	10,683	38	56	74	60	69	74	53	69	85	93	45	55	26	31
	Laundries	51,376	38	52	71	59	67	71	52	67	84	92	44	53	21	26
	General Farms	8,240	5	8	13	7	10	13	10	19	43	61	3	9	4	11

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APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	%	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...												
				Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs 1	Phs 1+UAs	All UAs	UA > 250	UA > 100	UA > 50	Inc > 50k	Inc > 25k	Inc > 10k	Inc > 5k	UAs	All	UAs	All
	SELECTED (90) 4-DIGIT CODES															
0181	Ornamental Nurseries	11,019	24	33	49	35	43	49	35	53	75	86	30	49	19	29
0211	Beef Cattle Feedlots	2,972	7	9	17	9	12	17	13	22	42	59	3	8	5	10
0212	Beef Cattle, not Feedlots	14,684	7	9	15	8	11	15	11	20	43	61	4	11	5	13
0213	Hogs	4,328	3	6	12	5	8	12	10	22	43	63	4	16	2	5
0214	Sheep and Goats	618	6	8	16	8	12	16	12	24	42	58	4	11	6	16
0219	Gen'l Livestock, not Dairy	1,160	5	7	12	6	9	12	9	17	39	58	3	8	3	8
0241	Dairy Farms	12,298	6	8	19	9	13	19	17	36	62	76	8	29	5	13
0251	Broiler, Fryer, Roaster Chicken	941	4	6	15	7	9	15	13	32	60	78	7	25	4	17
0252	Chicken Eggs	1,171	9	12	26	12	20	26	23	42	67	80	14	36	8	16
0254	Poultry Hatcheries	719	7	10	20	9	15	20	17	35	62	78	9	25	4	13
0273	Animal Aquaculture	595	17	18	25	17	21	25	18	30	59	77	17	33	15	27
0291	General Farms	8,240	5	8	13	7	10	13	10	19	43	61	3	9	4	11
0782	Lawn & Garden Services	36,369	34	52	70	56	65	69	49	65	83	91	42	55	25	33
0783	Shrub & Tree Services	7,260	27	42	60	46	55	60	43	60	79	89	35	49	18	25
4612	Crude Petroleum Pipelines	390	21	26	41	29	36	41	30	44	64	78	13	20	7	9
4613	Refined Petroleum Pipelines	347	24	34	49	36	43	49	37	51	73	84	22	32	12	16
4619	Pipelines, NEC	18	17	39	78	61	72	78	50	67	89	94	44	44	22	22
4731	Arrange. Freight Trans	12,303	49	66	82	74	80	82	58	73	88	94	59	65	24	27
4741	Rental of Railroad Cars	175	33	46	75	62	70	75	53	68	85	93	38	45	21	27
4783	Packing and Crating	1,099	39	60	79	68	75	79	55	70	87	94	52	60	23	29
4785	Weighing: Vehicle Trans.	332	40	60	77	66	74	77	55	69	85	92	58	69	20	26
4789	Transport Services, NEC	899	32	45	63	52	59	63	47	62	81	89	35	44	17	22
4925	Gas Producers, Distributors	604	11	18	28	19	24	28	21	34	58	74	12	22	7	11
4932	Gas & Services	212	25	34	49	36	43	49	36	52	73	84	24	31	11	14
4939	Utilities, NEC	297	20	25	41	27	35	41	28	43	63	75	24	34	14	22

APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ... %	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
4941	Water Supply	4,904	19	26	41	28	35	41	30	47	71	83	20	33	16	28
4953	Refuse Systems	10,797	26	40	58	45	53	58	43	59	79	88	36	49	15	21
4959	Sanitary Services, NEC	1,894	30	48	68	55	64	68	50	65	82	91	41	54	21	28
4971	Irrigation System	662	17	22	36	22	28	36	27	40	59	76	10	15	19	32
5031	Lumber, Millwork	13,836	37	50	67	54	62	67	49	66	83	91	38	48	20	27
5039	Constuct Materials	4,036	37	50	68	55	63	68	50	65	82	90	35	45	21	27
5051	Metal Service Centers	10,267	35	56	78	69	76	78	56	71	87	93	49	57	18	22
5052	Coal/Minerals & Ores Wholesale	1,384	23	31	48	35	45	48	38	57	79	87	18	23	7	12
5082	Constr. & Min. Mach.	7,143	34	46	62	48	57	62	46	63	81	90	30	40	17	23
5083	Farm Mach. & Equip.	13,670	11	15	24	15	19	24	18	32	55	71	9	20	7	12
5084	Industrial Mach. & Equip.	38,880	37	55	75	63	71	75	54	69	86	93	42	50	18	22
5085	Industrial Supplies	17,869	36	55	75	62	71	75	54	70	86	93	44	53	18	22
5144	Poultry & Products	1,495	27	37	53	41	48	53	41	58	77	87	32	41	12	19
5146	Fish & Seafoods	4,579	39	50	66	54	62	66	46	62	81	90	58	87	23	31
5147	Meat & Products	5,298	37	53	71	62	67	71	52	67	84	91	48	57	17	22
5154	Livestock	4,351	9	12	22	10	16	22	17	29	51	68	5	12	6	12
5159	Farm Products Raw Mats.	1,895	28	36	47	35	41	47	40	52	74	85	26	39	9	15
5169	Chemical & Allied Prod., NEC	10,355	37	56	74	63	70	74	52	68	85	92	43	52	19	24
5171	Petroleum, Bulk	8,086	9	12	22	12	17	22	16	29	53	70	8	19	5	10
5172	Petroleum Products/Dist.	11,128	22	31	45	33	40	45	34	49	69	82	23	36	12	17
5191	Farm Supplies	20,189	10	14	23	14	19	23	18	31	54	71	9	20	7	12
5211	Lumber & Build. Materials	34,757	21	31	47	34	41	47	35	51	73	84	27	41	13	21
5261	Lawn & Garden Supply	19,443	20	29	44	32	39	44	33	51	73	84	25	41	14	22
5511	Car Dealers, New & Used	37,387	22	32	49	36	44	49	36	54	75	85	28	41	13	20
5521	Car Dealers, Used Only	32,145	26	34	51	37	45	51	39	57	78	88	26	38	15	21
5541	Gas/Service Stations	91,924	23	34	49	38	44	49	35	51	72	84	29	42	13	19

APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...														
			%	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
5983	Fuel Oil Dealers	7,233	16	36	58	45	54	58	46	63	80	89	50	71	8	13
5984	Fuel and Coal Dealers	6,226	11	15	26	16	21	26	20	35	60	75	12	28	8	17
5989	Fuel Oil Dealers, NEC	1,075	17	24	39	27	34	39	34	52	73	84	19	34	10	20
7211	Laundries	2,940	36	47	63	50	58	63	48	63	82	90	35	46	15	20
7212	Garment Cleaners	7,280	43	57	76	67	73	76	57	71	86	93	52	60	21	25
7216	Dry Cleaning	22,042	38	54	73	63	70	73	52	68	85	92	48	56	21	25
7217	Carpet Cleaners	13,636	34	47	66	51	60	66	48	64	82	91	35	46	23	30
7218	Ind. Launderers	903	33	48	66	51	60	66	50	66	84	92	37	45	16	21
7219	Laundry Services	4,575	40	55	74	62	70	74	55	70	86	93	45	53	22	26
7221	Photographic Studios	20,010	39	51	67	55	62	67	51	66	83	91	38	47	22	28
7342	Disinfect/Exterminating	12,359	36	48	63	50	58	63	46	63	82	91	35	46	22	29
7384	Photo Finishing Labs	10,674	43	58	74	62	70	74	55	70	86	93	49	58	26	32
7513	Truck Rental	7,799	30	45	64	50	58	64	47	64	82	91	36	46	15	20
7514	Passenger Car Rental	7,939	38	54	74	59	68	74	53	69	85	93	46	57	22	29
7521	Parking Structures	3,088	58	72	90	82	88	90	74	83	92	96	64	69	13	16
7532	Top, Body Repair	48,800	26	39	56	43	51	56	41	57	77	87	33	45	16	21
7538	General Auto. Repair	87,994	30	41	56	45	52	56	42	58	77	87	34	45	19	26
7539	Specialized Repair	26,381	31	43	60	47	54	60	45	61	80	89	32	43	19	25
7542	Car Washes	12,842	28	43	62	47	56	62	46	62	80	89	32	42	16	21
7549	Misc. Automotive Services	13,571	34	49	68	56	63	68	48	65	83	91	40	51	21	27
7622	Radio and Television Repair	20,527	28	39	56	43	51	56	41	58	77	87	32	44	16	22
7623	Refrig. & Air Condition Repair	8,504	33	43	59	47	54	59	44	59	79	88	33	46	18	25
7629	Electrical Repair Shops, NEC	19,448	31	43	60	47	55	60	44	61	79	89	34	46	19	25
7692	Welding Repair	14,305	18	26	40	28	35	40	30	46	67	80	22	36	12	19
7694	Armature Rewinding Shops	2,865	23	32	49	35	43	49	37	54	76	87	26	39	12	18
7699	Repair Shops & Related Serv, NEC	70,095	31	42	58	45	53	58	43	59	78	88	34	46	19	26

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APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...													
			%	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
7948	Race Tracks/Stables	2,271	27	42	59	45	53	59	44	61	80	89	34	47	18	26
7992	Golf Courses, Public	4,295	18	28	46	31	40	46	35	54	75	85	25	45	14	21
7996	Amusement Parks	1,371	23	32	51	36	45	51	38	56	78	87	26	42	13	22
8221	Colleges and Universities	6,829	35	47	69	51	62	69	53	70	85	92	38	46	16	21
8222	Junior Colleges	1,850	27	37	54	41	49	54	40	57	77	87	31	44	14	22
8249	Vocational Schools	4,647	41	54	71	60	67	71	53	68	85	92	41	50	22	28
8422	Botanical Gardens & Zoos	285	41	55	71	56	67	72	53	68	83	91	42	56	21	27
8731	Comm. Research Labs.	6,382	39	58	75	62	71	75	53	70	86	93	48	58	27	34
8734	Testing Laboratories	4,301	37	53	72	58	67	72	52	68	85	92	41	50	23	28
9221	Police Protection	2,508	21	33	50	37	44	50	36	53	74	85	31	47	12	20
9223	Jails	1,714	29	37	52	37	46	52	40	57	78	88	28	44	14	21
9229	Fire Protection	389	34	45	62	46	55	62	47	63	81	90	32	43	15	22
9511	Air, H_2O & Solid Waste Mgmt.	3,688	24	34	50	38	45	50	38	54	73	85	23	36	14	21
9711	National Security	2,414	34	43	60	45	53	60	44	62	81	90	36	48	16	21
	ALL TWO-DIGIT CODES															
01	Ag. Product-Crops	148681	7	10	17	9	13	17	13	24	45	64	7	18	5	10
02	Ag. Product.-Livestock	53788	7	10	18	9	14	18	15	27	51	68	6	18	5	11
07	Ag. Services	100857	29	42	58	45	53	58	42	58	77	87	33	46	21	29
08	Forestry	4167	15	19	28	16	23	28	22	40	66	81	15	40	9	20
09	Fishing, Hunting	2593	19	25	42	25	36	42	30	47	70	82	36	78	17	30
10	Metal Mining	1762	35	41	49	37	45	49	37	51	65	78	12	18	28	45
12	Coal & Lignite Mining	5684	8	9	18	11	15	18	20	45	72	81	3	5	4	8
13	Oil & Gas Extraction	27254	26	33	44	33	40	44	36	49	69	81	11	18	7	10
14	Nonmetalic Minerals	5236	15	23	34	24	30	34	26	42	66	80	15	30	11	20
15	Building Contractors	292337	30	44	61	48	56	61	44	61	80	89	36	50	20	28
16	Heavy Const. Contractors	41258	26	36	51	39	46	51	37	54	75	86	29	43	18	27

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APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...													
			%	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
17	Spec. Trade Contractors	471505	29	43	61	48	56	61	44	61	79	89	36	49	19	26
20	Man. Food, etc.	28791	29	39	56	43	50	56	42	58	77	87	33	45	16	22
21	Man. Tobacco	267	47	55	74	56	68	74	59	72	87	93	44	53	19	22
22	Man. Textile	11592	32	45	60	48	55	60	47	67	84	91	40	49	12	20
23	Man. Apparel	27667	50	63	75	67	72	75	58	72	86	93	57	65	21	26
24	Lumber & Wood	42363	18	24	35	25	30	35	27	44	70	83	20	41	12	20
25	Furniture & Fixtures	16127	39	51	67	55	62	67	50	66	84	92	43	52	24	30
26	Paper & Allied Prod.	8656	32	50	71	59	66	71	51	67	85	93	44	55	15	19
27	Printing & Publish.	93128	40	55	72	61	68	72	54	68	84	92	46	54	21	26
28	Chemicals & Allied	19980	35	54	72	61	68	72	51	67	84	92	46	55	20	24
29	Petroleum & Coal	3453	30	44	61	50	57	61	44	60	80	89	34	44	17	21
30	Rubber & Plastic Pds.	16910	29	47	67	55	63	67	49	66	84	92	43	55	18	23
31	Leather/Products	3398	35	47	62	52	58	62	49	63	80	89	43	53	15	20
32	Stone, Clay & Glass	21388	27	37	53	41	48	53	40	56	76	87	30	41	17	24
33	Primary Metal Ind.	10560	27	44	67	55	62	67	49	66	83	91	43	54	15	19
34	Fab. Metal Pds.	42861	31	49	69	58	65	69	51	67	84	92	44	55	18	23
35	Machinery - electric	73472	29	47	66	54	62	66	49	65	83	91	42	53	19	24
36	Electronic Equip.	24834	38	57	75	64	72	75	54	70	86	93	49	57	26	32
37	Transportation Equip.	16339	36	48	64	52	59	64	48	64	82	90	43	57	26	32
38	Instrument & Related	17129	37	58	77	66	73	77	55	71	87	94	50	59	25	31
39	Misc. Manufacturing	32916	39	53	72	61	68	72	54	69	85	92	47	57	22	28
40	Railroad Transport	3113	20	28	47	35	42	47	34	50	71	82	21	31	9	13
41	Local Pass. Transit	21908	31	48	65	54	61	65	48	64	81	90	48	59	13	18
42	Trucking	145846	26	38	55	43	50	55	40	56	76	87	32	43	14	20
43	U.S. Postal Service	1669	18	29	54	38	48	54	40	57	74	85	32	46	14	25
44	Water Transport	10769	33	44	59	47	55	59	40	57	77	87	49	76	19	28
45	Air Transport	13841	36	47	63	50	58	63	46	62	79	88	35	47	19	27

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APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ...													
			%	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
46	Pipe Lines-Nat. Gas	755	22	30	46	33	40	46	34	48	69	81	17	26	10	13
47	Transport Services	44141	46	62	79	70	76	79	57	72	87	94	57	64	25	30
48	Communication	33732	29	39	55	42	50	55	41	57	76	87	30	41	16	23
49	Electric, Gas & Sani.	31120	21	31	47	35	42	47	34	51	71	83	26	38	13	21
50	Wholesale-Durables	369442	39	54	71	60	68	71	52	67	84	92	42	51	21	26
51	Wholesale-Nondurables	213239	36	49	64	54	60	64	47	61	78	88	41	50	18	22
52	Building & Garden Materials	103721	22	31	47	35	42	47	35	52	73	84	27	42	14	21
53	General Stores	48496	22	30	44	33	39	44	34	50	72	84	26	41	11	18
54	Food Stores	218896	28	39	55	43	50	55	41	57	77	87	35	48	14	21
55	Auto Deals & Service	234029	25	34	50	38	45	50	37	54	75	86	29	41	15	21
56	Apparel Stores	160303	38	51	67	55	62	67	50	65	82	91	44	54	21	27
57	Furniture Stores	170139	32	43	60	47	55	60	44	61	80	89	36	47	19	26
58	Eat & Drink Places	381020	33	45	63	51	58	63	47	62	80	89	39	50	18	24
59	Misc. Retail	533517	32	44	60	48	55	60	45	61	79	88	35	47	18	25
60	Banking	90152	30	43	60	48	55	60	44	60	78	88	38	50	16	22
61	Credit Agencies	34685	44	57	74	62	70	74	54	70	86	93	44	52	26	32
62	Security Brokers	30301	49	63	81	71	77	81	62	75	88	94	54	60	21	25
63	Insurance Carriers	13634	44	58	76	63	72	76	57	73	87	94	40	48	21	26
64	Insurance Agents	141608	32	45	63	50	58	63	46	62	80	89	35	45	18	23
65	Real Estate	333354	38	53	70	57	65	70	51	67	84	91	42	53	22	29
67	Investment Offices	28959	46	63	79	70	76	79	59	73	87	94	49	56	24	28
70	Hotels & Lodging	70760	23	29	43	30	38	43	33	49	71	83	25	44	17	30
72	Personal Services	291063	31	43	61	49	56	61	45	61	79	89	37	47	18	23
73	Business Services	386364	42	58	76	64	72	76	55	71	86	93	46	55	24	30
75	Auto Repair Services	228471	30	43	60	47	55	60	44	61	79	88	35	46	18	24
76	Misc. Repair	155412	29	40	56	44	51	56	42	58	77	87	32	44	18	24
78	Motion Pictures	38445	44	57	72	63	69	72	55	69	85	92	50	58	27	32

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APPENDIX G: GEOGRAPHIC ANALYSIS OF SIC CODES (CONTINUED)

SIC	SIC NAME	COUNT	PERCENT OF FACILITIES LOCATED IN PART OF COUNTY ASSOCIATED WITH ... %													
			%	Organized by "Urbanized Area" percent (cum.)					Organized by "Places" percent (cum.)				Coastal Areas percent		Growing Areas percent	
			Phs I	Phs I+UAs	All UAs	UA>250	UA>100	UA>50	Inc>50k	Inc>25k	Inc>10k	Inc>5k	UAs	All	UAs	All
79	Amusement Services	88067	30	42	61	47	55	61	45	61	79	88	37	49	18	25
80	Health Services	386373	35	50	68	56	64	68	50	66	83	91	43	51	20	26
81	Legal Services	127352	38	53	70	59	66	70	52	68	84	92	47	57	18	21
82	Educational Services	181729	24	36	52	40	47	52	39	54	74	84	31	44	13	19
83	Social Services	127245	32	43	61	47	56	61	46	63	81	89	36	48	17	21
84	Museums	5315	35	45	62	49	57	62	48	63	80	88	40	51	17	25
86	Membership Organizations	235386	30	40	59	45	53	59	44	60	79	89	33	44	15	20
87	Research & Development	253149	43	59	76	65	73	76	55	71	86	93	49	58	25	31
88	Households with Employees	645	23	29	45	33	40	45	33	49	71	82	28	41	17	23
89	Services, NEC	9974	45	60	76	65	72	76	58	72	87	93	48	57	24	31
91	Executive, Gen'l Govt.	26273	15	23	37	26	32	37	27	42	64	77	19	33	8	16
92	Justice, Public Order	16450	20	29	46	33	41	46	35	52	73	85	26	43	12	21
93	Public Finance, Taxes	1477	36	46	65	51	60	65	52	67	84	91	36	48	13	18
94	Human Resource Admin.	7853	23	32	48	35	42	47	38	53	72	83	26	38	9	15
95	Env. Quality & Housing Admin.	10344	22	31	47	35	42	47	35	51	72	84	25	38	12	19
96	Econ. Prog. Admin.	5692	30	39	54	41	49	54	41	57	76	86	28	40	13	20
97	National Security	3290	47	55	69	58	64	69	55	70	85	92	49	58	15	21

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APPENDIX H

EPA REQUEST FOR COMMENT ON ALTERNATIVE APPROACHES FOR PHASE II STORM WATER PROGRAM

federal register

Wednesday
September 9, 1992

VOL 12

Part IV

4480

Environmental Protection Agency

40 CFR Part 122

National Pollutant Discharge Elimination System, Request for Comment on Alternative Approaches for Phase II Storm Water Program

R0037789

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 122

[FRL-4202-9]

National Pollutant Discharge Elimination System, Request for Comment on Alternative Approaches for Phase II Storm Water Program

AGENCY: Environmental Protection Agency.

ACTION: Request for comment.

SUMMARY: In a memorandum dated January 28, 1992, the President asked regulatory agencies to review existing and proposed rules to improve cost effectiveness, minimize economic impact, and reduce regulatory burden. In response, today's notice requests information and public input on Phase II of the national storm water program mandated under section 402(p)(6) of the Clean Water Act (CWA). More specifically, EPA is today requesting public comment on a number of issues including scope of coverage under Phase II, identification of high risk Phase II discharges, alternative control strategies, and appropriate deadlines. With respect to each of these issues, the Agency is requesting input on how to meet environmental objectives and requirements set forth under section 402(p)(6) while at the same time identifying cost-effective control strategies that minimize the economic impact on the regulated community as well as the administrative burden on Federal, State and local government.

DATES: Comments on this notice must be received on or before November 9, 1992.

ADDRESSES: Respondents should send an original and two copies of their comments to Michael Plehn, Office of Wastewater Enforcement and Compliance (EN-336), United States Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, (202) 260-6929. The public record for this notice is located at EPA Headquarters, NE Mall room 220, 401 M Street, SW., Washington, DC 20460. Appointments to view the record can be made by contacting Michael Plehn at the above address. A reasonable fee may be charged for copying. The public record for previous rulemaking activity related to Phase I of the storm water program is located at EPA Headquarters, EPA Public Information Reference Unit, room 2402, 401 M Street, SW., Washington, DC 20460.

FOR FURTHER INFORMATION CONTACT: For further information on this notice, contact the NPDES Storm Water Hotline at (703) 821-4823, or Michael Plehn, Office of Wastewater Enforcement and Compliance (EN-336), United States Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, (202) 260-6929.

SUPPLEMENTARY INFORMATION:

I. Background

The 1972 amendments to the Federal Water Pollution Control Act (FWPCA, later referred to as the Clean Water Act or CWA) prohibit the discharge of any pollutant to the navigable waters of the United States from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Efforts to improve water quality under the NPDES program have focused traditionally on reducing pollutants in discharges of industrial process wastewater and discharges from municipal sewage treatment plants. This program emphasis developed because many industrial and municipal sources were not controlled at that time and were easily identified as contributing to water quality impairment. Over time, as pollution control measures were implemented for these discharges and as data collection efforts have provided additional information, it has become evident that more diffuse sources of water pollution, such as agricultural and urban runoff, are important contributors to water quality problems and use impairment. Some diffuse sources of water pollution, such as agricultural runoff and irrigation return flows, are exempted statutorily from the NPDES program. Controls for other point source discharge of storm water runoff, however, are addressed in this notice.

A. Environmental Impacts

Several national assessments have been conducted to evaluate the impacts of diffuse sources of storm water runoff on receiving water quality. The "National Water Quality Inventory, 1990 Report to Congress" provides a general assessment of water quality based on biennial reports submitted by the States under section 305(b) of the CWA. In section 305(b) Reports, States indicate the fraction of the States' waters that have been assessed, the fraction of those assessed waters that are not supporting designated uses, and the sources of use impairment for those waters (e.g., diffuse sources, point sources, and natural sources). The Report indicates that roughly 30 to 40 percent of assessed rivers, lakes and estuaries are not supporting the uses for which they are designated. Based on information from 51 States and Territories that reported on sources of pollution, the Report indicates that storm water runoff from a number of diffuse sources, including agricultural areas, urban areas, construction sites, land disposal activities, and resource extraction activities, is the leading cause of water quality impairment cited by States. For those States reporting in each category, diffuse sources were cited as causing use impairments in the following magnitudes: For rivers and streams, 11 percent of impaired river miles are caused by separate storm sewers, 6 percent are caused by construction activities, and 14 percent are caused by resource extraction. For lakes, 28 percent of impaired lake acres are caused by separate storm sewers and 25 percent are caused by land disposal. For the Great Lakes' shoreline, 6 percent of impaired shoreline miles are caused by separate storm sewers, and 41 percent are caused by land disposal. For estuaries, 30 percent of impaired acres are caused by separate storm sewers. For coastal areas, 36 percent of impairments are caused by separate

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storm sewers, and 37 percent are caused by land disposal.

In 1985, the States conducted a different study of diffuse pollution sources under the sponsorship of the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA) and EPA. The study resulted in the report entitled "America's Clean Water—The States' Nonpoint Source Assessment, 1985." In that study, 38 States reported urban storm water runoff as a major cause of beneficial use impairment. In addition, 21 States reported construction site runoff as a major cause of use impairment.

Studies conducted by the National Oceanic and Atmospheric Administration (NOAA) indicate that urban storm water runoff is indeed a major pollutant source that adversely affects shellfish growing waters.[1] The NOAA studies concluded that urban runoff affects 39 percent of harvest-limited area on the East Coast, 59 percent in the Gulf of Mexico, and 52 percent on the West Coast.

B. Water Quality Act of 1987

In response to growing concerns with the environmental impact of storm water runoff, Congress addressed this issue as part of the Water Quality Act of 1987 (WQA) by adding section 402(p) to the CWA to require the establishment of a comprehensive two-phased approach for the control of storm water discharges. Section 402(p)(1) prohibits EPA or NPDES States from requiring permits for storm water discharges until October 1, 1992, except for 5 classes of storm water discharges specifically listed under section 402(p)(2) (see appendix A). These 5 classes of discharges make up Phase I of the existing national storm water program and include storm water discharges:

(A) Permitted before February 4, 1987;
(B) Associated with industrial activity;
(C) From a municipal separate storm sewer system serving a population of 250,000 or more;
(D) From a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000;
(E) Which EPA or a NPDES State determines contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States.

Section 402(p)(3) confirms that, like all other point source discharges under the CWA, discharges of storm water associated with industrial activity must meet all applicable provisions of CWA sections 402 and 301, including technology-based requirements and any necessary water quality-based requirements. Permits for discharges from municipal separate storm sewer systems may be issued on a system- or jurisdiction-wide basis and must meet a new statutory standard requiring controls to reduce pollutant discharges to the maximum extent practicable (MEP).

Phase II of the storm water program covers all storm water discharges not addressed under the five Phase I classes described above. Under the current provisions of section 402(p), the existing statutory prohibition against permitting Phase II storm water discharges expires on October 1, 1992 (see appendix B).

Under CWA section 402(p)(5), EPA, in consultation with the States, is required to conduct two studies on Phase II storm water discharges for which permits cannot be required before October 1, 1992. The first study will identify those sources or classes of discharges that may be addressed in Phase II and determine the nature and extent of pollutants in such discharges. The second study is to establish procedures and methods to control Phase II storm water discharges to the extent necessary to mitigate impacts on water quality. These studies have not been completed.

Under section 402(p)(6), EPA, in consultation with State and local officials and based on the two studies, is required to issue regulations by October 1, 1992, which designate particular sources or classes of Phase II storm water discharges to be regulated to protect water quality and which establish a comprehensive program to regulate such designated sources. This program must establish priorities, requirements for State storm water management programs, and expeditious deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements, as appropriate.

The approach mandated by section 402(p)(2) is fully consistent with the intent and requirements of Section 319 of the WQA of 1987. Section 319 was enacted to require States to prevent and control nonpoint source pollution.

Under section 319 States are required to submit Nonpoint Source Assessment Reports identifying State waters which, without additional control of nonpoint sources of pollution, cannot be expected to attain or maintain designated uses. States were also required to prepare and submit for EPA approval a statewide management program for controlling nonpoint source water pollution to navigable waters within the State and improving the quality of such waters to levels sufficient for attaining or maintaining applicable water quality standards or goals. Furthermore, the State program submittal was to identify specific best management practices and measures which the state proposes to implement, in the first four years after program submission, to reduce pollutant loadings from identified nonpoint sources to levels required to achieve the stated water quality objectives.

Although the State nonpoint source programs are not enforceable under Federal law, States were encouraged to adopt both regulatory and non-regulatory approaches under State and local law. Section 319(b)(2)(B) specifies that a combination of "non-regulatory or regulatory programs for enforcement, technical assistance, financial assistance, education, training, technology transfer, and demonstration projects" may be used, as necessary, to achieve implementation of the best management practices or measures identified in the section 319 submittal.

To date, all States have approved section 319 assessments and approved management programs. EPA has awarded approximately $38 million in FY90 funds, $51 million in FY91 funds, and is in the process of awarding $52.5 million in FY92 funds to assist States in implementing the section 319 programs. EPA expects that State nonpoint source management programs will be revised and refined periodically in response to re-evaluated priorities and new strategies and technologies.

Numerous States and local governments have implemented regulations and enforceable policies to control nonpoint source pollution. States such as Delaware and Florida as well as local governments such as the Lower Colorado River Authority are aggressively pursuing storm water management goals through numerical treatment standards for new development. Many States and local governments have enforceable erosion and sediment control regulations. On a broader scale, nonpoint source pollution is being addressed at the watershed level by programs such as those being implemented by the State of Wisconsin and the Puget Sound Water Quality Authority and the states which are parties to the International Agreement on the Great Lakes. A number of individual States and local communities have adopted legislation or regulations like Maryland's Critical Areas Bill which limits development and/or

[1] "The Quality of Shellfish Growing Waters on the East Coast of the United States," 1989; "The Quality of Shellfish Growing Waters in the Gulf of Mexico," 1988; and "The Quality of Shellfish Growing Waters on the West Coast of the United States," 1989.

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requires special management practices in areas surrounding water resources of special concern. California has also recently created Storm water management districts to better address the control of nonpoint source pollution.

A further development in the area of Federally-mandated nonpoint source management occurred in 1990 with the enactment of section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA). Section 6217 provides that States with approved coastal zone management programs must develop and submit to EPA and NOAA for approval a coastal nonpoint pollution control program. Failure to submit an approvable program will result in the loss of Federal grants under both the Coastal Zone Management Act and section 319 of the CWA. State nonpoint pollution control programs must also include enforceable policies and mechanisms which ensure implementation of the management measures throughout the coastal management area. Management measures as defined in section 6217(g)(5) are: "Economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives."

The section 6217(g) guidance was issued for public comment in May, 1991. Final guidance is expected by October, 1992. The technology-based approach used in the guidance provides State Officials flexibility to meet the management measures using best management practices identified in the guidance or other methods and strategies which achieve equivalent or higher levels of pollutant control. If the technology-based approach fails to achieve and maintain applicable water quality standards and protect designated uses, additional management measures are required under CZARA section 6217(b)(3). Congress mandated a technology-based approach founded on technical and economic achievability under the rationale that neither States nor EPA have the money, time, or other resources to create and implement a program which depends on establishing cause and effect linkages between particular land use activities and specific water quality problems. Nonpoint sources addressed in the proposed guidance include: urban runoff from both developing and developed areas, roads, highways and bridges, agriculture, forestry, marinas, hydromodification, dams and levees.

C. Current (Phase I) Storm Water Permitting Program

EPA promulgated permit application regulations for Phase I storm water discharges on November 16, 1990 (55 FR 47990). The November 16, 1990 regulations established the scope of the Phase I storm water program by defining two major classes of storm water discharges identified under section 402(p)(2)(B), (C), and (D) of the CWA: Storm water discharges associated with industrial activity,[2] and discharges from municipal separate storm sewer systems (MS4s) serving a population of 100,000 or more.[3] In addition, the November 16, 1990 regulations established permit application requirements, including deadlines for these two classes of discharges (for a summary of Phase I see appendix A).

The November 16, 1990 regulations defined municipal separate storm sewer system serving a population of 100,000 or more to include municipal separate storm sewers within the boundaries of 173 incorporated cities, and within unincorporated portions of 47 counties that were identified as having populations of 100,000 or more in unincorporated, urbanized portions of the county.[4] In addition, the regulations allowed for additional municipal separate storm sewers to be designated by the Director of the NPDES program as being part of a large or medium MS4. The November 16, 1990 regulations establish comprehensive two part permit applications for discharges from large or medium MS4s. The permit application requirements for large and medium MS4s, among other things, require municipal applicants to propose municipal storm water management programs to control pollutants to the maximum extent practicable and to effectively prohibit non-storm water discharges to the MS4.[5]

The November 16, 1990 regulations also defined the term "storm water discharges associated with industrial activity" to include 11 categories of industrial facilities (see 40 CFR 122.26(b)(14)). The November 16, 1990 regulations establish two sets of application requirements for storm water discharges associated with industrial activity: Individual applications and group applications. In addition, the notice recognizes a third set of application procedures for storm water discharges associated with industrial activity referred to as "notice of intent" (NOI) requirements associated with general permits.

The Phase I storm water program takes two very different approaches to defining the roles of EPA and authorized NPDES States in controlling pollutants in storm water discharges. With respect to permits for large and medium MS4s, the efforts of the NPDES permitting authority (EPA or an authorized NPDES State) are directed to ensuring that municipalities develop and implement storm water management programs to control pollutants to the maximum extent practicable. Municipal programs address the control of pollutants in storm water from all areas within the boundaries of the MS4 that discharge to the system, including privately-owned lands, as well as modifying municipal activities (e.g. road deicing and maintenance, flood control efforts, maintenance of municipal lands, etc.) to address storm water quality concerns. The Agency has defined the role of municipalities under this program in a flexible manner that allows local governments to assist in defining priority pollutant sources within the municipality, and to develop and implement appropriate controls for such discharges. With respect to permits for storm water discharges associated with industrial activity, the NPDES permitting authority has a more direct role in regulating facilities.[6]

While today's request for comments focuses on developing Phase II of the storm water program, readers may find that a brief summary of progress to date

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[2] On June 4, 1992 the United States Court of Appeals for the Ninth Circuit found that EPA's rational for exempting construction sites of less than five acres and certain uncontaminated storm water discharges from light industrial facilities from Phase I of the storm water program to be invalid and has remanded these exemptions for further proceedings (see *Natural Resources Defense Council versus EPA* No. 91–70176).

[3] Consistent with Section 402(p)(2) of the CWA, the November 16, 1990 regulations address two subclasses of municipal separate storm sewer systems serving a population of 100,000 or more. Large municipal separate storm sewer systems are defined as systems serving a population of 250,000 or more (see 40 CFR 122.26(b)(4)). Medium municipal separate storm sewer systems are defined as systems serving a population of 100,000 or more, but less than 250,000 (see 40 CFR 122.26(b)(7)).

[4] See appendices F, G, H, and I to 40 CFR part 122.

[5] See 40 CFR 122.26(d)(2)(iv).

[6] NPDES permits for discharges from large and medium MS4s will establish municipal responsibilities for assisting EPA and authorized NPDES States in implementing controls to reduce pollutants in storm water discharges associated with industrial activity which discharge through large and medium MS4s. A more detailed description of the role of municipalities in addressing industrial storm water sources under this Federal/State/Municipal partnership, is provided at 56 FR 40972 (August 16, 1991).

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in implementing the first phase of the program would be helpful. Part of current implementation activities include outreach efforts and two rulemakings discussed in more detail below which are specifically designed to provide more flexibility and minimize regulatory and administrative burdens where possible.

As discussed above, the November 1990 storm water rule provided for three different options for storm water discharges associated with industrial activity to seek coverage under the program: individual, group, and general permit applications. Since November 1990, there has been a great deal of activity as EPA and the States have worked with the regulated community to provide guidance and implement the program. The Agency has established a four tier risk-based storm water permitting strategy which emphasizes the use of general permits (April 2, 1992, (57 FR 11394)). As part of the strategy, EPA called for the development of State storm water management programs to track permit issuance, provide for prioritization of risk, and create baselines against which to assess environmental results. As part of the same rule, the Agency extended the deadline for Part 2 of group applications until October 1, 1992, and also deferred regulation of storm water discharges from industrial activities owned or operated by municipalities with a population under 100,000 until Phase 2 of the program, pursuant to section 1068(c) of the Intermodal Surface Transportation Efficiency Act of 1991. In providing for greater flexibility, reduced burdens, extended deadlines, and deferred regulation, this recent storm water rulemaking addresses many of the goals underlying the President's January 28, 1992 request to review existing regulations.

Since November 1990, the Agency has received over 1,200 Part I group applications representing more than 60,000 facilities. EPA is currently processing these applications. Final decisions have been reached on over 1,000 to date. Approximately 75% have been approved, 20% withdrawn or determined not to be covered, and 5% denied. Part I group applications were due on September 30, 1991. Part II sampling information from approved groups is due on October 1, 1992.

At the same time that EPA has been receiving and processing group applications, States have been actively moving to provide for storm water general permit issuance. When the storm water application rules were issued in November 1990, only 17 out of 39 States authorized to administer the NPDES program were also approved to issue NPDES general permits. Since then, an additional 16 States have requested and received Federal approval to issue general permits. Over two thirds of the States that now have general permit authority are presently developing specific general permits to cover storm water discharges.

For the 12 States without NPDES authority, EPA is in the process of issuing storm water general permits that rely heavily upon industrial facilities developing and implementing their own storm water pollution prevention plans.

As part of the four tier risk-based permitting strategy referred to above and discussed in more detail in the Agency's April 2, 1992 notice, EPA believes that the majority of storm water discharges associated with industrial activities should be covered by general permits. The Agency urges all authorized NPDES States without general permit approval to obtain NPDES general permit authority.[7] EPA places a high priority on this effort and is providing direct technical guidance and assistance to support States both in obtaining general permit approval and in developing specific general storm water permits.

With regard to guidance, training, and outreach, EPA has undertaken a number of efforts to provide technical assistance and also to get public input on ways to streamline the existing program. In the area of guidance, EPA has published and distributed thousands of municipal and industrial permit application manuals in addition to numerous summaries, fact sheets and work shop materials over the past eighteen months. The Agency has issued additional guidance on storm water sampling, pollution prevention plan development, and storm water best management practices (BMPs), and is developing guidance for part 2 municipal applications. A list of EPA technical guidance, summaries, and storm water fact sheets can be obtained by calling the Agency's storm water hotline at (703) 821-4823.

In the area of training and outreach, EPA staff has participated in over 60 workshops and presentations throughout the country, training permitting authorities and educating the regulated community. For example, EPA Regions held fourteen public hearings to receive public comment on the Agency's proposed general permits in August and September of 1991. EPA held an additional 26 storm water workshops across the country this summer and would welcome hearing from groups or organizations interested in receiving workshop materials for further in-house or local training.

While EPA recognizes the importance of ongoing training and outreach efforts to provide information on the storm water program, the Agency also regards these activities as an effective mechanism for getting feedback on the program and identifying areas for further improvement. The new guidance documents referred to above and presently being developed reflect input from States and the regulated community on high priority areas requiring clarification and further technical assistance.

In addition to these activities, EPA has recently completed a study, in conjunction with the Rensselaerville Institute, to obtain direct public input and develop recommendations for streamlining the program and making it more effective. This study has two objectives. The first is to develop recommendations to streamline program implementation under existing regulations and legislation (Phase I). The second is to develop cost-effective options for addressing risks from storm water sources not currently required to be permitted that could potentially be addressed under Phase II of the storm water program.

Under the first objective, the Rensselaerville Institute sponsored 8 focus groups across the country with members representing state and local government, the regulated community, and environmental interests for uninterrupted full day discussions on ways to improve the storm water program. Five key issues were raised by all groups: (1) Groups felt that EPA has not been very clear about the intended goals of the regulations and should communicate storm water risks, objectives, and requirements more clearly to the general public as well as the regulated community, (2) participants noted that the cost of program implementation is significantly higher than original EPA estimates and there is great concern regarding the real costs of the program and of achieving compliance, (3) there was consensus that EPA and States must accelerate general permit issuance and focus on general permits to achieve efficient implementation of the program, (4) participants felt that technical outreach should be targeted at the State and local level as opposed to the national level and should provide better guidance on the regulations and how to implement

[7] Currently, DE, IA, KS, MI, NV, NY, OH, SC, VT and the Virgin Islands have authorized NPDES programs, but do not have general permit authority.

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them, and (5) groups noted that coverage under certain industrial storm water categories should be clarified.[8] EPA agrees with these recommendations and is taking steps, some of which are outlined above, to follow up in each of these areas.

The second objective of the Rensselaerville study, consistent with the purpose of today's notice, is to get as much input as possible on different options for identifying and addressing those Phase II storm water discharges not regulated under the current program. Under the study, however, the mechanism for encouraging feedback was more targeted and interactive. The Rensselaerville Institute has obtained input from national experts (representing permitting authorities, the environmental community, and regulated interests) and then followed up with a series of 3 expert discussion forums that were open to the public in June.

The public meetings were held in Denver, San Francisco and Washington, DC. Attendees were divided into task teams and asked to develop their own strategy for addressing Phase II sources. There were 16 task teams: Five each at the Denver and San Francisco meetings, and six in Washington, DC. They were given a strategy template to guide them in their discussion, but were not confined to the template in developing their strategies and recommendations.

Each team considered and then presented the option they had developed over a four hour period. There were common strategy characteristics mentioned across groups within meetings and also across meetings. The recommendations of the focus groups covered four specific areas: Targeting strategies, controls that should be put in place, timetable, and the role of EPA in Phase II. The recommendations made by focus groups regarding the first three areas are discussed below along with the options presented for comment.

With regard to the role of EPA, participants identified the areas of responsibility they felt it would be appropriate for EPA to assume under Phase II. Their recommendations can be classified by four common themes: (1) Teams felt that EPA should provide technical assistance, information dissemination, and do any research necessary as a part of Phase II, (2) participants suggested that EPA should provide funding for research or demonstration projects, but not for program implementation; (3) groups stressed that EPA should set broad guidelines for the program, but allow State and local governments to determine the level of specificity needed to effectively implement the program; and (4) teams felt that EPA should be responsible for training regulators in the program.

II. Today's Notice

A. Purpose and Intent

CWA sections 402(p)(5) and (6) require EPA to identify storm water discharges not covered under Phase I which should be regulated to protect water quality.[9] The purpose of this notice is to solicit public comment on ways to implement the second phase of the storm water permitting program for sources and activities not regulated under the existing program. EPA is seeking comments on approaches for meeting CWA Phase II storm water requirements while at the same time minimizing the economic impacts and regulatory and administrative burdens associated with additional Phase II storm water controls. There are a number of ways to identify additional categories of storm water activities for further controls and EPA requests comment on the alternatives listed below as well as on any other approaches that may not be identified in today's notice.

B. Alternative Approaches

EPA is interested in comments from the general public, state and local government, the regulated community and environmental groups on each of the options outlined below. The goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In practice, programs implemented under the Clean Water Act have two basic goals: To reduce pollutant loadings to the environment and to require more stringent controls where necessary to assure attainment of State water quality standards and designated uses. These goals are compatible. However, the specific regulatory strategy and pollution reduction alternatives to be chosen for addressing Phase II storm water discharges could have a large impact on the size of the regulated universe and regulatory burden associated with the program.

To generate discussion and input from commenters, today's notice discusses several alternative approaches for controlling storm water discharges from currently unregulated sources under Phase II of the storm water program. A number of different control strategies, with variations in scope and timing, are outlined below. They range from comprehensive permitting of all municipal, light industrial, and commercial activities that generate storm water runoff to little or no NPDES permitting of Phase II sources.

A major distinction between several of the options listed below is whether Phase II efforts should focus on developing requirements for targeted municipalities to develop source controls and management programs for storm water discharges within their jurisdictions (for example, see options (b) and (c) below) or whether Phase II should, instead, focus on point source discharges of storm water without reference to the municipality in which they may be located. Under the first approach, EPA would develop NPDES requirements that required targeted municipalities to develop and implement storm water management programs which address storm water discharges within their jurisdiction [10] to the maximum extent practicable. This approach would allow for flexibility based on local factors, but could lead to varying levels of control from one area to another. EPA requests comments on the ability of municipalities to effectively regulate storm water discharges. In addition, the Agency requests comment on appropriate funding mechanisms for municipal programs, in particular the feasibility of implementing storm water utilities, which are currently being used in more than 100 communities nationwide.[11]

To facilitate comment and analysis, the following discussion is organized in terms of three issues: Targeting, control strategies, and deadlines. Each of these areas overlap and any final decision must reflect choices from each group. However, the objective is to solicit input

[8] The regulatory definition of storm water discharge associated with industrial activity identifies 11 categories of industrial facilities (see 40 CFR 122.26(b)(14)). In particular, category viii (certain transportation facilities) and category xi (certain manufacturing facilities with materials and/or materials handling equipment exposed to precipitation) were identified as needing clarification.

[9] Section 502(14) of the CWA excludes agricultural storm water runoff from the definition of point source. Section 402(1)(2) prohibits EPA from requiring an NPDES permit for certain "uncontaminated" storm water discharges from mining sites and oil and gas operations. EPA cannot regulate these discharges under section 402(p)(6) of the CWA.

[10] One issue that needs to be resolved is whether targeted municipalities should be responsible for controlling all priority storm water discharges within their jurisdiction or only those that discharge directly to the MS4.

[11] For more information see "Storm Water Utilities: Innovative Financing for Storm Water Management", EPA, Water Policy Branch, OPPE, 1992.

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on three basic questions. First, what should be covered under Phase II, that is, what additional municipal separate storm sewer systems, municipal industrial activities, commercial, light industrial, retail, or residential activities not presently covered under Phase I of the storm water program should be targeted or identified as needing additional controls? Second, what control strategies should be developed and implemented to address these Phase II activities? Third, what deadlines or time frames should apply in implementing Phase II of the storm water program?

In addressing each of these questions, commenters are requested not only to provide their views on appropriate alternatives (including approaches that may not be included in this notice), but also where possible detailed rationales and additional data or other information which address the practical, administrative and legal feasibility and/or the environmental benefits, of a particular option. In addition, each of the approaches presented could be combined with others to achieve specific environmental objectives. For example, dischargers of specific pollutants in particular water bodies could be targeted for permits or more stringent controls. Along with input on individual options EPA requests comments on possible combinations or other approaches not outlined above. Commenters are also asked to address the roles and responsibilities of Federal, State and local governments under various approaches, particularly with respect to: (1) Identifying approaches that target MS4s in currently unregulated municipal areas as needing permits, and (2) approaches that identify classes of individual facilities (e.g. commercial or retail facilities) as needing permits.

The Agency also requests input on what type of information should be used in identifying sources to be covered and whether commenters believe there is presently sufficient information or monitoring data at the state and local level to expeditiously implement a particular option listed below. If on a national or regional basis there are not sufficient data, the next question to be addressed is whether a comprehensive monitoring and data gathering effort is warranted to assure effective implementation of one approach over another. In other words, there may be a trade off between: (1) Near term general targeting approaches combined with flexible control strategies based on information currently available, and (2) a heavier reliance on longer term specific geographic, watershed, or water body related targeting mechanisms which may require more comprehensive data gathering efforts on both a facility and stream reach basis.

1. Targeting

(a) Seek amendments to the CWA to eliminate Phase II and use designation authority to bring additional sources under Phase I. Section 402(p)(2)(E) presently provides that EPA or a State may designate non-industrial storm water discharges and discharges from MS4s other than those serving a population of 100,000 or more for control under Phase I where the discharge contributes to water quality violations or is a significant contributor of pollutants to waters of the U.S. Some commenters may conclude that the remaining unregulated discharges of storm water (associated with smaller municipalities, commercial activities, and some retail or residential activities) constitute, on the whole, a negligible source of environmental risks, relative to the discharges already regulated.

Under this option, Congress would amend the CWA to eliminate section 402(p)(6) (Phase II requirements) as a part of the NPDES program and expand use of the existing designation authority under 402(p)(2)(E) to designate individual or classes of storm water activities on a category, watershed, stream reach, loadings, or other basis for specific regulation under existing Phase I requirements. Under this option, those storm water activities not designated for Phase I controls could be addressed by an alternative means, possibly under the State nonpoint source management programs funded under section 319 of the CWA or coastal nonpoint pollution control programs developed pursuant to section 6217 of the CZARA. The Agency requests comments on: (1) Whether State programs funded under Section 319 can better ensure appropriate control of diffuse pollutant sources and: (2) whether heavier reliance on State nonpoint source programs to address Phase II storm water point source discharges would have adverse impacts on States' program resources and the ability of States to address agricultural sources. The selective nature of this designation option could reduce the potential economic impact on the economy and small entities. However, using 402(p)(2)(E) may be viewed by some commenters as a reactive approach which does not recognize the advantages of prevention of storm water pollution problems over remediation of these problems after they have been identified. This approach may also increase the administrative burden on States and local government to identify and undertake the necessary administrative process to include additional storm water activity under Phase I.

(b) Identify targeted MS4s as needing an NPDES permit under section 402(p)(6) of the CWA. The Phase I MS4 program currently only applies to municipal separate storm sewer systems serving a population of 100,000 or more. EPA has defined the scope of these Phase I requirements to specifically identify 173 incorporated cities with a population of 100,000 or more and 47 counties with a population of 100,000 or more in unincorporated, urbanized areas.[12] In general, this approach focuses on core cities of large metropolitan areas, but with the exceptions of 47 counties addressed, does not address urban fringes or suburban areas in large metropolitan areas, urbanized areas without large core cities, or smaller isolated cities or population centers.[13] EPA requests comments on factors that should be considered when evaluating options for addressing Phase II MS4s.[14]

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[12] The 220 cities and counties addressed by these definitions have a combined population of over 87.8 million people under the 1980 Census. However, a significant percentage of the population of the 220 municipalities are served by combined sewers (not addressed by the storm water program), which are found primarily in areas of older development.

[13] The 1980 Census indicates that 87.3 million people lived in areas designated as urbanized areas but outside of incorporated cities with a population of 100,000 or more. Portions of over 3,400 incorporated cities, towns and villages, 800 counties and about 1,300 minor civil divisions (unincorporated towns and townships) are in Phase II municipalities that are part of urbanized areas.

[14] EPA outlined seven factors it considered when defining the scope of large and medium MS4s (see December 7, 1988 (53 FR 49444), and November 16, 1990 (55 FR 48038)). These factors included: the advantages of developing system-wide storm water management programs for municipal systems; the inter-jurisdictional complexities associated with municipal governments; the fact that many municipal storm water programs have traditionally focused on water quantity concerns, and have not evaluated water quality concerns; the geographic basis necessary for planning comprehensive management programs to reduce pollutants in discharges from MS4s; the geographic basis necessary to provide flexibility to target controls on areas where water quality impacts associated with discharges from MS4s are the greatest and to provide an opportunity to develop cost effective controls; the need to establish a reasonable number of permits; Congressional intent to allow the development of jurisdiction-wide, comprehensive storm water programs with priorities given to the most heavily populated areas of the country. The Agency requests comment on which of these factors should be considered in identifying Phase II MS4 sources.

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The Agency also requests comment on the advantages of municipalities associated with urbanized areas coordinating storm water management efforts on a regional basis. The Agency notes that a number of municipalities have developed regional administrative approaches to flood control management.[15] Regional administrative approaches appear to provide opportunities for municipalities to lower overall administrative burdens, consolidate efforts to study or evaluate approaches, and adequately plan cost-effective approaches to consider and address the needs of all represented municipalities. The Agency requests input on how it could or should encourage the development and use of regional approaches to storm water management under the NPDES program. Specifically, EPA requests comments on the following targeting options as well as any that may not be included in this notice.

(i) *Focus on population.* Expand coverage to address additional municipalities based on population. Following the Phase I approach, coverage of municipalities could be expanded by lowering the minimum population requirement across the board or by designating additional municipalities or municipal systems by name. EPA requests comments on the appropriate role of county governments and appropriate ways to characterize the population of counties under this approach.[16] This approach controls more sources of storm water, but imposes regulatory burdens on additional municipal entities.

(ii) *Focus on population density.* Alternatively, EPA could focus on the population density of metropolitan areas instead of the population within a particular municipality or municipal system, and require permits for discharges from municipal separate storm sewers in areas of a specified density. Urban storm water runoff is related to the density of urban development, the increase in impervious areas, and the reduction in the area of recharge and infiltration zones. EPA requests comment on the use of urbanized areas designed by the Bureau of Census as a tool for characterizing population density and development patterns.[17]

(iii) *Focus on population growth.* Focussing on population growth in addition to, or in place of, population density might be an additional consideration in implementing this option.[18] Studies have shown that it is much more cost effective to develop measures to prevent or reduce pollutants in storm water during new development than it is to correct these problems later on.[19] In addition, appropriate storm water measures for new development can prevent or minimize irreversible degradation to surface waters. This approach might serve to minimize the impact of small and lightly-developed population centers, but it would still increase the burden on a number of municipalities not presently regulated under Phase I.

(c) *Continued reliance on Phase I MS4s to control Phase II sources which discharge through their system.* Under this approach, EPA would generally not designate additional individual sources (such as commercial and light industrial sources) which discharge through a large or medium MS4 as needing their own NPDES permit. Instead, EPA would continue to rely on municipalities to identify priority storm water discharges and develop appropriate controls for those discharges as part of requirements to develop and implement municipal storm water management programs. This option addresses some currently unregulated sources, allows for flexibility and consideration of local factors, and avoids duplicative regulation at the local, national and State level. This approach also relies on existing institutional frameworks of municipalities[20] as well as the institutional framework that EPA envisions municipalities will develop pursuant to NPDES requirements.[21] However, it imposes additional administrative and regulatory costs on local governments and may result in varying levels of control among municipal programs. The Agency requests comment on whether municipalities are in the best position (with assistance from EPA and authorized NPDES States through technical guidance) to identify priority sources which discharge through their MS4, or whether EPA should attempt to designate such additional sources as needing an NPDES permit. The Agency also requests comments on the appropriate funding mechanisms for MS4s (e.g. storm water utilities, various fees, general revenues, etc.), and opportunities for municipalities to modify existing functions to address storm water concerns.

(d) *Identify additional Phase II activities other than MS4s based on comparative loadings.* EPA could use available information (such as case studies and other research) to prioritize Phase II sources in terms of their relative pollutant loadings as well as the type and nature of those loadings. On this basis the Agency could issue regulations to target those general activities which contribute the highest loadings of pollutants to receiving waters as needing an NPDES permit. This option is consistent with the technology-based approach reflected in the existing CWA. It would provide more comprehensive coverage and clarify the program. It would also avoid expensive and time consuming debates regarding the specific causal relationship between a particular storm water discharge and site by site specific receiving water quality impact. However, it would impose further administrative and analytical burdens in terms of gathering additional loadings information on a national basis. This approach may also result in including

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[15] For more information see: William A. Macaitis, "Regional Storm Water Management Trends", and: L. Scott Tucker, "Current Programs and Practices in Storm Water Management", Water and the City: the Next Century, Public Works Historical Society, 1991.

[16] The 1990 Census indicates that 447 counties have a population of 100,000 or more. The current definitions of large and medium MS4 address 47 of these counties not already covered by Phase I of the program.

[17] The Bureau of Census defines urbanized areas comprised of a central city (or cities) with a surrounding closely settled area. The population of the entire urbanized area must be greater than 50,000 people, and the closely settled area outside the city, the urban fringe, must have a population density generally greater than 1,000 persons per square mile (just over 1.5 persons per acre) to be included. The Bureau of Census defined 396 urbanized areas in the United States based on the 1990 Census. These urbanized areas have a combined population of 158.3 million, or 63.6 percent of the nation's total population. However, these areas only account for 1.5 to 2 percent of the land surface of the country.

[18] Most Urban growth occurs in urban fringe areas outside of large core cities. For example, between 1970 and 1980, the population in those parts of Census designated urbanized areas that are outside of incorporated cities with a population of 100,000 or more increased by 18.9 million. During this same time period, the population of incorporated cities with a population of 100,000 or more (Phase I cities) increased by only 0.6 million, with the population of many of these cities decreasing.

[19] For example, see "Results from the Nationwide Urban Runoff Program, Vol 1—Final Report", EPA, 1983.

[20] Examples of municipal functions that can be adapted to provide for consideration of storm water concerns include oversight of new development, fire safety inspections, pretreatment program implementation, flood control activities, management of municipal lands and activities, and maintenance of public roads.

[21] The NPDES regulatory framework for permits for large and medium MS4s envision that municipalities will be required to develop and implement storm water management programs to reduce pollutants in non-storm water discharges (e.g. illicit connections and improper dumping); storm water from residential and commercial areas; storm water discharges from industrial activities; and storm water discharges from construction activities.

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more sources than necessary due to differences in loadings and existing storm water controls, both structural and non-structural, across similar activities. The regulatory burden would be determined in large part by the overall control strategy chosen to implement this approach.

This approach differs from those outlined under options (b) and (c) in that it relies on direct permitting by EPA and authorized NPDES States rather than requiring municipalities to develop programs to address sources. The Agency requests comments on which sources of pollutants are better addressed by specific NPDES permit requirements rather than through municipal storm water management programs required pursuant to NPDES permits for MS4s. For example, activities generally located in rural areas such as feedlots, orchards, and golf courses most likely are not suited for control through municipal storm water management programs required under permits for MS4s. Although large feedlots (those subject to effluent limitations guidelines) presently are covered under Phase I, smaller feedlots represent a significant source of pollutants such as suspended solids, BOD, and nutrients such as nitrates and phosphates. In addition, storm water discharges from commercial activities such as greenhouses, nurseries, and golf courses might be more effectively controlled under a separate NPDES permit requirement than through a MS4 program. As another example, many commenters from all levels of State and local government have expressed concern about municipalities being required to control pollutants from State highways (see November 16, 1990 (55 FR 48041)).

(e) Geographic targeting. EPA could regulate Phase II storm water activities on a watershed, waterbody, or regional basis to protect water quality, control water quality problems and attain designated uses in specific areas. EPA could:

(i) Designate additional municipal and individual sources for permitting in specific areas. A key aspect of this approach would be developing a list of waters that are not meeting designated uses due to pollution from storm water runoff (from section 305(b) reports or from the section 304(l) list of waters) or where sensitive waters or outstanding national resource waters need special protection. This approach could help to achieve water quality goals and would avoid imposing a burden on other dischargers, but would not be uniformly applied on a national basis. This option is also reactive in nature, and overlooks the advantages of prevention over remediation. The availability of technical information and water quality data limitations and the administrative and regulatory burden associated with collecting and analyzing additional data would have to be carefully considered in evaluating the feasibility of this approach.

(ii) Designate additional sources for permitting or special requirements within rainfall zones. The nature of storm water problems varies between areas with frequent rainfall, where storm water flows are high with continual pollutant loadings, and areas with low or seasonal rainfall, where intermittent flows carry highly concentrated loadings of pollutants accumulated during dry weather which result in high shock loadings to receiving waters. This option would recognize these regional variations and tailor regulatory requirements for Phase II discharges (monitoring, best management practices, reporting) to the local nature of rain events. However, immediate environmental benefits could be delayed due to the inexact nature of rainfall zones and the scarcity of comprehensive information upon which to base regulatory requirements.

(f) Establish requirements for State storm water management programs. Under this approach, EPA could develop requirements for State storm water management programs under section 402(p)(6) for the CWA which would require States to identify additional classes of storm water discharges for control. This approach may offer the advantages of additional flexibility for States to target sources based on State specific factors (climate, water resources, development patterns) and provide additional flexibility in the type of administrative program developed. However, the disadvantages of this approach include the need for generating additional resources at the State level at a time when State capacity is also strained, and possible disparities in programs in different States. Such disparities could make it hard for a State to develop an aggressive program when neighboring States have lesser requirements. Further, this approach may create additional burdens on EPA to provide adequate oversight of the State programs. EPA also requests comments on the appropriate role of EPA in reviewing State plans or developing minimum requirements for State plans and how that role should change, if at all, for States without authorized NPDES programs. The Agency requests comments on appropriate criteria for evaluating the adequacy of State programs, and appropriate procedures for periodic review and evaluation of such programs. EPA also requests comments on whether this approach could be harmonized with the requirements of section 402(p)(6) for EPA to take the lead in developing management practices and controls for Phase II sources, or whether this approach might also require statutory change.

(g) Rensselaerville focus groups. There were several common themes recognized by the focus groups with regard to identifying potential sources to be included in Phase II.

(i) Groups suggested that targeting be done on a watershed basis, with information gathered as a part of Phase I used to help identify sensitive watersheds. It was noted that this type of targeting approach may require intergovernmental agreements for effective implementation.

(ii) Teams emphasized that the focus of Phase II should be on "bad actors", i.e. those sources that are known to cause significant water quality problems. Sources identified by team members included: Gas/auto service industries, transportation, highway systems, land use development and agricultural sources. There was a consensus among groups that facilities not contributing to impairment of water quality should be able to gain an exemption from controls, permits, fees, and implementation of BMP's. Teams concluded that SIC categories are an ineffective way to designate covered sources and that targeting should be done based on the degree of risk that a given facility poses, due to possible differences between facilities in any one industry.

(iii) Focus groups recommended that small municipalities be included in Phase II but with simplified application requirements. Participants felt that municipalities impacting watersheds of concern or those connected to larger MS4s should be targeted.

(iv) Participants in the study felt that EPA should hold off on selecting sources for Phase II until the Agency has carefully looked at the date gathered during Phase I. It was noted that numerous sources of information are available which could help determine targeting priorities, for example, 305(b) reports, information from Phase I program sources, NURP, and the first Report to Congress.

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2. Control Strategies

The current Phase I storm water program for industrial sources is implemented through the NPDES program with a heavy emphasis on the use of general NPDES permits which require the implementation of best management practices including development of site specific pollution prevention plans. Phase I requirements for large and medium MS4s focus on system-wide permits which require the development and implementation of municipal storm water management programs.

Regardless of how additional Phase II storm water activities are identified—whether they are designated under 402(p)(2)(E), comprehensively covered, or selectively targeted for further controls, a key issue on which EPA requests comment is what are the appropriate tools or control strategies to put in place which assure pollutant loading reductions and water quality improvement?

(a) Continued reliance on NPDES program. One option is the continued reliance on individual or general NPDES permits for individual sources, and system-wide permits for MS4s. Developing or processing specific application forms for and issuing individual permits for all Phase II sources may well be the most resource intensive of any control approach. Consistent with EPA's four tier Phase I permitting strategy for industrial storm water sources, individual permits may be most appropriate in those case specific situations where a particularly difficult or complex discharge situation needs to be addressed. By contrast, input from the public and regulated community to date suggests that heavy reliance on general permits may well be a very effective alternative within the NPDES system. EPA solicits comments on whether continued reliance on NPDES permitting as the overall control strategy for Phase II is the most appropriate approach. An extensive State and national administrative NPDES infrastructure already exists and is being relied upon for Phase I and reliance on the general permit is increasingly favored as an appropriate storm water control strategy. However, the capacity of the current system with its existing resources to accommodate a significant number of additional permittees has already been called into question for Phase I. A very real issue exists as to whether the permitting Agencies have the resources to address more than a limited number of additional Phase II permittees.

(b) Continued reliance on nonpoint source program. Another approach includes continued reliance on the State nonpoint source programs under section 319 of the CWA and future reliance on programs under section 6217 of the CZARA in coastal areas to control Phase II storm water sources not explicitly addressed or designated under Phase I.

The structure, organization, and working relationship within EPA and State offices for the section 319 program are established and proven successful. The States have taken the lead under section 319 to develop assessments of storm water/nonprofit source impacts and management programs to implement controls. EPA has approved all States assessments, 44 complete management programs, and portions of all the remaining State management programs. The States management programs typically include continued problem assessments and monitoring, voluntary control measures, mandatory control measures established under State and local authorities, State funding assistance, public outreach, technical assistance, enforcement, targeting of priority waters, and coordination with other Federal and State programs and agencies. Therefore, the section 319 program's potential ability to control Phase II sources is high. Also, section 319 programs are founded on a watershed planning and pollution prevention/source reduction approach which may be an effective vehicle to provide program and technical assistance to State and local governments.

In addition, the new CZARA program provides an excellent tool to address Phase II sources in the coastal zone in a comprehensive manner. EPA emphasizes that the goals of the NPDES and CZARA programs are complementary. Many of the techniques and practices used to control urban runoff are equally applicable to both programs. While different legal authorities and geographic coverage may apply to specific sources. States have the option to implement CZARA section 6217(g) management measures throughout the coastal zone, as long as NPDES requirements are met for those entities subject to NPDES requirements. States outside of the coastal zone may also voluntarily incorporate the management measures appropriate to particular sources or specific problems into the State's CWA section 319 program.

(c) Mandatory performance standards, guidelines, management practices and/or treatment requirements. An alternative option might also be to develop a set of mandatory national Phase II control guidelines that apply directly to Phase II storm water activities without a permit. The national pretreatment categorical effluent guidelines is an example of this approach. Permits by rule or general permits without application or reporting requirements are a similar concept. A variation on this approach might include the development of minimum categories or classes of BMP's or pollution prevention approaches with a requirement that elements from each class be chosen and implemented on a facility or system specific basis. At one level, this approach would appear to reduce the regulatory and administrative burden associated with submission of Phase II storm water applications. However, as a technical matter, it may be extremely difficult to develop one national rule that appropriately addresses all Phase II storm water activities. Developing such a rule may take a significant amount of time and may also entail substantial monitoring and data collection. A further issue upon which EPA solicits comment is whether a national rule would be the most effective approach given that many members of the Phase II universe may not be familiar with national regulations and may not even be aware that such requirements apply to them. EPA recognizes that implementation of control strategies other than NPDES permitting would probably require statutory change and requests comments on what changes would be appropriate.

(d) Rensselaerville focus groups. Focus groups identified several common themes with regard to controls that should be put in place for Phase II:

(i) Focus groups recommended that if a permitting process is to be continued for Phase II sources, NPDES general permits should be used, and the focus should be on the implementation of effective BMP's. Participants felt that permits should be simpler, less costly, and that EPA should make absolutely clear to applicants what information is required through the use of checklists of inclusion, a menu of potential BMP's, and other documents to assist permitees. The team members again stressed that exemptions from permitting should be available for sources not contributing to water quality problems.

(ii) The teams concluded that education is often overlooked and that it should be a primary component of any Phase II program. Team members felt that education is important for all audiences and that local level education

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for the public and affected industry is critical to the success of the program.

(iii) There was an agreement among teams that there should be more emphasis on voluntary programs, perhaps similar to those under the 319 nonpoint source program. Groups also suggested that for facilities that have contact with storm water, there should be limited additional governmental intervention, but rather an emphasis on pollution prevention incentives, BMP's, and specific pollution prevention techniques. Participants stressed that pollution prevention should be emphasized, particularly with new development. Some suggested prevention methods included: recycling storm water, good housekeeping practices, plantings to minimize runoff, street sweeping of work areas on a daily basis, storm water collection methods, coverage of storage areas, changing manufacturing processes to minimize pollutants and better controls of air emissions.

(iv) Groups felt that there should be correlation between the severity of the problem and the degree of controls required and that fines and fee structures could be used as "carrot-stick" measures to aid implementation.

3. Deadlines

Section 402(p) presently provides that the current prohibition against permitting Phase II sources expires on October 1, 1992. EPA solicits comment on the possible options for alternative deadlines for Phase II permit application requirements and statutory revisions of the CWA. One option is for Congress to extend the current October 1, 1992 deadline for Phase II sources. Under this option, EPA requests comment on what the new Phase II date should be and why one particular extension is more appropriate than another. For example, one possible date might be October 1, 1995, to allow one year for additional data gathering and public input on appropriate Phase II sources and control strategies and then two additional years to propose and finalize Phase II regulations.

Another strategy might be to adopt a phased set of Phase II deadlines with high priority storm water sources covered first and lower risk sources addressed at a later date.

A third approach follows option 1 under Targeting; that is, to eliminate the Phase II deadlines and follow option 1 or direct EPA to follow some other option.

Focus group recommendations from the Rensselaerville study suggested that a minimum of 2–3 years is needed to prepare for Phase II, with at least a year dedicated to looking at data gained from Phase I of the storm water program and other documents such as the first Report to Congress. Participants also felt that the effectiveness of presently used BMP's needs to be looked at to determine variations in effectiveness between different geographic locations and pollutants.

III. Request for Comments

EPA is requesting comments on all aspects of the Phase II storm water permitting program. EPA is soliciting general comments on environmental objectives and economic impacts, as well as specific recommendations and implementation advice on each of the options outlined above. Based on comments received and the results of the two studies required under CWA section 402(p)(5), EPA may propose a rule under section 402(p)(6) or solicit additional comments on options again when more data becomes available. In addition, EPA welcomes data or information from ongoing studies that support specific comments or recommendations.

A. General Issues for Comment

Based on the discussion above and the President's memorandum on reducing the burden of government regulation, EPA requests comment on the advantages and disadvantages of each option outlined above as well as any other potential approaches in terms of the following factors.

1. How well does the approach perform with respect to the environmental goals of protecting water quality, reducing pollutant loadings, and achieving designated uses in impaired waters? EPA requests comment on which of these approaches most lends itself to the documentation and establishment of environmental baselines and identification of appropriate environmental indicators against which to evaluate progress. EPA specifically solicits input on appropriate environmental indicators in connection with any of the approaches outlined above or identified by a commenter.

2. Does the option balance the need for regulation to protect/improve the environment with the desire to minimize the regulatory burden and maximize the cost effectiveness of the approach?

3. Does the option help to reduce the regulatory burden on potential permittee, while still maintaining environmental benefits?

4. Does the option help to reduce the administrative burden on Federal, State and local government, so that resources are used to address important environmental problems efficiently?

5. To what extent does the option support or provide an incentive or additional flexibility for implementing pollution prevention and other innovative permit approaches?

6. Does the option allow or encourage the use of market incentives or trading to promote greater or more effective loadings reductions and water quality improvements?

7. What is the impact of the proposed approach on small businesses [12] and communities?

8. does the option allow consideration of the issue of affordability as a factor in determining which Phase II sources should be controlled? For example, some data indicates that average per capita income in suburban fringe areas is substantially higher than in core cities. Does the option allow this to be factored in when identifying high priority groups or selecting appropriate control strategies?

EPA requests specific implementation recommendations based on the respondent's general evaluation of the options outlined above. EPA also seeks detailed comments on how the option will be implemented and ways to refine the respondent's preferred approach. For example, address issues of affordability, cost effectiveness and possible funding mechanisms and sources, in addition to providing case examples where available of successful State or local implementation of a preferred option. Respondents should also consider the need for statutory changes or rulemaking to implement recommended approaches.

B. Current Classification of Regulated Discharges

The current regulatory framework of Phase I is summarized in appendix A. This information may help respondents to understand which types of municipalities and commercial and light industrial activities are not currently regulated under Phase I of the program. Sources exempted from Phase II and some sources potentially covered under Phase II are summarized in appendix B.

IV. Review and Analysis Requirements

Various reviews and analyses are required to assess the economic or paperwork impact of new rulemaking activities under Executive Order 12291, the Paperwork Reduction Act (44 U.S.C. 3501, et. seq.), and the Regulatory Flexibility Act (5 U.S.C. 601, et. seq.).

[12] With respect to impacts on municipalities, the agency requests comments on options municipalities have for generating the revenue required to run such programs.

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These assessments are not necessary for this notice, which merely requests comments on ways to reduce the regulatory burden of potential future rulemaking.

Dated: September 1, 1992.

Martha G. Prothro,

Acting Assistant Administrator.

Appendix A. Facilities Covered in Phase 1

1. Industrial Facilities

EPA has defined the term "storm water discharge associated with industrial activity" in a comprehensive manner to address over 100,000 facilities. All storm water discharges associated with industrial activity that discharge directly to waters of the United States or through municipal separate storm sewer systems are required to obtain NPDES permits, including those which discharge through systems located in municipalities with populations of less than 100,000. Discharges of storm water to a combined sewer system or to a Publicly Owned Treatment Works (POTW) are excluded. Facilities with storm water discharges associated with industrial activity include: manufacturing/industrial facilities; construction operations disturbing five or more acres; hazardous waste treatment, storage, or disposal facilities; landfills; certain sewage treatment plants; recycling facilities; powerplants; mining operations; some oil and gas operations; airports; and certain other transportation facilities. Operators of industrial facilities that are Federally, State or municipally owned or operated (with the exception of certain facilities owned or operated by a municipality of less than 100,000 people [1] that meet the description of the facilities listed in 122.26(b)(14) (i)–(xi), described below, must also submit applications.

SUMMARY OF INDUSTRIAL ACTIVITIES COVERED UNDER PHASE I OF THE STORM WATER PROGRAM

40 CFR 122.26(b)(14) Subpart	
(i)	Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutants effluent standards under 40 CFR, Subchapter N (except facilities which are exempt under category (xi)).
(ii)	Facilities classified as
	SIC 24 (except 2434)—Lumber and wood products.
	SIC 26 (except 265 and 267)—Paper and allied products.
	SIC 28 (except 283 and 285)—Chemicals and allied products.
	SIC 29—Petroleum and coal products.
	SIC 311—Leather tanning and finishing.
	SIC 32 (except 323)—Stone, clay and glass products.
	SIC 33—Primary metal industries.
	SIC 3441—Fabricated structural metal.
	SIC 373—Ship and boat building and repairing.
(iii)	Facilities classified as:
	SIC 10—Metal mining.
	SIC 11—Anthracite mining.
	SIC 12—Coal mining.
	SIC 13—Oil and gas extraction.
	SIC 14—Nonmetallic minerals, except fuels.
(iv)	Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA).
(v)	Landfills, land application sites, and open dumps that receive or have received any industrial wastes including those that are subject to regulation under subtitle D or RCRA.
(vi)	Facilities involved in the recycling of material, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as.
	SIC 5015—Motor vehicle parts, used.
	SIC 5093—Scrap and waste materials.
(vii)	Steam electric power generating facilities, including coal handling sites.
(viii)	Transportation facilities covered by the following SIC codes which have vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category, are included.
	SIC 40—Railroad transportation.
	SIC 41—Local and suburban transit.
	SIC 42 (except 4221-25)—Motor freight and warehousing.
	SIC 43—U.S. Postal Service.
	SIC 44—Water transportation.
	SIC 45—Transportation by air.
	SIC 5171—Petroleum bulk stations and terminals.
(ix)	Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including lands dedicated to the disposal of the sewage sludge that are located within the confines of the facility, with a design flow of 1.0 Million Gallons per Day (MGD) or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA.
(x)	Construction activity including clearing, grading, and excavation activities except operations that result in the disturbance of less than 5 acres of total land area which are not part of a larger common plan of development or sale[1].
(xi)	Facilities under the following SICs [which are not otherwise included in categories (ii)–(x)], including only storm water discharges where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to storm water[1].
	SIC 20—Food and kindred products.
	SIC 21—Tobacco products.
	SIC 22—Textile mill products.

[1] In the Intermodal Surface Transportation Efficiency Act of 1991, Congress provided that industrial activities owned or operated by municipalities with a population of less than 100,000 be placed into Phase II of the storm water program with the exception of airports, power plants and uncontrolled sanitary landfills.

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SUMMARY OF INDUSTRIAL ACTIVITIES COVERED UNDER PHASE I OF THE STORM WATER PROGRAM—Continued

40 CFR 122.26(b)(14) Subpart	
	SIC 23—Apparel and other textile products
	SIC 2434—Wood kitchen cabinets
	SIC 25—Furniture and fixtures
	SIC 265—Paperboard containers and boxes
	SIC 267—Converted paper and paper board products (except containers and boxes)
	SIC 27—Printing and publishing
	SIC 283—Drugs
	SIC 285—Paints, varnishes, lacquer, enamels
	SIC 30—Rubber and misc. plastics products
	SIC 31—(except 311)—Leather and leather products
	SIC 323—Products of purchased glass
	SIC 34 (except 3441)—Fabricated metal products
	SIC 35—Industrial machinery and equipment, except electrical
	SIC 36—Electronic and other electric equipment
	SIC 37 (except 373)—Transportation equipment
	SIC 38—Instruments and related products
	SIC 39—Miscellaneous manufacturing industries
	SIC 4221—Farm products warehousing and storage
	SIC 4222—Refrigerated warehousing and storage
	SIC 4225—General warehousing and storage

[1] On June 4, 1992 the United States Court of Appeals for the Ninth Circuit found that EPA's rational for exempting construction sites of less than five acres and certain uncontaminated storm water discharges from category xi light industrial facilities from Phase I of the storm water program to be invalid and has remanded these exemptions for further proceedings (see *Natural Resources Defense Council v. EPA* No. 91-70176).

Source: FEDERAL REGISTER, Vol. 55, No. 222, p. 48065, November 16, 1990

2. Municipal Facilities

"Municipal separate storm sewer" is defined as any conveyance or system of conveyances that is owned or operated by a State or local government entity designed for collecting and conveying storm water which is not part of a Publicly Owned Treatment Works. The application requirements do not apply to discharges from combined sewers (systems designed as both a sanitary sewer and a storm sewer). Municipal separate storm sewer systems that are addressed by the November 16, 1990 regulations include storm sewers located in one of 173 cities with a population of 100,000 or more; located in one of the 47 counties identified by EPA as having large populations in unincorporated, urbanized areas; and systems that are designated by the Director based on consideration of the location of the discharge with respect to waters of the United States, the size of the discharge, the quantity and nature of the pollutants discharged to waters of the United States, and other relevant factors. These are named in Appendices F–L of the November 16, 1990, regulation.

INDUSTRIAL AND MUNICIPAL PERMIT APPLICATION DEADLINES

Type of Application	Deadline	
● Individual	October 1, 1992	
● Group	Part 1	Part 2
All industrial activities except those owned or operated by a municipality with a population of less than 250,000	September 30, 1991	October 1, 1992
Industrial activities owned or operated by a municipality with a population of 100,000 to 250,000	May 18, 1992	May 17, 1993
● General Permit NOI	Deadline established in the general permit, but no later than October 1, 1992 for existing sources.	
	Part 1	Part 2
Large Municipalities	November 18, 1991	November 16, 1992
Medium Municipalities	May 18, 1992	May 17, 1993

Appendix B. Potential Universe of Phase II Dischargers

Phase II potentially includes all point source discharges of storm water to waters of the United States (including Municipal Separate Storm Sewer Systems) that are not regulated under Phase I of the storm water program (See Appendix A). The following table illustrates those types of operations which have been statutorily exempted from both Phase I and Phase II of the NPDES storm water program along with a general list of potential Phase II sources:

Statutory / Regulatory exemptions:	● Non Point Source Silviculture Activities. ● Agricultural Runoff and Irrigation Return Flows. ● Uncontaminated discharges from Mining, Oil and Gas Operations.
General categories of sources	● All municipalities with populations less than 100,000.

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- All industrial activities not regulated under Phase I (including those owned/operated by municipalities under 100,000 [illegible] farms, auxiliary facilities [illegible])
- Commercial activities with industrial components (gas stations, dry cleaners)
- Construction activities involving less than 5 acres [1]
- Large parking lots (shopping malls, stadiums)
- Residential property
- Recreational areas (ski areas, golf courses, amusement parks)
- Livestock facilities (stables, feedlots not addressed by Phase I regulations [2], etc.)
- Greenhouses, nurseries

[1] On June 4, 1992 the United States Court of Appeals for the Ninth Circuit found that EPA's rationale for exempting construction sites of less than five acres from Phase I of the storm water program to be invalid and has remanded the exemption for further proceedings (see *Natural Resources Defense Council v. EPA* No. 91-70176).

[2] Feedlots, as a class of facilities, have been associated with high loadings of pollutants such as suspended solids, BOD, and nutrients such as nitrogen and phosphorus, and could be an example of a targeting approach based on high loadings.

[FR Doc. 92-21653 Filed 9-8-92; 8:45 am]

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APPENDIX I

REPORT ON THE EPA STORM WATER MANAGEMENT PROGRAM (RENSSELAERVILLE STUDY)

United States
Environmental Protection
Agency

EPA830-R-92-001
October 1992

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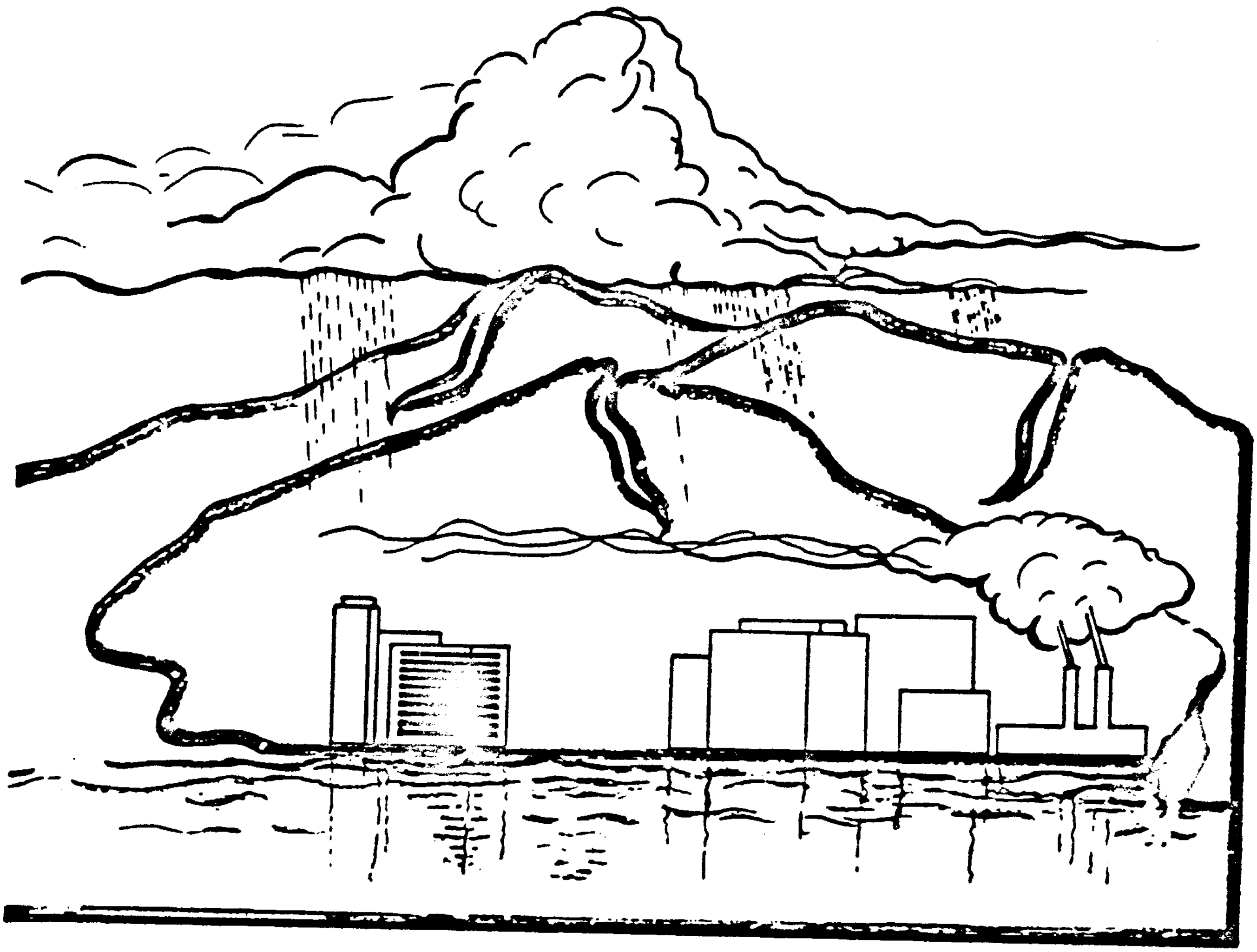

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Report on

The EPA Storm Water Management Program

Conducted for the U.S. EPA Office of Wastewater Enforcement and Compliance
by The Rensselaerville Institute

Volume 1

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Report on

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Conducted for the U.S. EPA Office of Wastewater Enforcement and Compliance by The Rensselaerville Institute

Volume I
Final Report Submitted: October 1992
EPA Report # 830-R-92-001

ACKNOWLEDGEMENTS

We are most grateful for direction and guidance for this project provided by the Office of Wastewater Enforcement and Compliance, Michael B. Cook, Director; James Horne, Project Officer.

We also acknowledge the efforts of those persons who participated in the focus groups, the expert surveys, the public forums, and the "design team" session. The thoughtfulness of opinions and insights voiced is impressive.

We are encouraged by the willingness of people with very different perspectives to not only listen carefully to each other but to seek common ground. The prospects for collaborative work are strong.

Mary E. Marsters
Harold S. Williams
The Rensselaerville Institute

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EXECUTIVE SUMMARY

In December 1991, the Deputy Administrator of the U.S. Environmental Protection Agency (EPA) asked the Office of Water to undertake a research project with two objectives: 1) identify ways to improve and streamline the existing storm water regulatory program implemented by the agency under Section 402 (p) (2) of the Clean Water Act: and 2) define and annotate options for controlling sources of storm water runoff designed for Phase II of this same section.

In response to this request, the Office of Wastewater Enforcement and Compliance (OWEC) engaged The Rensselaerville Institute to develop a two-part project to gather and integrate diverse opinion and insight on ways to improve the efficiency and effectiveness of the existing Phase I program and the best possible response for the Phase II program designed to cover remaining storm water sources and problems.

Part I of the project was conducted during February and March, 1992 when six focus groups were held around the U.S. to gain user feedback on how the current regulations and implementation procedures could be improved and streamlined. These groups, which included representation by both public- and private-sector permittees as well as regulatory agencies, private consulting firms, industry, and environmental interests, identified numerous ways EPA and others could address permitting and compliance procedures seen as difficult or problematic.

Part II of the project began with an Expert Survey of 32 persons highly knowledgeable in storm water and its control who represented different perspectives (academic/research, state/local government, commercial development, environmental advocacy, and consultant/engineering) and different geographic areas. Experts were asked to respond to a set of options for targeting and controlling sources and to suggest additional alternatives as well. Insights on voluntary measures that have proven effective in storm water control were solicited through a separate survey of five experts in nonpoint program approaches.

Based on the results of these surveys, three public meetings were announced in the Federal Register and held in Denver, San Francisco and Washington, DC during June, 1992. Those attending were divided into teams and asked to define their own preferred strategies for a Phase II program response, including definition of sources to be regulated, the preferred method of control (permit-based or other) and their sense of both timetable and the role EPA should play.

Finally, a small group of insightful individuals representing diverse viewpoints from both point source and nonpoint source programs was convened for a strategy design meeting for the purpose of adding greater depth and breadth to one or more Phase II approaches identified in the public meetings. From this group, a ten-point strategy was created, as well as a series of recommendations to EPA on developing the second phase of the storm water program.

This Executive Summary presents the findings from each of these activities in summary form. More complete recommendations are contained in the body of Volume I. The project data base is contained in Volume II.

Summary of Findings on Improving Phase I of the Storm Water Program

Forty individuals participated in focus groups held in Atlanta, GA; Hartford, CT; Chicago, IL; Washington, DC; Seattle, WA; and Phoenix, AZ. Together, the participants included all identified viewpoints and separable interests--including EPA regional staff, state and local government officials, engineering consultants, environmental advocates, and representatives of corporations included in Phase I permitting.

Participants responded to a set of questions which probed for opinion and insight on such matters as the unclear aspects of the Phase I regulations, additional steps that should be taken to simplify the process and help permittees to achieve compliance, and the relative merits of individual and group permits. In addition to participant responses to core questions, the afternoon of each session was used to further elaborate problems and solutions of interest to participants in an informative format.

While many issues raised were location- or source-specific, some spanned geographic and demographic boundaries. Eight issues common across all focus groups were identified as key areas to be clarified and/or modified to improve program implementation:

1. EPA has not been clear about the intended goals of the regulations. A stronger sense of the relative importance of storm water in the framework of environmental risk is needed, as is clarity about short range and long term targets. There is a difference, for example between clean water standards and stream health standards. It is clear that there are storm water permits. It is not clear how the permits reflect a coherent program.

2. The expense of program implementation is significantly higher than EPA has estimated. There is great concern over what the program's real costs have been in terms of dollars and manpower costs of preparing a permit application, and the anticipated costs of achieving compliance. A broader concern: municipalities now beleaguered by resource shortfalls cannot reasonably afford the combined costs of compliance with all environmental regulations.

3. The administrative complexity of the program is enormous at the federal, state and local levels, and has quickly outpaced the availability of resources and manpower needed to carry it out. In some cases, field staff have been

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pulled in simply to process the paperwork involved.

4. Clarification is needed on the roles and expectations EPA has for itself, states and permittees. What is clear to everyone is that EPA does not have the capacity to administer and enforce the program alone. This cannot be seen as an EPA program administered in a "command and control" style totally from Washington. It must involve active participation, not simply passive compliance, from all levels involved.

5. More technical support for the program is needed. Expanded information explaining the regulations and how to implement them is especially needed. Also, there should be less "national level" support and more focus on regional conditions. Much of the content of storm water workshops held at EPA headquarters is irrelevant to any given participant.

6. States need EPA to either clarify how to interpret unclear points of the regulations, or allow them the latitude to make the interpretations themselves. One unclear area is the inconsistencies and inequalities created by use of industrial SIC codes in such areas as transportation. Another murky area is the group application process.

7. EPA should consider consolidating programs in order to address water pollution in an efficient and cost-effective manner. A watershed approach is preferable to current practices of separating problems by media.

8. General permits are "the way to go" and EPA should continue to focus on and accelerate efforts in this direction.

Many focus group members made a point of indicating their pleasure with the focus group format used and the ways in which EPA had 1) encouraged interaction and customer insight and 2) listened carefully to their advice. A complete report on focus group responses and conclusions is contained in the body of this publication.

Summary of Findings on Designing Phase II of the Storm Water Program

Expert Survey

The second part of the Rensselaerville project began with a survey of a select group of 32 point source storm water program experts from across the country. The purpose was to solicit opinions on ways to implement the second phase of the storm water program. Five perspectives were represented: academic/research; commercial development; consultant engineering/legal; environmental advocacy; and state/local government. A first mail-back survey round gained opinion and consensus on relevant issues and

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options for addressing Phase II sources. Data from the first set of returned surveys were analyzed and given back to participants in a second survey round, which refined positions and created more options for Phase II consideration.

To ensure inclusion of all critical perspectives, five nonpoint source program experts were asked to provide feedback, with emphasis on potential voluntary approaches for addressing Phase II sources.

While approaches recommended differed by profession and geography, these common targeting themes emerged for identifying whom to include in Phase II:

- develop a geographically-based phasing plan by watershed impairment/severity of threat;
- determine selection criteria for pollution sources and use these to identify municipalities that should participate;
- do pilot projects first, evaluate, and then develop and implement a strategy;
- encourage and fund comprehensive basin research and planning to guide targeting;
- require Phase II industries to be covered under Phase I general permits;
- develop national guidelines, and leave selection of sites and methods to state discretion;
- require smaller communities (< 100,000) to apply for permits only when their storm water contributes a significant pollution problem;
- designate problem areas, establish permit requirements for municipals regardless of population, and allow municipals to exclusively regulate industries; and
- initiate a focused dialogue with key stakeholders (applies to both targeting and controls).

Common themes expressed for control strategies included:

- build a Best Management Practices (BMPs) menu that can be used by states to implement and verify progress;

- require localities to select from a list of BMPs the ones most appropriate for their needs and apply industry-specific BMPs nationwide with allowance for state/local officials to modify;

- provide nationwide public education and community-wide public education on the need for storm water control;

- establish national or industry-specific minimum practices for controlling storm water;

- implement good housekeeping and source reduction practices;

- require routine certification and audit of storm water pollution plans and practices;

- establish industry-specific and watershed-specific BMPs; and

- establish BMPs required nationwide and strictly enforce. Require facilities to further treat storm water discharges where BMPs are not effective.

The strongest additional factor in nonpoint survey responses was the degree of emphasis placed on education at all levels, including the general public, local and state officials, and local businesses and industry. Education was seen as the key to making voluntary approaches effective. Voluntary compliance, in turn, was then advanced as highly cost effective.

Respondents feel that EPA must be the "stick" that would fall--with permit requirements, fines, etc.--if a storm water source does not voluntarily take action and achieve certain minimum goals. But limited manpower and financial resources form a rationale for not addressing Phase II with the costly conventional federal mandates of Phase I.

Public Meetings

Three meetings were conducted to gain public responses to options for targeting and controlling Phase II sources. They were held in Denver, CO; San Francisco, CA; and Washington, DC during June, 1992. At each meeting, three experts selected from the Expert Survey process presented their ideas on a regulating strategy for the moratorium sources. Participants were then divided into small task teams, and given the charge of devising their own strategies for targeting and controlling Phase II sources. A strategy template was provided to guide group consideration of three key issues: 1) who should be covered under Phase II; 2) what controls are needed; 3) over what timeframe the program should be implemented. At the end of each public meeting, the task teams presented their options to other participants for discussion.

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Common strategy characteristics emerged, in many cases paralleling those apparent in the expert survey. For targeting:

- Targeting should be done by watershed. Information gathered from Phase I should help identify sensitive watersheds. This may require intergovernmental agreements.

- The focus should be on "bad actors", i.e., those that are known problem sources. The ones most frequently identified were: gas/auto service industries, transportation, highway systems, land use development and agricultural sources. There needs to be the ability for facilities not contributing impairment of water to gain an exemption from permits, fees, implementation of BMPs. Categories are an ineffective way to designate covered sources - should be done by the degree of risk a given facility poses, because it may not be a whole industry, but rather individual facilities.

- Small municipalities should be included, but they should have a much simpler application process. Or, only small municipalities where a storm water problem is identified should there be required action.

- EPA should defer on selecting targeted sources until the agency has carefully looked at the data gathered during Phase I. Numerous sources of information are available which would help determine targeting priorities, e.g., information gathered through 305b reports, information from Phase I program sources, the NURP study.

For needed and desirable controls, these themes emerged:

- If a permitting process is to be continued for point sources, NPDES general permits should be used, and focus should be on implementing Best Management Practices (BMPs). Permits should be simpler, and much less costly. EPA should make clearer to the applicant what information is required, e.g. provide the permittee with a "checklist of inclusions" for the application, develop a menu of BMPs. Permit exemptions should be granted to those targeted sources who offer no contribution to the problem.

- Education should be seen not as an "add-on", but rather as a primary tool for effective control. Locally implemented education for public and industry is especially important; the premise is that information and conviction born of education will encourage many to take the needed preventive and remedial steps.

- More emphasis should be placed on voluntary programs, e.g., 319 nonpoint

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source-like programs. For facilities with contact with storm water, there should be little or no government intervention, but rather emphasis on pollution prevention incentives, BMPs, and measures of pollution prevention.

Pollution prevention programs should be emphasized, particularly with new development. Some suggested prevention methods included: recycling storm water, "good housekeeping" practices, plantings to minimize runoff, street sweeping of work areas on a daily basis, storm water collection methods, coverage of storage areas, changing manufacturing processes to minimize pollutants, and improvement of air emissions.

- Closer correlation should exist between the severity of the problem and the degree of controls required. Fines and fee structures could be used as "carrot-stick" measures.

- BMPs should be required based upon the specific pollutant problem. EPA should develop a menu of BMPs to assist businesses in determining the appropriate BMP for their problem.

In terms of a timetable for phasing in Phase II, two widespread opinions emerged:

- A minimum of two years is needed to prepare for Phase II, with at least a year dedicated to looking at data gained from Phase I of the storm water program. Effectiveness of presently used BMPs needs to be studied to determine differences in effectiveness between geographic locations and pollutants.

- Whatever the period established for phase-in, it should not begin until promulgation of the regulations.

A final question in the strategy template: "**For whatever strategy is chosen, what could EPA do to make the decision-making process for Phase II more responsive?**" generated responses focused on some common themes:

- Coordinate information dissemination, e.g., set up regional clearinghouses offering such program information as general permit writing, effective applications of BMPs, and examples of successful efforts from programs around the country.

- Provide funding not for program implementation but for needed research, e.g., on BMP effectiveness, and for demonstration projects.

- Set broad guidelines for the program and establish minimum standards, and then allow state and local regulatory agencies determine how to achieve them.

- Develop and implement training programs for regulators, including regional and state, on the program. These people are the ones who will be the informational source for the regulated community, and need to know the details of the program.

As with the focus groups the participants in the public meetings felt positive about the format used. A mail-back survey returned by more than 30% of meeting participants showed that they strongly favored this interactive process over what they perceived as the conventional practice of a stream of public comments that encouraged adversarial positioning and boredom for those listening. Comments of attendees included:

- "The opportunity to formulate an entire strategy to deal with this issue was very useful;"
- "I obtained a better point of view of government's problems and felt that government representatives also obtained a better point of view of industry's problems;"
- "Result was a much less confrontational and much more problem-solving atmosphere;" and
- "It was a valuable way to address drafting of regulations, allowing the regulated community to feel a part of the process."

The body of this report contains a further elaboration of the process and the ways in which it might be used by the EPA in other communication and outreach efforts.

Design Team Meeting

A meeting of seven point and non-point storm water program experts, all of whom were survey respondents, and selected EPA staff was convened in Washington DC on September 17-18, 1992. The purpose was to gain the experts' varied insights on development of the Phase II storm water program and to build a strategy, or multiple strategies, for addressing Phase II sources.

Many discussions were specific to certain types of activity--not only municipal or industrial, but to specific kinds and levels of enterprise. Others focused on regional differences--for example the strong distinctions from places that are uniformly wet, uniformly dry, or highly volatile in hydrological terms. Still others found differentiation in scale--such as the difference in impact a regulation would have on a city as compared to a small town. These distinct findings are contained in the full report which follows in this volume.

A broader set of ten recommendations emerged for the major Phase II challenge which generally transcend such differences. They include:

1. **It is possible and desirable to identify priority target areas for which there is widespread consensus concerning their contribution to water pollution.** These areas begin with new development and redevelopment--both residential and commercial. They also include transportation corridors, dense existing development and automotive services.

2. **EPA needs to communicate more clearly and regularly with everyone impacted by the storm water regulations.** The priority focus should be less on the amount of communication and more on different kinds of communication.

3. **EPA could improve program effectiveness, efficiency and cost control in Phase II by "starting small".** The concept of regional and even local prototypes is a way of getting proposed new Phase II frameworks into the hands of users in prompt fashion to build and refine based on early use.

4. **Selectivity in data collection and monitoring is essential.** At present, some data collection frameworks consume tremendous time and money only to yield bad or useless data or murky or disputed conclusions. At other times, very simple actions taken with known consequences require simple verification, not extensive measuring.

5. **More customer differentiation is also needed.** At present the mind-set appears to be that one size fits all. While giving the appearance of equity, this concept actually creates strong inequalities. The same programs and regulations that befit a large corporation or municipality are simply not equitable for smaller enterprise and communities, for example.

6. **While the ultimate goal is water quality standards, this is very difficult to achieve and/or to measure in the short term.** Therefore, while retaining water quality standards as the ultimate goal, EPA should be focusing on best management practices, and in particular those that reflect preventive and non-structural solutions.

7. **The most functional unit of both analysis and intervention is the watershed.** Most people in our samples for opinion and recommendation strongly suggested the watershed approach--not only on the macro level (e.g., Chesapeake Bay) but the micro-level as well.

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8. **EPA's role is to offer technical support and direction more than program funding or even full guidelines for state and local implementation.** In particular, building useful data bases and collection methodologies not only on water quality but on practices to achieve it is critical. Such practices should include education, given that prevention and voluntary compliance are much less costly than litigation.

9. **A collaborative approach to developing effective solutions is possible.** The interactive elements of this project are one reflection of the ability of those with strikingly different perspectives (ranging from strong environmental protection to a focus on economic development) to work cooperatively.

10. **Agriculture's absence from the storm water program is notable and regrettable.** In many regions, agriculture (which includes livestock as well as crops) is a primary contributor to surface water pollution. Permitting or in other ways controlling the transport of agricultural products introduces intervention too late.

The remainder of Volume I amplifies these findings and presents the rationales and key data points which underlie them. Volume II includes the complete data base, including all instruments used to collect and analyze information.

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PART I: IMPROVING PHASE I OF THE STORM WATER PROGRAM

In December, 1991, the Deputy Administrator of the U.S. Environmental Protection Agency asked the Office of Water to undertake a project that would achieve two results: first, identify ways to improve and streamline the existing storm water regulatory program currently being implemented by the agency; and second, develop options for controlling sources of storm water runoff not currently required to be permitted under Section 402(p)(2) of the Clean Water Act.

In response to this request, the Office of Wastewater Enforcement and Compliance (OWEC), working with The Rensselaerville Institute, developed a two-part project. This section addresses the outcomes from Part I, which focused on identifying improvements to the existing regulatory program.

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Description

As the first part of The Rensselaerville Institute's project to help EPA assess the effectiveness and efficiency of the existing Storm Water Program, focus groups were held in diverse regions of the country to gain feedback on how the regulations promulgated on November 16, 1990 could be streamlined and improved. Six such meetings comprising representatives from state, municipal, private industrial and environmental groups were conducted between February 24 - March 2, 1992.

A total of 40 individuals participated in the focus groups, which were held in Atlanta, GA; Hartford, CT; Chicago, IL; Washington, DC; Seattle, WA; and Phoenix, AZ. The format for each meeting was the same: participants provided feedback on eleven questions developed by EPA and Institute staff. The questions:

1. **Which aspects of the storm water regulations are least clear?**

2. **What additional steps would be helpful in assisting permittees achieve compliance in the allotted timeframe? Who should take those steps?**

3. **Exactly what kinds of guidance and information are needed to help people implement the program? How would you prioritize these listed storm water program activities in terms of their usefulness?**

4. **Is there a need for EPA to do more national workshops on the storm water regulations? What about regional or local workshops? On which subjects?**

5. **What support should states, as opposed to EPA or other organizations, be expected to provide to their "universe" of permittees? What resources do they need in order to provide those supports?**

6. **If you had to name three ways to streamline the permitting process, what would they be?**

7. **What could EPA do to encourage those states without general permit authority to get it? What steps are needed to get general permits out? What simple, short-term grassroots efforts can associations and trade groups take to help this effort, and how could EPA support those efforts?**

8. **What outreach efforts to explain to permittees what they have to do to comply with the regulations have been most effective to date? Are there informational pieces that EPA could prepare that would best help these efforts?**

9. What are the techniques, methods or strategies you would recommend to help permittees achieve water quality standards? In what timeframe should permittees be required to comply with WQS?

10. Given that construction activities are most often local in nature and temporary in duration, do you have suggestions about how EPA could more effectively regulate such activities?

11. What suggestions would you offer in terms of the most efficient way to enforce EPA existing regulation requirements, both application requirements and substantive permitting requirements?

Responses to question #6 were revisited in the afternoon of each session, when participants were asked to further define their recommendations, indicate who they felt should be responsible for initiating the changes, and list the initial steps they would take.

Response summaries were drafted following each meeting and sent to participants for additions and modifications. Their changes were incorporated into their respective reports. This overall report summarizes, interprets, and analyzes group discussions and conclusions.

Focus Group Findings

Despite the many issues surrounding implementation of the regulations, the consensus of all focus groups, including industrial representatives, was that storm water control is needed and appropriate. There was general agreement that storm water is a significant contributor to water pollution. Some felt that a regulatory program was appropriate to address the problem. A number of participants expressed that, overall, the storm water program is significantly more rational and easier to deal with than other EPA water programs, for example, the wetlands program.

Yet the storm water regulations still inspire much confusion and frustration. There is frustration with EPA, as well. Many felt there was a lack of consideration given to their inputs by the agency prior to promulgation of the regulations, and some thought that EPA had been unresponsive to questions and concerns voiced since the regulations went into effect. When pressed, however, most admitted that they perceived this to be an endemic or generic problem of government. For a few, this perception will not be changed. However, most were impressed that EPA was now willing to actually look at the storm water program and solicit input from those dealing with the regulations on how they could be improved or streamlined.

Reservation was voiced, however, that EPA would do nothing with the recommendations generated from these focus groups. Their concern was that the results would have as little impact on EPA's decision-making and responsiveness as had previous efforts to make their opinions known.

It is critical, therefore, that EPA identify those procedural changes made in response to the recommendations, and make them known both to focus group participants specifically and to the permitted and regulatory communities in general.

The range of concerns voiced was large, and differed between geographic regions and the representational make-up of the group. Each group raised issues that were quite specific to themselves or their region, e.g., New York City was concerned about the effects of tidal flow and backwater as they relate to water quality; Utah and other arid and semi-arid states were concerned about sampling procedures when there was scarce rainfall; Seattle felt that the regulations did not allow its storm water program to build on earlier work; general contractors do not understand why concrete mixing requires a separate permit even though it is done on the construction site, etc. The specificity of concerns for each group is reflected in the individual summary reports, which are included in Volume II.

Some issues and concerns identified, however, spanned geographic and demographic boundaries. They were raised across groups as key areas in need of clarification and/or modification. There were seven broad areas identified where members felt efforts should be made to improve and streamline the storm water regulations.

1. **Permittees and regulatory agencies feel that the EPA has not been clear about the intended goals of the regulations. A view of the "bigger picture" is wanted.**

   While group members agree that storm water is a contributory factor to water pollution, there does not seem to be an understanding of what EPA hopes to achieve with the regulations promulgated in November 1990. A frequently heard comment was that "the big picture" is missing. Participants felt that EPA has not been clear about how these regulations will accomplish the goal of achieving clean water, and in what timeframe. This has hampered efforts to comply because many do not understand what they should be setting as performance targets.

   One participant said, "What is a clean urban stream?" The point: participants were not sure what goals they need to attain to comply with the regulations and protect themselves from being sued or fined for non-attainment. Almost all participants felt that water quality standards were useful as the ultimate goal toward which to work, but were unachievable in a two- or three-year period. When asked what they felt would be a reasonable timeframe, estimates ranged from five to thirty years, with a few participants indicating that, given the large number of pollutant sources impacting on a given water body, achievement of water quality standards through the storm water program alone is a strong improbability. One participant stated that the scientific community's perspective is, "...there is no way water quality

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standards can be achieved with known storm water technologies"; it will take further research and development of BMPs before water quality standards could be achieved.

It was clear that members need more guidance about where the program is headed. Participants want EPA to be more explicit about what should be achieved in terms of improvement of water quality in the timeframes that have been given and with the technologies that are presently available.

Group members were aware that environmental advocacy groups will bring pressure on EPA to hold to established numerical water quality standards, and that reducing or replacing them is not likely a viable option. As one representative from an environmental advocacy organization stated regarding water quality standards, "...(they are) the heart of the Clean Water Act." Participants felt, however, that EPA needs to explicitly acknowledge that cleaning up the waters of the U.S. is a long-term effort that requires federal, state and local governments to work in partnership with permittees rather than through "command and control" relationships. Permittees fear being sued for non-compliance when in fact they are making the best efforts possible.

Permittees and regulatory agencies want EPA to provide them the time and support they need to design and implement storm water programs that make sense in terms of effectiveness and cost. They feel that EPA, by not clearly stating goals, has hampered efforts to deal with the problem; permittees are not sure which approaches to take because they don't know what they have to achieve. They want the guidance and information necessary to implement the most appropriate measures available for their discharges, and the time to evaluate those efforts. As one group member observed, "...What is needed is a longer period (than the permit period) to do BMPs - and then monitor their effectiveness. Where necessary, go back and change things. It's an evolutionary process. This is not a quick tech fix! EPA is creating more problems than answers. October 1 should not be 1992, it should be 1995."

If EPA is to achieve success with the program, it needs to address confusion over program goals and timeframes. The agency needs to be explicit about what it expects industrial and municipal permittees to accomplish in the first permit period, what they expect them to achieve in the longer term, and what they anticipate the impact of the storm water program to be on overall water quality.

2. **The cost of program implementation is significantly higher than EPA estimates. There is great concern over what the program's real costs have been in terms of dollars and manpower.**

A great concern of focus group members was the excessive cost of preparing a

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permit application, and the anticipated costs of achieving compliance. A number of state representatives indicated that implementation of their state program took, in terms of staff time alone, more than all other water programs combined - without the concomitant added federal dollars that those programs provided. That EPA has provided minimum federal dollars for the program is a major issue. Municipalities and industries were concerned with the significant additional costs of manpower and technology needed for both application and compliance. One focus group participant brought for discussion a study done by the School of Public and Environmental Affairs at Indiana University. The study has identified that the actual mean cost for Part 1 of the municipal application process for 59 cities exceeded by <u>six times</u> the EPA-estimated costs of the program [Gebhardt & Lindsey (1992), "NPDES Requirements for Municipal Separate Storm Sewer Systems: Costs and Concerns"].

That EPA has set aside some monies to assist in program development is not commonly known information. There was confusion among a number of focus group members about the availability and applicability of grant monies, e.g. 104(b) funds, that <u>are</u> dedicated to implementation of the program. For example, within the same focus group, one person said that they had applied for and received the funds to help prepare their application; another member replied that they were told that the monies could <u>not</u> be used for that purpose. Members of some groups were unaware that the funds were available at all. This indicates that communication from EPA has been inadequate in letting eligible groups know that there are some, albeit limited, dollars available to help them in setting up their programs, and that there has been inconsistent communication about the guidelines for use of those funds. Further, every person who indicated knowledge of the money also noted that the funds available were minuscule in comparison to what was needed to actually get their programs up and running.

Some states have developed the necessary revenue-gathering mechanisms to fund their storm water program. One state representative indicated that, by charging permit fees, they have been able to hire six staff people for the program. A few other state representatives indicated that storm water utilities had been successful in helping to raise the funds necessary for program operations. A significant number, however, contend that their state does not have the funds to implement the program, nor do they have a system devised to raise these funds. Therefore, wholehearted efforts are not being made to respond to the regulations. Further, some states have implied that they do not consider storm water a priority, and therefore are not willing to devote any portion of their budget to the program. This latter point creates a significant problem for the thousands of permittees in such a state that are then without a critical support system to provide them guidance and technical assistance.

The storm water field in general is perplexed that EPA could promulgate these regulations without at least providing "seed monies" to assist the application process and help states set up their own revenue-generating systems. To some, the message EPA sent by not providing funds is that the agency itself is not invested in the program. If EPA plans to continue to regulate storm water without providing financial assistance, one way it could assist permittees is to provide guidance and examples of successful fund raising systems that some states have devised, e.g., storm water utilities.

3. **The administration of the program is enormous. Clarification is needed on the roles and expectations EPA has for itself, states and permittees.**

Much of the controversy surrounding the regulations arises from unclear delineation of the roles, responsibilities and authority of each level. What is clear to everyone is that EPA alone does not have the capacity to administer and enforce the program. Therefore, much responsibility must fall on state and municipal levels. However, the regulations do not delineate the responsibilities of each level. Group members were clear that they want EPA to be more decisive and explicit about what is expected of states and municipalities in terms of administration and enforcement, and the areas where they will be allowed authority and flexibility in decision-making.

Some state and local governments have not waited for EPA to define their roles. The regulatory deadlines were powerful motivators for them to move forward without such guidance. Thus, frequently heard was states' hesitancy to discuss with EPA what they were doing programmatically, because they were afraid they might not be doing it "right", i.e. in accord with what EPA wants done. They were concerned about asking EPA for clarity they feared the agency might take away their assumed authority since it had not been specifically assigned in the first place. A number of state representatives admitted that they interpret the regulations in their own way rather than wait for EPA to provide interpretation. As one state representative put it, "...we looked at the regs as guidance rather than rules. We do it our own way. We are not sure if it is appropriate, (so) I have concerns asking for guidance from EPA because they may take away our latitude to make our own judgments."

The vagueness in assignment of responsibility and authority has clearly hampered program implementation. It may have been the intention of EPA to be less specific so that other entities would make their own interpretations, but they clearly do not feel comfortable assuming responsibility or authority. Many have been frustrated by the agency's lack of response when trying to gain clarity of the regulations. For example, one trade association representative stated that, in order to inform his membership about the regulations, he wanted to publish in their trade newsletter an article that outlined their members' responsibilities under them. To ensure that his interpretation was in accord with EPA's, he submitted the article to

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EPA for review. In his words, "I waited a month, and when EPA did not respond, I went ahead and printed it. They [EPA] didn't like that."

Some state representatives said that they were unwilling to help industrial people make decisions on whether they are covered by the regulations, because they do not want to be held accountable when EPA has not specifically given states the authority to make interpretations of the SIC codes. Participants felt that the states are more likely than EPA to know the specifics of the industries in their boundaries, and also to know which ones are high-risk pollutant sources. But states do not feel that EPA has given them the authority to use that knowledge to make their own judgments on whether an industry is covered or not.

Industries also feel unsure about their responsibilities under the regulations, and are turning to the states for guidance. The regulations are unclear, for example, about what level of program implementation is expected in a given timeframe. As one state representative put it, "...there needs to be some guidance from EPA to the <u>states</u> on what (industries) need to do!"

States feel they have more knowledge of the industrial risks within their boundaries, and know what is needed to bring those risks into compliance. A number of focus group members cited the uselessness of having EPA develop requirements and guidance for <u>any</u> given industry when it did not <u>understand</u> specific industries. They felt it far more effective for EPA to work <u>with</u> industrial representatives when developing materials to ensure clarity and correctness. This would likely create the added benefit of gaining industry's commitment to achieving certain results.

Given the magnitude of these regulations, the lack of funding available to support implementation, the fiscal constraints under which all levels of government are operating, and the limited staff at each level, working in partnership with states and permittees rather than through a "command and control" relationship could get the program in place more quickly and maximize its effectiveness. EPA needs to determine each government level's responsibilities, be explicit about what decisions and flexibility can be allowed, and be clear about what <u>results</u> are expected from each level of government if given the authority to interpret certain aspects of the regulations.

4. **More supporting information for the program is needed, and dissemination of that information needs to be improved.**

Information supplementary to the regulations, explaining them and providing explicit information on how to implement them, was cited as a critical need that had only partially been met. All focus group members gave feedback on those pieces of EPA-generated information they thought was useful, what they felt was not helpful, and what other information they desired or felt was needed. They also addressed the regulations themselves as a source of information.

a. Written Documents

Written information EPA has provided to supplement the regulations, such as guidance documents and supportive materials, received overall good reviews. Numerous participants stated that both the Industrial and Municipal Permit Application Guidances were helpful.

The primary problem with much of the written guidance and information is that it is coming out too late to be useful. A number of participants indicated that a model general permit would have been helpful, but that they were at the point of writing their own, so for them it was too late. Often group members' suggestions for specific informational documents were accompanied by the caveat that it was needed now, e.g., permit writers guidance; Model Permits for MS4s: a BMP manual; Construction Activity Guidance.

Not everyone wants to receive new information at this point in the program. A number of participants said, "Don't do anything...We have a track: anything that would confuse that would be a problem. Even clarification. We have an idea for what we want to do and if guidance comes out now, it might conflict with what we want to do."

One person commented that EPA should prepare guidance documents so that they can be released concurrently with promulgation of the regulations. This would avoid not having them ready in a useful timeframe. A number of participants felt that EPA should be more willing to release information in draft form if the final document is going to be late. EPA should make preparing information for Phase II of the program a priority; the timeliness of delivery is a reflection of the program's credibility and of EPA's commitment to the program. It is clear that those who have gone forth without the support of written guidance are going to be highly resistant to any input by EPA that would require them to modify what has already been done.

Dissemination of EPA documents has been inconsistent. Regions vary in their thoroughness of distribution. One group member said, "...EPA needs to be better at getting this stuff to us. I often have somebody walk into the office with something that has been out for three months that I have not seen." This frustration was echoed in a number of the focus groups. EPA needs to publish a list of available documents which people can request either in writing or through the Hotline.

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b. Verbal Communications

The Storm Water Hotline received mixed reviews from group members. The primary response was that it effectively addressed very basic questions, but that the program had advanced quickly to the point where more technical information was needed. Trust in the ability of those answering the phones to address complex issues was low. However, this is not an unusual response to Hotlines; often callers complain that information given is inadequate, inconsistent, or not appropriate to the situation of the caller.

Some focus group members stated they were pleased with the response they had gotten from the Hotline. Some indicated that they were relieved just to have someone to call for program information. Others felt it was a good way to confirm their "hunches". Overall, given the size of the program and the number of phone calls that have been received, the perception of the Hotline is relatively positive.

Some alternative roles were suggested for the Hotline. Members stated that it could be used as an information clearinghouse, having available a list of sources that callers could turn to for more technical information. One person suggested that operators have lists of experts in categories to whom they could refer callers for more information.

One frustration voiced was that reaching EPA staff people was a problem. This has created for some the perception that EPA headquarters staff are unapproachable. On the practical side, however, responding to all the phone calls they receive would tie up all available staff for the duration of the program; headquarters staff would do nothing but answer phone calls. Yet it is important to recognize that this problem influences people's perception of EPA's commitment to the program. Perhaps with EPA's attention to the more substantive items listed in this report, e.g., getting documentation out in a more timely manner and with more thorough dissemination, etc., this perception will self-correct.

c. Workshops and Presentations

All groups felt that workshops of national scope were no longer needed, because the issues being dealt with were now more technically specific to certain industries or areas. The consensus was that state and local workshops, providing industry-specific guidance and information on water pollution control, were most needed. Most felt that such workshops should be sponsored and planned by trade associations and other membership associations like APWA, WEF, ASIWPCA, etc. rather than EPA. They did feel that EPA should be a speaker at the programs, and be willing to help address the federal perspectives in response to local concerns.

A main concern of group members, from coast to coast, is reaching those

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industries who are covered by the regulations: many businesses covered under the regulations do not know that they must apply for a permit. Trade associations were recommended as one of the best ways to get to the harder-to-reach permittees (usually referred to as "Mom-and-Pops"), but even they are limited to those businesses who are members. Group members mentioned other avenues through which they have tried to reach these businesses, such as direct mailings to municipalities and working through Chambers of Commerce. None have been completely effective. Most members said that this was not solely EPA's responsibility, but also one of states, local governments and trade associations as well. EPA could support this effort by suggesting methods for reaching these businesses, and contacts at the national level that could be helpful, e.g., Small Business Administration.

d. <u>The Regulations as Information</u>

The Federal Register notice of the regulations was considered by participants to be a key source of information about the program. Numerous comments were made about its inability to convey needed information clearly and concisely. Length, layout, language and accessibility were identified as deterrents for many "laypeople" to comprehend them.

One member said the length was approximately 127 pages too long; he felt it should have been three pages, with a focus on what the regulations will do to reduce water pollution. Many felt that the regulations were not user-friendly because of the language used, which they referred to as "legalese". One person remarked, "What is needed is an English version of the regs!" The citations were claimed to be confusing, and some felt substantive requirements were "buried" in the wrong section, e.g., important permitted industrial activities were in the Definitions section, and municipal requirements were scattered throughout rather than placed in a "Municipals" section. Another noted that the three-column format was difficult to read for most not used to the Federal Register format.

Many noted that the Federal Register is a publication that may be picked up by <u>some</u> large businesses, but would rarely find its way into the smaller ones. Given the widespread impact of the regulations, there is valid concern that EPA views the Federal Register as a primary method to "get the word out." They felt this was not a good assumption, since circulation of the Federal Register is very limited, leaving the vast majority of those industries covered by the regulations unaware that they are affected.

There is need for a more clearly stated version of the storm water regulations. Trade associations have done a great deal to try to reduce the regulations to laymen's terms for their members. But when supplemental guidance documents, which are more reader-friendly than the regulations, are not quickly forthcoming

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and the regulations provide the only source of information, confusion is inevitable.

5. **The regulations lack clarity on a number of key aspects. State authorities need EPA to either clarify these points of the regulations, or they need EPA to allow them the latitude to make the interpretations themselves.**

During each focus group, members discussed many particular points of the regulations that they had found unclear. These varied from group to group, depending on the perspectives represented. As one would guess, points that to a municipal person lacked clarity were often different than issues of concern to an industrial representative. For example, industrial representatives spoke of confusion with deadlines as a result of the Surface Transportation Act amendments, how to pick the appropriate permit to apply for, and how industries connected to municipal sewer systems should deal with the regulations. Municipal representatives, on the other hand, mentioned specific sampling and field screening methods, the definition of Maximum Extent Practicable, what to do about application sampling requirements in the face of drought conditions, and how to classify industrial parks as issues that lacked clarity. Further, participants felt there were some aspects where there was room for interpretation. Important to them was knowing where they would have latitude to <u>make</u> interpretations.

Presented here are the areas <u>commonly identified</u> as in need of clarification by EPA.

a. Who is covered under the Industrial SIC codes:

Every group questioned EPA's use of the Standard Industrial Classification codes to determine which industries should be included under the regulations. The consensus was that these codes, which are economic indicators, are inappropriate for regulations that deal with environmental issues. Their use has caused a great deal of confusion as various industries try to apply them to their "primary" activities. Businesses don't know how to use them to determine if they are included under the regulations - and regulatory agencies are <u>very</u> reluctant to make that call for them given the "downside" of either decision. Group members indicated that the Transportation category (#8) and the category of Exposure (#11) were the most problematic and inconsistent.

One state representative said that trying to get businesses past this first decision point had consumed most of the manpower in their office. They were receiving 80-90 phone calls a day <u>just</u> on that question; they had to hire a "temp" to respond to these phone calls and refer callers either to an EPA field office or a consultant. Another group member said that they did one informational mailing to businesses in their county, and were flooded with 7,000 phone calls; they did not know how to respond to callers, so they ended up hiring a consultant to handle the questions.

One comment from a member in the Phoenix group accurately represents the feeling expressed across focus groups: "It is virtually impossible to determine who needs a permit...You are not looking at the runoff quality with the SIC codes. I do not know of an existing code that looks at runoff, and that ought to be the basis of the code (used for these regulations)."

EPA needs to clarify how these codes are to be used. As one member stated, "OMB decided to use the SIC codes for other than they were intended. EPA (therefore) must define how to use it; this needs research and an environmental interpretation done." EPA also needs to be explicit about states' liability if their interpretations of coverage are different from what EPA's would have been. One group member suggested that EPA put together a brief (1-2 page) guidance summary to help industries decide whether they are covered, and also to develop descriptive categories of industries covered. EPA needs to define the minimum criteria for coverage to help regulatory agencies and industries determine their status, and then give latitude to states to use Best Professional Judgment when making decisions to include or exclude a given industry.

b. Exposure:

The category of "exposure" was cited by all groups as one of the two most difficult to determine. Members requested that EPA allow regulatory agencies to use Best Professional Judgment in determining which industries should be covered. Examples were mentioned, included the artist doing metal sculptures (all his activities took place indoors), and the farmer trucking potatoes to the potato chip factory (he was advised to cover his load with a tarp). As one member stated, decisions on whether an industry falls under the exposure category need to be determined on a case-by-case basis, and may require a site visit for a final decision to be made. Members did feel this category was "good" because it is the only one that is risk-based, yet "bad" primarily because exposure is "fuzzy".

EPA needs to allow states to develop their own definition and criteria for exposure, reach agreement with them, and be comfortable with the possibility that states may be different. The enormous number of covered industries under the category would otherwise exhaust EPA's resources to deal with it.

c. **The group application process:**

Focus group members feel that the group application process has created significant confusion among permittees: there is no such thing as a group permit, yet there are large numbers of industries that participated in a group application still under the impression that they will be covered by a group permit. As a number of participants stated, "(those who applied for one) think group applications mean group permits. And that is not the case."

One industrial member voiced their frustration: "Industry feels that the group application was misrepresented. (We thought,) this looks good; we can band together, demonstrate our likeness, devise sampling techniques, and regulate accordingly. Then we heard that you don't get a group permit; you get sent to the next tier down - the state. And the state then decides what you get... This has discouraged us from being proactive, forward thinking, because the rules keep changing in mid-stream."

Some members thought the group application was a useful process. One stated, "The group application process will get the best information at the least cost. It is the best research process because you can control it. For example, the textile industry: consultants will get together with them to determine how sampling and BMPs will be done. It provides a source of comparison within industry."

EPA needs to let participating industries know what the process is about, what the next steps will be for them after application review, and where there will be extended timeframes for them to submit a NOI under a general permit or an individual permit application.

6. **EPA needs to consider consolidating programs in order to address water pollution in an efficient and cost-effective manner.**

All groups suggested that EPA look at consolidating the different water programs for greater cost-efficiency and effectiveness. Rather than looking at it by different water source, e.g., storm water, wastewater, wetlands, etc., limited federal resources could be applied on a prioritized basis by watershed. Group members felt that this approach would eliminate redundant efforts across programs, allow dollars to be spent by risk priority rather than through separate program allocation, and have a more profound effect on reducing water pollution.

The perception is that present programs are more interested in "bean counting"; that is, keeping their present funding levels at the expense of the environment. One group member said, "Avoid bean counting...Transfer the funds to where it makes sense. Some water bodies have five different funding streams. (EPA) should look at one water body, and look at point and non-point factors. See if we can pull the program together to yield an environmentally efficient program that brings all this together. This would form a prototype of pollution elimination by integration of programs." Another suggested the development of a "water pollution block grant."

In no group was there a concrete discussion on how EPA would accomplish this at a federal level, although many thought that a start would be to get people from each of the programs to "sit down together in the same room" to discuss ways of working together toward the same goals. State representatives were aware of program separation at their level, and cited the different funding streams - with some programs having far more than others - available for each one. It is clear that most would like to see a strategy in place that allows monies to be allocated based upon watershed priority. This ability to be able to shift funds between programs many felt would have eased the financial burden of getting their storm water programs up and running.

7. **EPA should continue to focus on general permits in order to get the program implemented as efficiently as possible.**

One of the most-mentioned ways of reducing regulatory burden was the use of general permits to cover as many industries as possible. Many state participants voiced frustration at EPA's slowness in getting a model general permit out, and some remarked on their slowness in reviewing state applications for general permit authority. One indicated that it had taken their state nine months for approval. Yet groups were unanimous that general permits are an excellent way to streamline the program.

Participants felt that states should **want** permit authority; as one member put it, "...they should want control over their own destiny." States that have not applied for general permit authority, such as New York, are seen by permit applicants as unhelpful. One voiced frustration that his state DEC office could not provide assistance when he needed it, because the state had chosen to "ignore" the regulations; he has looked to the regional EPA office for assistance, even though he was not sure that was the "right" route for him to go. Another state representative said that her state wants authority because "they could then issue more permits, cover more people. It's revenue-producing, and the dollars would come into (our) department."

Many participants predicted that states without general permit authority will be overwhelmed by the number of individual permits. They felt that EPA, as well as state and national trade associations, should make states aware of the consequences of not having general permit authority. One suggestion often heard was to get trade associations involved in lobbying state legislatures to put pressure

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on their state government. Some members recommended that EPA also put pressure on states to apply for permit authority by using a carrot-stick approach: assist them to apply, but withhold program monies from non-delegated states. Others suggested that the carrot be dollars, such as the 106 monies, used as an incentive. Participants felt that getting most industries into the program under a general permit umbrella would establish a baseline for the program so that a tiered approach could be used to identify and deal with pollutant sources.

It was evident from comments that some state representatives would like to see a model general permit. They are looking for guidance in developing their own, and models--either EPA-generated or state-generated--would obviously assist states in drafting their own. Critical to this effort is that this assistance be made available as quickly as possible.

There is a common thread across these seven issues. That thread is the need for more and clearer communication, from use of terminology and language more familiar to the "layperson", to explicit guidance on fund raising approaches to support program implementation.

In many organizations, "improved communication" is cited as a sought-after end, but it is often set forth without identification of the means by which to achieve it. With this project, EPA addressed the means by asking the "experts"--those people at the regional, state and local levels who have to ensure that the regulations are implemented--where communication has faltered and what is needed to address the problem. It will be the continued involvement of these people in working on solutions that will ensure successful achievement of the end.

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PART II: DESIGNING PHASE II OF THE STORM WATER PROGRAM

The second part of The Rensselaerville Institute project was conducted during April-September 1992. It consisted of three distinct efforts: a survey of point source and nonpoint source program experts to gain their insights on the development of a strategy for Phase II of the storm water program; three public meetings to gain citizen advice on key elements that should be considered for the Phase II program; and facilitation of a "design team" effort with selected experts to generate a detailed strategy to guide EPA in planning and implementing Phase II of the storm water program.

For each effort, the focus was on three elements: **targeting** (which sources shall be included and by what categories); **control** (e.g., should permits be used or another strategy developed); and **timetable** (with what schedule and over what period of time should Phase II be implemented, particularly with regard to the October 1, 1992 deadline established in the Clean Water Act amendment).

This report profiles project activities, then summarizes the findings from each of them. The reader is referred to the supporting documentation in Volume II of this report for the database compiled during this project, including analysis and comments from the Expert Survey.

Expert Survey

Part II of the project began with survey input from a select group of 32 storm water experts from throughout the country. Five perspectives were represented: academic/research; commercial development; consultant engineering/legal; environmental advocacy; and state/local government. A Delphi-type survey approach was used to obtain initial opinion and consensus on relevant issues and options for addressing Phase II sources.

Two survey rounds were conducted with point source program experts. The instruments presented respondents with a series of potential targeting and control strategies along with timing options. Survey participants were asked to identify the strengths and weaknesses as well as steps and resources needed to implement each option and were also given the chance to suggest an alternative strategy to the ones presented.

Five nonpoint program experts received one survey designed to capture more specific information on voluntary approaches for achieving program success. They were asked to provide the same level of detail for their preferred strategy as point source experts. Please see Volume II of this report for survey transcripts and analyses.

Survey Findings

Respondents were asked to identify, from a list of 18 potential sources, which sources they felt to be the top five that "must be" regulated in Phase II. In descending order with frequency of response in parentheses, the sources identified were:

1. "Some industrial activities not covered under Phase I because of anomalies in the SIC codes." (24)

2. "Suburban areas of large metro areas outside city boundaries." (20)

3. "Some commercial activities with industrial components." (18)

4. "Large retail complexes." (15)

5. "State highway systems." (13)

The themes that characterized the designation of these sources as the top five included: 1) contribution to pollution load; 2) risk posed; 3) administrative efficiency of control; and 4) cost-effectiveness of control.

Respondents were presented with specific strategies for targeting and controlling Phase II storm water sources. They were asked to assign a level of desirability and feasibility to each. The scale used ranged from "1" (least desirable, least feasible) to "7" (most

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desirable, most feasible).

The three targeting strategies, and ratings and comments they received, are listed below.

Responses to Strategy I were spread across the scale: 39% of respondents felt it was "very desirable" and 36% rated it "not desirable". The same response pattern was given to feasibility: 21% rated it highly feasible while 29% rated it not feasible. That strategy was:

Strategy I: "Eliminate Phase II as a separate part of the storm water program and expand the current designation authority under Section 402 (p)(2)(e)."*

> *** 402(p)(2)(e): A discharge for which the Administrator or the State, as the case may be, determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.**

Some of the comments made by experts regarding this strategy included:

- "Gives the Administrator too much authority."
- "This approach provides the greatest flexibility and provides time so that we can learn from current programs."
- "Not feasible...unfortunately, the science is often not good enough to pinpoint culprits; the database...is weak; it is difficult to single out one of many candidate polluters."
- "Allows resources to be focused strictly on problem sources from the Phase II universe."
- "Arbitrary and capricious interpretation of intent of Congress."
- "Very desirable and feasible. It makes sense to target programs to areas that contribute to water quality standard violations and are significant contributors of pollutants."

Responses to Strategy I were the most mixed. While some saw it desirable because sources covered would be more selective and limited and therefore the program would require less resources and administration to implement, others did not support it because they were unsure what criteria would be used for targeting sources, and were concerned about the types of information used in decision-making as well as the experience of those making the decisions.

Most respondents felt that Strategy II would be costly, complex and unwieldy, and resemble Phase I in terms of its drain on resources and manpower. Some respondents felt it would expand the number of groups opposing storm water regulations.

Strategy II: "Cover all remaining point source storm water discharges under existing Phase I requirements."

This strategy received a mean rating for desirability of 2.25 and a mean rating of feasibility of 2.43.

Some of the comments regarding this strategy included:

- "Inadequate resources would pose a major implementation problem."
- "Ill advised and will be increasingly costly. There is no need to promulgate new regulations that we know will not be enforced."
- "Would be an administrative nightmare."
- "Too broad with respect to potential benefits."

Strategy III was seen by a majority of respondents to be the most equitable and rational of the three choices, as well as the most scientifically based. Concern that political pressures might sway the development of targeting criteria was expressed by some respondents. That strategy is:

Strategy III: "Apply Phase II controls selectively (e.g. on the basis of such factors as population density, pollutant loadings, or geographic targeting, or others you find to be appropriate)."

This strategy received a mean rating for desirability of 4.64 and a mean rating of feasibility of 3.75. It was rated the most desirable and feasible of the three suggested strategies.

Some expert comments on this strategy were:

- "Best of all worlds - reasonably objective."
- "Strategy III is the most desirable of the three strategies because it maximizes efficiency, effectiveness, and the flexibility to address water pollution problems based on site-specific factors, especially risk."
- "Sound on a technical basis, but probably requires too many resources, particularly information needed to do intelligent targeting."

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- "Desirable - this focuses scarce resources on likely and easily identifiable problem areas. Feasible - the factors (e.g. population density) are easily identifiable."

In the second round of surveys, respondents were asked to recommend a fourth strategy if they did not support one of the three suggested by EPA. Most frequently mentioned was a strategy that was **a combination of Strategies I and III.**

Four control strategies were presented to respondents for similar ratings of desirability and feasibility. These strategies were:

1. **"Mandatory reliance on general permits."**
2. **"Direct regulation under a national Phase II guideline, which may well require a national rulemaking by EPA."**
3. **"Requiring direct regulation of Phase II municipalities under 100,000 and requiring them to develop necessary controls for priority sources discharging into the municipal storm water system."**
4. **"Control under the nonpoint source program authorized under Section 319 of the Clean Water Act."**

Desirability ratings for the first three strategies were approximately the same: respondents felt that they were "somewhat" desirable. The fourth strategy was rated as slightly less desirable. The greatest feasibility was assigned to Strategy 1. The least feasible strategy, in the respondents' opinions, was Strategy 4.

In the second survey round, respondents were asked to describe implementation of their preferred strategy. When asked what minimum control strategies they would use, the following methods were mentioned:

- a menu or roster of BMPs from which could be selected the most appropriate approaches for the industry or watershed;
- public education;
- erosion and sediment control methods;
- "good housekeeping" and source reduction/elimination methods;
- establishment of national minimum standards;
- elimination of illicit connections;

- emphasis on pollution prevention.

Few respondents saw the implementation of Phase II to be a short-term process. Most suggested a phase-in approach over a period of five to ten years. During this time, BMPs could be tested for effectiveness and cost-benefit in terms of reducing and eliminating storm water pollutant problems, and programs could establish solid components of education, training and technical assistance.

<u>Nonpoint Source Perspectives</u>

Nonpoint program experts also favored Strategy III: "Apply Phase II controls selectively..." for targeting Phase II sources, with a mean rating of <u>4.0</u> on Desirability. The ratings ranged, however, from "1" (not desirable) to "6" (very desirable). Some of the comments included:

- "Is inequitable. Establishes economic hardships for those required to participate. Only strength is less administrative burden."
- "Would be easy to identify sources that fall under criteria. Could be preventive since you are not waiting for a problem to happen."
- "Excellent in theory, but would require a lot of data for prioritization, and would create confusion for some period of time."

The survey instrument used for nonpoint program experts was a modified version of the point source expert survey that included a fourth EPA-suggestedtargeting strategy for consideration. It was:

Strategy IV: "Target and address problems and significant storm water sources and pollutant loadings by using Section 319 and CZARA programs."

Respondents' mean ratings of the strategy were <u>3.2</u> for desirability and <u>2.8</u> for feasibility. Comments included:

- "These programs lack real regulatory teeth. CZARA 6217 applies only to coastal regions. They just aren't aggressive enough."
- "Section 319 is broader than NPDES and has more technical experience with BMPs. CZARA 6217 results in specification by EPA of management measures, in effect setting standards and providing impetus to explore alternatives."
- "Since only limited 319 funds are available, it would be difficult to get much done."

- "This is an important piece of a multifaceted approach, but not adequate alone."

Respondents were given the same control strategies for consideration as the point source program experts. Of the four, #3: "Requiring direct regulation of Phase II municipalities under 100,000..." was most favored, with a mean rating of 5.2 for desirability and 3.8 for feasibility. This control strategy was the only one to receive ratings higher than "5" for either desirability or feasibility.

The majority of respondents were opposed to extending the October 1, 1992 deadline. The reasons given included:

- "The longer we wait to address the problem, the more costly, less technically capable and less environmentally effective the solution will be. There are more opportunities today, especially in less populated areas, than tomorrow to solve and prevent problems."

- "Storm water-related use impairment is a serious problem. Currently, there is little being done to remediate existing problems and no assurance that problems related to new development will be prevented. It is clear that the voluntary approach is not adequate."

- "Things aren't getting better. Forum and impetus are already in place - capitalize on it."

Many of the recommendations made by point source program experts for targeting and controlling storm water sources were echoed by nonpoint survey respondents. Some of the targeting similarities include:

- selection of Strategy III: "Apply Phase II controls selectively..." as the most desirable of EPA-suggested strategies. The most mentioned reasons for preference were ease of identifying targeted sources, and the more efficient use of resources;

- target by watershed impairment/threat severity;

- conduct pilot projects first, evaluate, and then develop and implement a strategy;

- develop minimum national guidelines, and leave selection of sites and methods to state discretion;

- initiate a focused dialogue with key stakeholders (for both targeting and controls).

Some of the similarities in preferred control strategies included:

- build a BMP menu that can be used to implement and verify progress: allow selection of most appropriate BMPs based on industry and watershed;
- provide public education on need for storm water control;
- provide national criteria with flexibility for local implementation of most appropriate controls;
- develop baseline control standards for all new development.

One primary difference between point and nonpoint respondents was the application of the "stick" by EPA, with the "stick" being the requirement of permits for those sources that did not achieve significant movement toward program goals via voluntary efforts within a reasonable timeframe. As one nonpoint respondent phrased it, EPA should keep permit requirements as the "gorilla in the closet" to be used as needed when voluntary efforts were not adequate for the problem.

A number of nonpoint respondents indicated that the 319 and CZARA 6217 programs do not have the "teeth" they need to ensure compliance. Most feel that a combination of programs is needed for successful achievement of water quality goals.

EPA STORM WATER PUBLIC MEETINGS

Description of the Meeting Format:

Three public meetings were conducted to gain citizen suggestions on options for targeting and controlling Phase II sources. These meetings were held in Denver, CO; San Francisco, CA; and Washington, DC. Approximately 200 people attended the three meetings.

At each meeting, three experts selected from the survey process presented their ideas on a regulating strategy for the moratorium sources. Following their presentations, attendees were divided into small task teams with an assigned facilitator, and given the charge of devising their own strategies for targeting and controlling Phase II sources. The strategy template provided to guide group consideration of key issues is presented below. During the latter half of the meeting, each task team presented their option to the other attendees for discussion.

Teams were asked to consider these issues:

1. Targeting (What light industrial, commercial, retail, residential, or other areas or other areas do you include in Phase II?)

2. Control (Do you use continued reliance on the existing NPDES permitting process or something else such as nonpoint source programs, selected permitting based on risk, geographic targeting, etc.?)

3. Timetable (How would you phase in the major components of the strategy and over what timeframe? Do you suggest full implementation on October 1, 1992 [as stated in CWA] or do you recommend a different set of deadlines and why?)

4. Key steps to implement (Please indicate up to five critical, major steps to take in implementing your strategy and the timetable for each.)

5. How will costs of your strategy be distributed over key players and how will costs be understood and controlled?

6. What measures of performance will you use and how will you verify the environmental results? (Do you rely on numerical measures and quantitative pollution indices or other factors?)

7. Strategy Strengths (Name four key strengths of your strategy which, in your judgement, make it preferable over alternative strategies.)

8. Strategy Vulnerabilities (Name four most critical points at which your strategy is most vulnerable to failure or shortfall in implementation.)

9. For whatever strategy is chosen, what could EPA do to make the decision-making process for Phase II more responsive?

Meeting Findings:

A total of sixteen task teams presented their strategies for Phase II of the storm water program. The individual task team strategy outlines offered a diversity of approaches for designing, implementing, monitoring, and funding Phase II of the storm water program. Individual strategies presented a large range of methods for targeting and controlling sources, and many different timeframes over which the program could be phased in.

Despite the different representations, experiences and expertise, there were points of congruence between many of the proposed strategies. Common strategy characteristics across task teams included the following:

1. **Targeting:**

a. Targeting should be done by watershed. Information gathered from Phase I should help identify sensitive watersheds. May require intergovernmental agreements.

b. The focus should be on "bad actors", i.e. those that are known problem sources. The ones most frequently identified were: gas/auto service industries, transportation, highway systems, land development and agricultural sources. There needs to be the ability for facilities not contributing impairment of water to gain an exemption from permits, fees, implementation of BMPs. Categories are an ineffective way to designate covered sources. Selection should be done by the degree of risk a given facility poses rather than categorical inclusion.

c. Small municipalities should have a much simpler application process, or have the opportunity to be excluded if they do not contribute to the pollution problem. In addition to impact on a watershed, proximity to larger municipalities should be considered as well.

d. EPA should defer on selecting targeted sources until the agency has carefully looked at the data gathered during Phase I. Numerous sources of information are available which would help determine targeting priorities, e.g. information gathered through 305b reports, information from Phase I program sources, NURP.

2. **Controls:**

a. If a permitting process is to be continued for point sources, NPDES general permits should be used, and focus should be on BMPs. Permits should be simpler, and much less costly. EPA should make clearer to the applicant what information is required, e.g. checklist of inclusions, menu of BMPs. Exemptions should be available for non-contributors.

b. Education should be a primary form of control. It is important at all levels and for all audiences, yet is often overlooked or underrated.

c. There should be more emphasis on voluntary programs, e.g. the "319" nonpoint source program. For facilities with contact with storm water, there should be little or no more government intervention, but rather emphasis on pollution prevention incentives, BMPs, and practical measures of pollution prevention.

Pollution prevention programs should be emphasized, particularly with new development. Some suggested prevention methods include: recycling storm water, good housekeeping practices, plantings to minimize runoff, street sweeping of work areas on a daily basis, storm water collection methods, coverage of storage areas, changing manufacturing processes to minimize pollutants, improvement of air emissions.

d. BMPs should be required based upon the specific pollutant problem and strategies known to be effective in its mitigation or elimination. The focus must be a known connection between solution and its effect on the problem. BMPs must also recognize financial constraints, providing actions that are relatively higher in terms of cost-effectiveness.

3. **Timetable:**

a. A minimum of two years is needed to prepare for Phase II, with at least a year dedicated to looking at data gained from Phase I of the storm water program. Effectiveness of presently used BMPs needs to be looked at to determine differences in effectiveness between geographic locations and pollutants.

b. Whatever the period established for phase-in, it should not begin <u>until</u> promulgation of the regulations.

4. **Role of EPA Headquarters.**

a. Research, information dissemination, technical assistance.
EPA should also provide focus within these areas. Also, the current efforts are too diffuse, and imply a complexity that makes applications seem difficult and formidable.

b. Funding, not for program implementation, but for research.
Two areas of research requested are water basin pollution control and determination of effectiveness of BMPs. The majority of participants recognize that EPA does not have the fiscal resources to fund programs. What they <u>do</u> want from EPA is guidance in establishing fund raising mechanisms, such as storm water utilities.

c. Establishing broad guidelines for the program within which local flexibility is allowed and encouraged.
Flexibility, at the same time, does not provide an excuse for inaction or postponement. Rather, it recognizes that different actions and action sequences are appropriate to different contexts and conditions.

d. Responsibility for training regulators in the storm water program.

Until those administering the program are well equipped to enable action, effective responses will be difficult.

Please see Volume II of this report for copies of the individual strategies developed at each of the public meetings.

<u>Reflections on Meeting Format</u>

A presumption shared by EPA and the contractor, The Rensselaerville Institute, was that the conventional format for public hearings and meetings is of limited value in engaging citizens or of making the critical transition from criticism to advice on how best to do things. Given this belief, a different format was devised that proved quite different from the typical approach of lectures by experts and/or testimonies read to the record by concerned citizens.

In the interactive approach used, participants were advised that they would be asked to form into task teams to first listen to experts offer their insights, then to develop, as a team, a preferred strategy for responding to Phase II of the storm water program. Each team comprised a cross-section of those attending--including where there are possible strong environmental, industrial, and local government perspectives.

In all three meetings, participants accepted the format and energetically engaged in the task of constructing a preferred solution. This included the session held in Washington, D.C. where participants from major interest groups were in the habit of providing critical feedback and criticism more than engaging in a positive design process.

To gauge participant responses to the different public meeting format, a mail-back questionnaire was used inviting comments by the some two hundred participants in the three public meetings. Approximately 35% of those attending completed the survey. They were first asked to comment on their assessment of the more traditional public hearing format. Most held a clear and consistent view of the traditional approach as focusing primarily on prepared statements. Where dialogue was included, it was seen as argumentative and contentious. The general conclusions:

- opinions are solicited for the record and to insure the perception of public participation but not to provide genuine input. The sense is not of active government listening.

- primary participants are those with strong convictions and often special interests; they are not a representative sampling of public opinion and tend to run the gamut of extreme perspectives on a given issue.

- sessions tend to become adversarial or at best argumentative. No mechanism for cooperation is available and differences tend to get magnified, not resolved.

- the focus is on the problem much more than on ideas for resolving it. On the one hand this attracts critics more than implementors. On the other, it provides little guidance to people who full well know the problem and are looking for ways to deal with it.

Participants were much more positive about the format used. Among the sentiments voiced:

1. Participants had a full chance to participate--not only to be heard but to be directly engaged in finding solutions.

   "It was a valuable way to address the drafting of regulations--allowing the regulated community to feel part of the process";

   "Encouraged the regulated community to get involved and feel involved";

   "Participants felt that EPA was actually listening and dialoguing."

2. The process was genuinely two-way, allowing both EPA staff and those effected to better understand each other.

   "It made you appreciate the USEPA's tough job of satisfying the concerns of many people while protecting the environment";

   "Felt it draws out better data";

   "Actually got to interact one on one with industry and government and consultant representatives. Obtained a better point of view of government's problems and felt that government representatives also obtained a better point of view of industry's problems."

3. The format created an atmosphere for cooperation and even for collaboration among people with very different viewpoints.

   "The meeting went a long way towards promoting the creative thinking, open discussion, and presentation of ideas";

   "Group discussion is a fine vehicle to provide input as well as learning tool. It forces you to think through participation, rather than just simply sitting and trying to absorb by osmosis.";

"Small diverse groups allowed ideas to be evaluated fairly and fostered "brainstorming" and allowed ideas to be developed to better fit broad based objectives."

The positive elements of the meeting extended beyond the effective communication of opinion and position to EPA to broader understandings of issues, complexities, and solutions. Indeed, the sessions seemed as influential in creating new insights as in communicating old ones.

Respondents suggested two primary ways to improve the format for future uses. The first is the need for more detailed advance preparation--in part, needed to change the mind-set and expectations which people tend to have for a traditional public hearing or meeting. The second suggestion: minimize expert presentations, even when used in the "pump-priming" mode employed in this session. Trust the process and get right to the participants.

When asked if they would advise the EPA to use this kind of interactive task-focussed approach with other meetings designed to get public input, over 90% said "Yes." Two persons indicated that it depends on the issue and only two indicated that they preferred to remain more passive.

THE "DESIGN TEAM" MEETING

Meeting Description:

A meeting of seven point and non-point storm water program experts, all of whom were survey respondents, and selected EPA staff was convened in Washington, D.C. on September 17-18, 1992. The purpose was to gain the experts' insights on development of Phase II storm water regulations, and the intended outcome was to build a strategy, or multiple strategies, for regulating Phase II sources.

Participants included:

Mr. Gail Boyd
Woodward-Clyde Consultants, Portland, Oregon

Ms. Diane Cameron
Natural Resources Defense Council, Washington, D.C.

Mr. Dennis Dreher
Northeastern Illinois Planning Commission

Mr. Tom Mumley
San Francisco Bay Regional Water Quality Control Board

Mr. Earl Shaver
State of Delaware Department of Natural Resources and Environmental Control

Ms. Coleen Sullins
State of North Carolina Division of Environmental Management

The participants selected were deemed, by their peers nationwide and EPA, insightful and highly articulate exponents of all major viewpoints on the storm water program.

Also in attendance were these key people from U.S. EPA:

Mr. Michael Cook, Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Geoffrey Grubbs, Director
Assessment and Watershed Protection Div.
U.S. EPA, Office of Wetlands, Oceans and Watersheds

Mr. James Horne, Special Assistant to the Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Ephraim King, Chief
NPDES Program Branch, Permits Div.
U.S. EPA, Office of Wastewater Enforcement and Compliance

Mr. Jack Lehman, Deputy Director
U.S. EPA, Office of Wastewater Enforcement and Compliance

Session Findings:

1. Development of a ten-point outline describing a potential strategy for Phase II of the storm water program.

Consistent with the overall purpose of the meeting, participants identified ten core elements that they feel constitute a potential strategy for Phase II of the storm water program. These elements are:

A. Objective: To get certain BMPs, ordinances and education programs into place over a 10-15 year period. Progress would be measured by getting these elements into place, with direction toward water quality standards and beneficial uses over a longer period of time. EPA would work with all states to help them develop Phase II programs.

B. Priorities: EPA would set these. They would include: the sources listed by the group, using a watershed approach where feasible, focusing first on those local governments with the size and capability to get going.

C. Education/outreach/technical assistance: these are all critical components of a successful program.

E. Mandatory Interim Milestones: EPA needs to determine interim milestones state programs need to meet which would show they are on track.

F. Financial Plan: states/local governments need to develop plans for financing the program.

G. Guidance: guidance is needed on BMPs and local ordinances. These would be generated at the federal level, and states could adapt/modify as needed.

H. "Default" system: local governments would take the lead with their programs, but there would be a built-in default system where the states or EPA would take over with more stringent controls if the locals fail to meet requirements.

I. Permit issuance: for high priority categories, could issue permits that allow flexibility or some alternative mechanism at state's option. Permits might be just for high priority categories; would include site design performance standards.

J. Phasing: there would be a schedule for issuing permits to key municipalities: high priority to low (e.g. coordinate by watershed); high flexibility to "getting tough" with recalcitrant localities. These would be based on inspections, on-site reviews.

K. Monitoring: this would be the difficult part of the program because of cost. Need is to be able to design something useful. The system might be "tiered" - highest to lowest priority; or "strategic" - focused only on gathering what we really need to know.

2. Sources to be targeted in Phase II.

The participants identified a number of specific unregulated pollutant sources that need to be targeted in Phase II of the storm water program. An approach recommended by some of the participants for controlling these sources is a "whole basin approach", which would focus attention and resources on activities impacting the water quality of a given watershed.

The group identified approximately 40 pollutant sources that they believe need to be included in Phase II of the storm water program. The sources identified include the following:

New Development/Redevelopment (commercial and residential)
Transportation Corridors
Dense Existing Development (commercial and residential)
Automotive Services
Federal facilities/military facilities
Feedlots (including dairy)
Failing septic systems
All incorporated places with less than 100,000
Non-urbanized watersheds yet to be determined
Parts of watersheds where land use is in a state of flux
Dry cleaning shops
Parking lots
Some forest operations
Nurseries/orchards
Recreational areas (e.g., stadiums, golf courses)
Landfills
Office parks
Grain elevators
Concrete cutting sites
Commercial pesticides
Landscaping industry
Car washes
Mobile washing units
Equipment maintenance
Boat yards
Tank farms
Shopping malls
Restaurants
Airports
Janitorial services
On-site solid waste (collection, hauling, transfer stations)
Atmospheric deposition
Cemeteries
Commercial strips
Wood stoves
Marine ports
Animal waste
Warehouses/storage facilities
Exterior building maintenance
Bridge maintenance

Members of the group suggested that rather than use the Phase I approach of including sources by category into the regulations, regulatory staff time and resources should be allocated on a water basin approach, i.e., target a watershed, identify impacting activities and their location within the watershed, and determine a set of criteria to deal with the problems impairing the watershed. This would allow limited resources to have maximum impact.

3. Source priorities.

After listing the range of sources that they felt should be included in the Phase II program, participants voted for what they considered to be the top priority sources, i.e. those sources that EPA should address immediately and diligently. The top sources selected are listed below, in order of decreasing number of votes received. All sources were selected by at least 50% of the participants. The sources identified as top priority for addressing in this order:

A. New Development/Redevelopment (commercial and residential)

B. Transportation Corridors

C. Dense Existing Development (commercial and residential)

D. Automotive Services

E. Federal facilities/military facilities

F. Feedlots (including dairy)

G. Failing septic systems

4. Lessons from a case study.

One participant presented an outline of the basic components of the Puget Sound Water Quality Management program. The program is a multifaceted approach toward the achievement of improved water quality which heavily emphasizes voluntary measures in its implementation strategy.

The program includes minimum BMP standards for all jurisdictions with additional water quality treatment BMPs, guidance and requirements for higher risk storm water dischargers. Key facets include: vigorous technical assistance, education, state financial support, education and support for storm water utility development, highway runoff regulations, a full nonpoint watershed management program, storm water operation and maintenance requirements, source controls, and local control and flexibility.

The program is being phased in over several years. It is a combination of mandatory requirements, technical guidance and voluntary compliance. There are specialized focus areas, such as shellfish protection districts and conservation districts. There is a coordination effort with individual and general permittees in the Puget Sound area.

The program views its strengths to be greater local flexibility and acceptance of requirements, a strong sense of teamwork between all levels, better water quality results, and better targeting and use of limited resources than if they were regulated by NPDES. They view the NPDES program as the "gorilla in the closet" that can be brought to bear if and when a source does not meet minimum standards and requirements.

5. Principles for Phase II.

Participants discussed the basic principles they believed should drive the Phase II program at the national level. For the program to be successful, it would require that the following pieces be put into place:

A. Require that people gather documentation of information regarding dischargers' activities and accomplishments and provide outsiders with that documentation;

B. Formally define gaps where additional information and understanding is needed. There needs to be an incentive to close these gaps;

C. Support (with encouragement and incentives) efforts that will close these gaps, and advance the state of the art and/or provide a technically sound basis for the programs' requirements;

D. Actively encourage a broad spectrum of understanding and involvement (the general public, community leaders, service groups, environmental groups) via educational programs and materials;

E. Strategically identify "good" guys and "bad" guys in the regulated community;

F. Provide clear guidance regarding programmatic and physical actions that are required/expected. Actively seek out evidence that people know <u>what</u> to do, and provide technical training to be sure that people know <u>how to do</u> what is required (technical transfer);

G. Require relevant/credible/useful monitoring only. Don't waste people's time/money/energy running data collection programs that yield bad or irrelevant data.

6. State suggestions of what EPA needs to consider in developing the Phase II program.

A sub-group of participants from state regulatory agencies met, and set forth a list of suggestions for EPA to consider in developing Phase II. The following recommendations were made:

A. EPA needs to provide states with the minimum program requirements they must achieve, and then allow states flexibility on how they will do it. The components must include:

- requirements/BMP standards for new development
- education/technical assistance
- control requirements for illicit connections/dumping
- developing state-specific priorities

B. EPA should require states to adopt regulations that specify program components that must be included;

C. To assure program funding, EPA needs to require that state and local governments set up funding mechanisms, e.g. storm water utilities, permit fees, etc.;

D. EPA needs to compile and disseminate technical information that would support programs, e.g. set up a national or regional clearinghouse of information on storm water plans being implemented, BMP-specific information and materials, etc.;

E. EPA needs to compile a national BMP manual that would assist members of the regulated community in determining and implementing appropriate BMPs to address their storm water problems. EPA needs to recognize, however, that BMP application will differ between regions, e.g. climatic differences will require different approaches;

F. EPA needs to require that states develop and implement education, technical assistance, and training programs; EPA also needs to hold the states responsible for effectiveness of these programs, and require permitting in the event that these measures do not work;

G. EPA needs to maintain the right to require permits in a reasonable amount of time (e.g. 2-3 years) if a state's program is not meeting federally determined requirements;

H. EPA needs to determine what short and long term goals they wish the

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storm water program to achieve.

7. Identification of problem areas and needs of the regulated community in dealing with the storm water program.

Participants were asked to identify what their "hot buttons" were, i.e. elements or considerations that EPA might include in the Phase II program which would cause major problems for them, or those which if not considered by EPA would create needs for the regulated community.

The list of "hot buttons" include the following:

A. Penalizing those who have already solved their problems by requiring permits.

B. Liability for water quality standards, sediment standards, and resource damage clean-up in the first round.

C. Failure to provide technical transfer - permittees need to know what to do and how to do it.

D. Failure to promulgate revised and simplified NPDES regulations that get around the complicated approval process.

E. Possible backlash from local governments if they are held responsible for instances of independent commercial activity that they cannot address or control when they don't know about it.

F. Lack of research on BMP effectiveness from a watershed perspective. There is inadequate federal/state money to look at BMPs because monitoring is so expensive.

G. Possibility of EPA not basing the program on permits (except in cases where the state can show that it can reach goals alternatively).

H. The inherent substantial risk of tremendous backlash that would affect people's livelihoods, i.e. failure to try to sell the program to regulators and public, including the NPDES permit process.

I. Prevention v. wetlands - determining how to prevent storm water problems while protecting wetlands.

J. Not addressing the roadblocks created by the regulations themselves. The system is so complicated, it now takes two generations for permits to get

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to goals.

K. Lack of federal monetary assistance. Some states may be reluctant to develop adequate programs without it.

L. Not getting rid of the acronyms in the regulatory language. No one understands what EPA is saying.

M. Concern that mainstream design is end-of-pipe treatment. This is not prevention! CZARA is on a better track.

N. Allowing states to cut monitoring activities first. They need to be encouraged to not eliminate that element disproportionately from their budget.

O. Need to figure out how to sell the program - to get through to OMB and top levels of state governments exactly what it is going to take to get the program into place.

P. Not identifying funding incentives and disincentives.

Q. Not giving praise for progress.

Additional Advice

Additional suggestions for development of the Phase II program were generated by the group during the two-day meeting. Included in those recommendations are the following:

1. **EPA needs to revisit and revise the terminology used in the regulations.**

- the problems are often with the common words, e.g. runoff, storm water, nonpoint source, point source. EPA staff have attached certain meanings to words that are not conveyed to the regulated community, so there is inherent danger that people are not talking about the same thing. Words need to have clear and referenced meanings.

- the enormous number of acronyms used by EPA creates significant comprehension problems for regulatees. The regulations need to be written with fewer acronyms, and all communications need to be sensitive to the level of use.

2. **EPA needs to clearly define the goals of the program.**

- all levels of feedback (focus group, survey, and meeting results) generated during The Rensselaerville Institute project have pointed out that the regulated community does not understand what EPA is trying to achieve with the storm water program. Assumption of what the goal is ranges from achievement of set water quality numerical limits to returning a water body to its original uses.

Confusion over the goals causes confusion for regulatees in terms of selecting the tools that need to be used to reach them. EPA needs to determine what the federal purpose is with regard to the storm water regulations given the reality of limitations of presently available methods and resources for preventing and treating storm water pollution.

3. **Citizen involvement can play an important role in achieving program goals. EPA, states and local governments need to promote citizen education and enforcement authority.**

Participants gave numerous examples of how citizens could play an active role in implementing and monitoring pollution reduction efforts. Given the limited resources of federal, state and local governments, voluntary citizen involvement can support successful program outcomes, including enforcement. Education of citizens at different levels, e.g. qualitative vs. quantitative monitoring, stream health vs. compliance monitoring, etc. would be needed. Guidance manuals can be developed to guide public education.

General Recommendations

The ten summary recommendations stated at the conclusion of the Executive Summary are here amplified to reflect the discussions and insights generated in this project. While not all persons involved agree with each observation and recommendation, these are advanced as having widespread support.

1. **It is possible and desirable to identify priority target areas for which there is widespread consensus concerning their contribution to water pollution.**

   These areas begin with new development and redevelopment--both residential and commercial. They also include transportation corridors, dense existing development and automotive services. Further, the priority of these target sources is relative to the watershed upon which they are impacting.

   Strategically, approaches that focus on a small number of priorities based on relative risk will show stronger results than one that initially targets a broad set of sources in Phase II. Also, it much more cost-effective to identify and pursue the "bad actors" (eg. those contributing toxicity as opposed to sediments or turbidity) as a priority, then get to those adding incremental pollution through routine activity.

2. **EPA needs to communicate more clearly and regularly with everyone impacted by the storm water regulations.**

The priority focus should be less on the amount of communication and more on different kinds of communication. Specifically, communications should be:

- more interactive--the examples of the focus groups and public meetings used in this project are often cited as productive formats for future citizen input;

- more localized to contexts--as in more regional workshops and fewer national ones. This means communications less inclined to reflect the national complexity of the program and more inclined toward addressing the specific information and guidance needs of the local person involved in a specific and delimited way. It also means less "canned" content and more consultative dialogue;

- less laden with acronyms and technical language that confuse and irritate many of the people who are the true "customers" of the program, and who are required to carry out the federal mandate. Along with this, more attention should be paid to finding and marketing simplicities rather than complexities.

3. **EPA could improve program effectiveness, efficiency and cost control in Phase II by "starting small".**

The concept of regional and even local prototypes was advanced by many people as a way of getting proposed new Phase II frameworks into the hands of users in prompt fashion to build and refine based on early use. This was generally seen as preferable to the comprehensive approach in which new programs are developed fully and then introduced comprehensively at a point when modification is difficult and expensive.

Related to prototypes is the case study--in which an analytical eye is turned to current programs that demonstrate one or more strategies or best practices for storm water implementation. An example is the Puget Sound model, with its focus on the tangible and cost-saving values of voluntary compliance by small businesses (a summary of this approach is contained in Volume 2).

The use of a small scale plays to the strength of regional differences as well as the reality that an equal stress on comprehensive large programs may so paralyze states and localities that nothing is done expeditiously.

4. **Selectivity in data collection and monitoring is essential.**

At present, some data collection frameworks consume tremendous time and money only to yield bad or useless data or murky or disputed conclusions. More attention should be paid as to what constitutes "good science" and activities that may show the appearance of effective activity but in reality be consuming scarce resources to no clear gain. This also relates to the adage, "what you measure is what you will get." While the tendency is to see monitoring and assessment as questions of methodology, they must first be viewed as questions of substance. What are we trying to measure and at what level of detail and accuracy?

Not all measuring and assessment need be arcane. In development projects, for example, the use of hay bales is known to contain overflows. No great study of cause or effect is needed. And if there is floating oil on a body of water, we can start by verifying that it is there--a useful step even if we do not "measure" its amount. At the same time, other kinds of assessment are meaningless without extensive (and expensive) levels of detail and analysis.

A related point is that documentation of discharger activity and accomplishment is as critical as scientific study of water conditions.

5. **More customer differentiation is also needed.**

At present the mind-set appears to be that one size fits all. While giving the appearance of equity, this concept actually creates strong inequalities. The same programs and regulations that befit a large corporation or municipality are simply not equitable for smaller enterprise and communities, for example. More broadly, some specific operations within a given source category contribute significant pollution; others contribute none. Some way to either make the initial process much less costly or to more quickly separate out those who do not need continuing attention must be found.

One form of general differentiation is between those who are causing a problem by clearly inappropriate activity (the "bad actors") and those contributing to storm water pollution by standard and at times inadvertent practice.

6. **While the ultimate goal is water quality standards, this is very difficult to achieve and/or to measure in the short term.**

While retaining water quality standards as the ultimate goal, EPA should be focusing on best management practices, and in particular those that reflect preventive and non-structural solutions. An example is stronger standards and technologies for storm water control in new residential and commercial construction. In many instances, the correlation is clear between the management practice and the consequences for cleaner water.

The codification and communication of best management practices applies not only to those targeted and controlled but to state and local actors implementing storm water programs. For example, a set of "carrots and sticks" known to promote voluntary compliance is just as critical to disseminate as a new approach to storm retention ponds in a sub-division.

While BMPs are set in place, interim milestones for water quality are also critical--and feasible--as a way of measuring progress. The transition from progress by practice to achievement by water quality measure must begin now.

7. **The most functional unit of both analysis and intervention is the watershed.** Most people in our samples for opinion and recommendation strongly suggested the watershed approach--not only on the macro level (e.g., Chesapeake Bay) but the micro-level as well. In particular, this means looking at stream quality issues beginning at the headwaters for early contributions and alterations. Most felt that functional differentiation of pollutant sources is not really meaningful in terms of either regulation or effective change at the watershed level.

8. **EPA's role is to offer technical support and direction more than program funding or even full guidelines for state and local implementation.** In particular, building useful data bases and collection methodologies not only on water quality but on practices to achieve it is critical. Also key are training and support programs and development of effective dissemination networks. In all EPA roles, the need is to recognize both regional differences and the need for a multi-faceted set of strategies, tools, approaches, solutions.

   Another EPA function is to focus on the connection between best management practices and long term consequences for water quality. While those who introduce them are in the best position to refine BMP's, they often do not have the tools to verify a correlation (let alone a causal connection) to water quality. This is an important EPA function.

9. **A collaborative approach to developing effective solutions is possible.** The interactive elements of this project are one reflection of the ability of those with strikingly different perspectives (ranging from strong environmental protection to a focus on economic development) to work cooperatively. If adversarial and polemical dynamics can be set aside, the gains are far greater.

   Collaboration must begin within EPA itself, where there is a tendency for those focussing on permits and "harder" tools of compliance and those focussing on education and "softer" elements of prevention to not fully connect with each other. In reality, there is a strong common theme from the need to see the storm water program as a way of enabling local communities and industries to change their behaviors to help the environment in ways that will directly benefit them as well as

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all other citizens.

10. **Agriculture activities should be included more directly in the storm water program.**

In many regions, agriculture (which includes livestock as well as crops) is a primary contributor to surface water pollution. While the present NPDES program requires permitting of the transport of agricultural products, this brings intervention too late. The critical first steps of agricultural activities, e.g. soil preparation, growing, and harvesting, must be included.

Beyond this reality is the signal sent that for whatever set of reasons, some interests are exempt from a program in which they clearly belong.

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THE U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WATER

EPA GROUP INVOLVEMENT PROJECT

CONDUCTED BY: THE RENSSELAERVILLE INSTITUTE

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EPA GROUP INVOLVEMENT PROJECT

Introduction

In early 1993, The Rensselaerville Institute undertook a project designed to gain various groups' involvement in development of Phase II of the Storm Water program. Working with the U.S. EPA Office of Wastewater Enforcement and Compliance, The Institute implemented an approach whereby groups and people with interest in the Storm Water program became actively involved in identifying and discussing a series of program design options.

A series of meetings were held in Dallas, TX; Washington, DC; Chicago, IL; and Falls Church, VA. Approximately 150 people participated in the meetings.

This report describes project implementation and the method utilized, highlights the results of the project, and provides a set of recommendations for program development.

Project Implementation

One of the first steps of the project was to craft a number of options to describe how the Phase II program could be organized and implemented. At a Phase II Options Identification Meeting held in January 1993, 14 different options for target and control of Phase II storm water discharges were outlined. From the original 14, seven options were developed; each designated certain program responsibilities and authority between federal, state and local entities.

These seven options were used as the basis for focusing team work at each of the meetings. Briefly, the presented options were:

1. **State Target Selection - Non-NPDES Control.**

   Phase II sources would be targeted by the states, using information from 305(b), 303(d) and 304(l) reports to target sources in watersheds where storm water is a significant source of impairment. Individual States would be able to select from a mix of controls to attain water quality standards. There would be no provision for Federal oversight of State control options.

2. Eliminate Phase II; Expand Phase I Designation Authority.

This option would eliminate Phase II of the storm water program. NPDES permitting authorities would retain designation authority to target and control any high risk sources of concern under Phase I of the program. The remainder of Phase II sources would be prioritized and controlled by States through existing non-NPDES control strategies.

3. NPDES Permits for Federally Selected Municipalities Not Covered Under Phase I.

Under this option, EPA would target urbanized areas and emerging growth area portions of municipalities and counties. NPDES permits would be issued to selected municipalities/counties and would require the implementation of a storm water management program through which the municipality would control commercial/industrial/residential sources within their jurisdiction.

4. Tiered Federal and State Target Selection - Tiered NPDES and Non-NPDES Control.

The first tier of high risk sources would be selected on a national basis with this option. Potential targets would include categories of facilities or activities, and urbanized and associated developing area portions of municipalities and counties. Additional sources may be selected by individual States based on information available to the State, including watershed data generated through 305(b) reports as well as 303(d) and 304(l) information. First tier high risk sources would be controlled through NPDES permits (State/EPA). Second tier sources would be controlled through a range of control measures under State discretion.

5. Federal Target Selection - Non-NPDES Control.

With this option, high risk sources would be Federally selected. Potential targets include categories of facilities or activities and municipalities located in urbanized and associated developing areas. Individual States would select their own control mechanisms for all Federally selected sources. There would be no provision for Federal oversight of State control mechanisms.

6. State Target Selection Consistent with Federal Criteria - State NPDES or non-NPDES Control.

EPA would develop selection criteria for sources (criteria would include watershed targeting and reliance on 305(b) reports as well as 303(d) and 304(1) lists as appropriate). States would identify high risk activities using these criteria. Potential targets would include categories of facilities or activities, urbanized and associated developing area portions of municipalities and counties, and sources located in affected watersheds. The State may implement either point or non-point source control measures as they see fit. Federal oversight would be exercised; sub-options would provide for different oversight schemes.

7. Federal Target Selection - NPDES Control.

With this option, high risk sources would be selected at the Federal level. Potential targets would include categories of facilities or activities, and urbanized and associated developing are portions of municipalities and counties. All sources identified would be controlled through NPDES permits.

At each of the three public meetings held, participants were presented the above list of options, and were provided the opportunity to ask clarifying questions about each one. For their first task, they were asked to identify strengths and weaknesses of each option in terms of targeting, control and timing strategies, and decide what changes if any they would make in the option to improve it. Participants were also given the opportunity to create their own option(s) for consideration.

The second task for participants at each public meeting was to list the key components that they felt should be included in a Phase II program for it to be successful, and to identify actions that EPA should avoid taking because the actions would have major detrimental effects on program success.

Participants were divided into small working teams of 6-8 people. Each team appointed one person to record group responses to each of the tasks. Following each task, teams reported out to the rest of the group.

Individual meeting reports of team responses to the options are appended to this Executive Summary. The list of options for the first meeting was slightly different than the list used for the remaining meetings in both order of option presentation and wording. The list was modified for two reasons: 1) there was a sense that, because the options were presented from most to least Federal control, people in the first two meetings may have been

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unintentionally drawn to 'middle of the road' options; and 2) initially, one option explicitly included a watershed approach, and therefore people may have felt that it was the only option that could incorporate it, even though the other options in no way excluded using the approach. Thus, participants in the second two meetings received the options in a different order and with explicit reference to the watershed approach given in a number of option descriptions.

Two final 'expert meetings' was held in Chicago, IL and Falls Church, VA, where national storm water experts convened to review the options and suggest overall criteria for selecting a Phase II option.

Project Results

Task I: Identifying Strengths and Weaknesses of Options

At each public meeting, individual teams presented their responses to each of the options listed above. The responses of all teams for all meetings were compiled for this report. The responses of any individual team can be found, by meeting, in the appendix. Below, in discussion of various favored options, a sampling of responses across teams and meetings is presented.

Option Responses:

Across the board, meeting participants identified Option #6, 'State Target Selection Consistent with Federal Criteria - State NPDES or non-NPDES Control' and Option #4, 'Tiered Federal and State Target Selection - Tiered NPDES and Non-NPDES Control' as their most favored options.

Option #6, which would have States target high risk sources based upon Federally established criteria for selection and would include Federal oversight of State programs, was seen to provide the consistency needed nationwide for target selection while still allowing states the flexibility needed to control sources and identify high-risk polluters. This option was seen as easily incorporating a watershed approach, and including both point and non-point sources. Some of the strengths identified for Option #6 included:

- uniformity of selection criteria of sources among States;
- removal of the burden on States to develop selection criteria of their own;
- the flexibility to allow non-point source controls;
- giving States, who are closer to the problems and issues, more input into the decision-making process;

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- giving States more latitude to develop programs which meet their own needs and high risks;
- establishing a partnership model between EPA and States, not a command-and-control model.

Some of the weaknesses that participants associated with Option #6 included:

- the probability that there would be inconsistencies between States on requirements;
- that it does not protect unimpaired waters, because the focus is on remediation not prevention;
- the potential for disagreement between State and Federal levels on the criteria established. The State may differ in the prioritization of pollutant sources;
- that Federal criteria may not be applicable to the State because of geographic, industrial, or other unique characteristics;
- a State may not have the resources to handle the program;
- the potential for State and local disagreement over controls used;
- that it could penalize progressive States that have already taken the initiative to develop a program, only to have EPA set criteria that don't "mesh" with their progress;
- the possibility that industries with multiple facilities in different States would have to deal with differences in requirements, timing, etc.

Option #4 was identified by participants as the next most favored option. According to that option, EPA would identify the first tier of high risk sources, and then the States would target additional sources as appropriate. The EPA-targeted sources would be permitted by EPA or delegated States, and then the States would have the latitude to use a range of control strategies for additional identified sources. Some of the strengths that teams listed for Option #4 included:

- would allow for quickly addressing severe problems, so the State would have more time to deal effectively with other problem sources they identified;
- provides more options for compliance in its latitude for control strategies;
- allows States more discretion and time to identify and prioritize sources;
- provides a potential advantage for industries to keep themselves clean enough so that they are not targeted for (State-selected) Tier II. This option might act as an incentive to get industries to focus on pollution prevention;

- offers the ability to incorporate less resource-intensive controls to lesser risk sources such as 404-type permits;
- Tier I allows non-contributors out of the system (since EPA would be targeting only determined high risk sources);
- seems to be more equitable than Phase I targeting and control strategies.
- permitting provides a clear point of control, i.e. the "gorilla in the closet".

Some of the weaknesses that teams associated with Option #4 included:

- the time and expense of performing risk assessments, which the States would need to do in order to target Tier II sources;
- promotes 'buck-passing' of responsibility between Federal and State levels;
- the possibility that it would create inconsistencies among States for targeting and controlling industrial categories (high risk sources);
- EPA/State coordination could be difficult, which could prolong the time it would take to implement this option;
- the potential inconsistencies that could occur for States regulating interstate waters, e.g. Chesapeake Bay.
- EPA may not have adequate information to screen and identify high risk sources on a national basis.

There did not seem to be a consistent "worst choice" option among meetings. However, among teams at the Dallas meeting, one option - Option #7, in which high risk sources would be selected at the Federal level and controlled through NPDES permits - stood out as unfavorable for six out of eight teams. Their common reason was that the Federal level would be the primary decision-maker in this option. Across all meetings, teams favored options that promoted a system of shared decision-making and responsibility reflecting the need for a partnership between Federal and State entities.

In one of the Washington public meetings, two options - option #5, in which high-risk sources would be Federally selected, with no provision for Federal oversight of control mechanisms; and Option #1, in which States would select sources and controls, with no provision for Federal oversight - were deemed the <u>least</u> favorable. In terms of Option #5, participants did not see the federal "teeth" that they felt would be needed to enforce the program. Many people across meetings felt that if there was not "the gorilla in the closet", i.e. the threat of EPA enforcement of the regulations after incentives were tried and failed, the program would not work.

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Sentiment was similar regarding Option #1, and again centered around the sense that some States would do very little if the Federal government were not driving them.

It was quite apparent that, while involved groups do not want a standard command and control situation with every aspect of the program dictated at the Federal level, they still see a need and role for Federal regulatory enforcement as a motivator to get States and the regulated community to implement effective storm water programs.

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Task II: Contributors to Program Success

The purpose of Task II was to have participants identify the critical factors that would help to ensure a successful storm water program, no matter which option or combination of options was selected. Teams were asked to identify the essential and basic components of a program that they believed would be required for the program to be successful. Further, they were asked to advise EPA on what the agency needed to avoid doing in order to further ensure successful program outcomes.

A summary of team responses to each of these tasks is presented below.

Task II a: Key Components for Program Success

Teams were asked to identify and list what they believed to be the key components of a successful storm water program. Responses to this task differed between group representation (e.g. State government, local government, etc.) and geographic region. There were, however, common components listed by teams across meetings. The first four items were mentioned by more than half of all work teams; the remainder were mentioned by 25-50% of the teams. The items teams identified as key to a successful program included: (in parentheses are comments made by some of the individual teams re: the item)

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1. Public education and awareness programs (e.g. through trade associations, at schools, use of various media - everybody needs to be educated);

2. Training for regulators and the regulated community (e.g. for States, regions, permit writers, permittees; periodic regional/national meetings; hands-on training for municipalities and industry; dialogue and feedback between EPA, States and locals; technical assistance);

3. Timely guidances (get guidances out ahead of time as regulations are passed; provide guidance on technology transfer and innovative technology; include case studies and a data clearinghouse);

4. Determination of what lessons were learned from Phase I of the program, and mechanisms for Phase II that will allow tracking and assessment of the program within reasonable timeframes. A key factor is to allow enough time for an adequate review process of Phase I to see how Phase II could build on and expand those efforts;

5. Clear regulations (e.g. straightforward as possible; user friendly, clarity of coverage/applicability; clarity in criteria; be more specific in naming industrial activities covered under the regulations);

6. Use of a Watershed approach to implement the program;

7. National guidelines for the program (e.g. identify measurable goals for regulated sources, standards, designated use impairments, mechanisms for oversight, long range planning; recognize cost and implementation of compliance; provide realistic measures of success);

8. A phased-in approach for the Phase II program (e.g. reasonable time schedule, long-term phase-in). The most common timeframe mentioned by teams was 3-5 years for program implementation;

9. Pollution prevention incentives (send out guidance on pollution prevention to potentially regulated facilities now; offer exemptions; reduce requirements as an incentive for successful use; possibly provide a menu of programs on pollution prevention plans from which entities can pick and choose);

10. Program flexibility (e.g. to change deadlines based on hydrological flow; to implement and use elements of a watershed approach to bring in stakeholders and implement a program).

Approximately half the teams noted that there need to be some dedicated funding sources available to States, local government and permittees to assist in successful implementation of these program components. Teams felt that EPA should either provide funds or provide guidance on how States and local governments could implement fund-generating systems, e.g. storm water utilities. Team suggestions included: funding could first be made available through congressional appropriation to EPA to help programs start, and then programs could generate on-going funds through permit

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fees; EPA should make available federal grants and loans to States, locals and permittees.

Task II b: EPA Actions that would be a Barrier to Program Success

Teams were asked to identify and list those actions that EPA should avoid taking lest those actions prevent programs from being successful. The actions most frequently mentioned include:

1. Unnecessary/unusable program requirements, including excessive monitoring, unrealistic BMPs and compliance criteria, cost-prohibitive Best Management Practices;
2. Fully developing requirements before pilot testing various proposed components of the program to catch inconsistencies, problems, etc. In other words, do small scale testing of program elements and use knowledge gained from those pilot tests to refine the regulations before they are put into effect;
3. Unrealistic deadlines and goals;
4. Implementing program regulations without providing dedicated program funding;
5. Promulgating the requirements without providing written guidances and technical assistance concurrent to doing so.

Criteria for Selecting A Phase II Option

The final meetings brought together storm water experts from across the country to develop an option in detail for the Phase II program. One of the products from those meetings was a developed set of criteria on which to base option selection.

Those criteria are that the program:

1. Does not rely solely on the actions of just one player. The program needs to include multiple levels: EPA, States, targeted municipalities and industries. For example, the Federal government should not be designer and decision-maker, educator, enforcer and funder. The program needs a balance of players across levels, each with a clearly defined role. Also, there needs to be a clear avenue for intervention at the Federal level if States or municipalities fail to implement the program, i.e. "the gorilla in the closet".

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2. Provides clear guidance and unambiguous targeting categories and words (e.g., words like "sufficient" should be avoided, at least if there is no way to define what they mean in a given context). Simplicity and clarity should be favored; words that are ambiguous or hazy should be avoided. The regulations must be clear to the regulated community in terms of goals, objectives and implementation if EPA is to gain "buy-in" from them.

3. Provides the resources (not only dollars, but people as well) or suggests how they can be obtained for that option. The program needs to be clear on who pays for what, e.g. Federal, State, local, permittee.

4. Is flexible, especially in recognizing regional and local differences, not only in terms of storm water pollutant loadings but also in terms of their environmental impact. For example, even if all gas stations put out an equal volume of pollution, the environmental impact may vary depending on location. Or as another example, recognition of the vast differences between States, such as mid-Atlantic compared to Southwest, which would mean a vast difference in what they need in terms of a storm water program.

5. Needs to be nationally consistent in the underlying methodology used, i.e. consistent national guidelines, identified goals, measures of success, etc. while at the same time recognizing regional differences and allowing flexibility to implement a program that best addresses the particular characteristics of local problems.

6. Emphasizes the need for program responsibility and authority that is "pushed" down to a local level. The sense of some of the participants in this meeting was that the best understanding of the problem and how to deal with it is the people closest to the problem who have to deal with it, i.e. local problem/local government and groups. Note: People representing local government at the meetings were extremely concerned about the lack of resources and technical expertise that might be found at the local level in many situations. The need for adequate funding was again identified as a critical issue, and some suggested that utility districts would be the only real way to fund the program unless the cost is low enough that it could be covered in a regular budget. The group agreed as a whole that resources and technical expertise not withstanding, this program must be accepted and supported at the local level if it is to be successful.

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7. Provides the opportunity to integrate other water issues and concerns--e.g., groundwater. For example, restriction on certain BMPs affects groundwater impacts. The methodology used should allow integration with groundwater, habitat, and other water programs. It needs to integrate or be compatible with other sections of the Clean Water Act, e.g. right now 402 causes 401 and 404 compliance problems.

8. Needs to build on and tie to Phase I, where much work was done and where momentum has been established. A lull now means the need for a new start up - right now the energy level is high and awareness of the storm water program has been growing, so EPA needs to tap into that forward movement. If EPA waits too long in getting Phase II out, inertia will set in, and it will take much more energy and effort to get it in place. And the talented people will go on to something else (208 was given as an example).

Other key areas of expert discussion around Phase II program considerations included:

1. **EPA needs to recognize the potential gaps between "best efforts" and performance standards.** On the one hand, we have a variety of ways of characterizing best efforts: Best Management Practices (BMP's) and Maximum Extent Practicable (MEP) are examples. These are inputs, presumed to influence water quality. On the other hand, we have water quality standards that are outcomes. One question: what do we do if people follow BMP's and water quality does not improve to the standards we set? What if the "maximum extent practicable" is deemed in place and we still have an outcome shortfall?

2. **Two distinct structural premises are in play.** One is of a national program which is administered by the States. In this view, EPA provides mandates, and supports state and local efforts to reach them. The other premise is more decentralized. It is seen as a set of State programs and initiatives which share a national performance target. In at least some respects, the structural premise held suggests different programmatic approaches in such areas as desired and allowable variability among states and localities.

3. **Much wisdom about storm water controls are not readily generalizable.** BMP's in the residential development field, for example, were said, by some experts, to hold true for a scale of 5 - 50 acres. And many watersheds for which solutions are designed are actually very small. It is hard to "scale up" answers.

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4. **Program "champions" are often a factor in program success.** One expert observed, and others agreed, that the individuals involved in storm water programs were as much a reason for high program performance as was the program plan. We should be careful to allow for this factor in the emphasis on rules, procedures, and even workplans.

5. **Pollution prevention should be emphasized.** While often anecdotal, a variety of examples were offered of situations in which preventive steps solved a water quality problem. These examples, like the Puget Sound program discussed in our earlier report, were generally focused and interactive. They did not rely on the spread of information alone to prompt changes in behavior.

6. **EPA needs to allow State and local flexibility to address priorities as they have identified them.** The theme of selectivity combined often with local flexibility. e.g., in some areas, a little more grease has a tremendous negative impact on the environment. In others, it does not. Selectivity on targeting is also clear, e.g., that BMP's on new land development (commercial as well as residential) would pay high dividends vs. other generalized targets.

7. **Several equity or fairness issues emerge and persist.** One concerns those sources targeted. If a discharger has done everything in their permit -- all the BMP's are in place -- and the water is still dirty, is he or she liable? Another is the distinction between larger organizations (corporate or municipal) with resources to handle permits and processes and much smaller ones which lack that capacity. To what extent is the same rule as "fair" for the small town as for the big city?

8. **The Federal role in the program to establish a partnership with States, and be an enabler rather than an enforcer.** Participants felt that EPA's responsibilities would be to develop national goals and guidelines, set national selection criteria, establish a selection methodology, and develop a universal methodology for selecting controls that would allow programs to choose alternatives based upon their needs, e.g. regional and local differences. Participants felt strongly that Federal oversight is a necessary component to ensure that States do implement programs, i.e. be the "gorilla in the closet". However, in a partnership capacity, participants felt EPA should first be ready to provide support and technical assistance rather than punitive measures to programs that were not meeting standards despite best efforts.

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APPENDIX J

SUMMARY OF PHASE II COMMENTS

Organization of Phase II Comments

I. Targeting

A. General Targeting Approaches for Both Municipalities and Industries

	Yes	No
■ Examine Phase I data before selecting Phase II sources. **[1.g.iv]**	52	0
■ Amend CWA and eliminate Phase II/ cover additional sources under Phase I **[1.a]**	28	7
■ Establish requirements for State storm water programs to identify additional sources. **[1.f]**	18	5

■ **Examine Phase I data before selecting Phase II sources. [1.g.iv]**

The majority of the commenters (52 commenters) agree that a close examination of Phase I is essential before launching into Phase II. Many of these commenters also stressed that EPA should complete the Reports to Congress, as specified under section 402(p)(2)(5) of the CWA. Such an examination would allow EPA to evaluate whether the current approach is achieving the intended goals, or whether another approach to storm water permitting would be more effective. As discussed in detail later, commenters expressed a number of concerns about the storm water program, including 1) the high cost associated permit compliance and program administration; 2) the ineffectiveness and inequity of "blanket coverage" of particular industrial activities that do not pollute while other "bad polluters" remain unregulated; and 3) a general uncertainty about the goals of the storm water program and whether, in fact, these goals are being achieved under current program.

■ **Amend CWA and eliminate Phase II by covering additional sources under Phase I; administer through NPDES or section 319 (NPS) or section 6217 (CZARA). [1.a]**

To address these problems associated with Phase I, commenters indicate that a change in how facilities are targeted is necessary. Of the 91 commenters, approximately a third (28) favor amending the CWA to eliminate Phase II of the storm water program and to bring additional sources under Phase I. As far as regulating these Phase II sources under Phase I, the majority of commenters prefer a continued reliance on the NPDES program as opposed to State non-point source programs (funded under Section 319 of the CWA and/or section 6217 of the CZARA). While commenters support continued reliance on NPDES, they overwhelmingly agreed that Phase II

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sources should not be targeted by EPA headquarters but rather by State and/or local entities.

These commenters argue that by eliminating Phase II and bringing additional sources under Phase I, the problems associated with Phase I storm water permitting will be most effectively addressed. In particular, by designating facilities under section 402(p)(2)(E), States can target those industrial activities that are impacting sensitive watersheds and/or posing the greatest environmental risk. One State agency notes EPA should "maintain national data for determining environmental risk, establish priorities for additional activities to be covered under a storm water permit, and coordinate compliance, enforcement and educational information among the States."

The majority of commenters believe that designation authority in the hands of the State would be the most cost-effective targeting approach. However, other commenters express concern over shrinking State budgets and indicate that additional funding would be needed, particularly if the program were administered under section 319.

Those commenters opposing the elimination of Phase II (7 commenters) argue that for reasons of equity Phase II sources should be subject to the same requirements as Phase I. The concern is that State designation of Phase II sources may result in inconsistencies throughout the country. One municipality argues that in order to effectively protect water quality, smaller municipalities should be required to develop the same storm water management programs as the medium and large municipalities were required to under Phase I.

- **Establish requirements for State storm water programs to identify additional sources. [1.f]**

18 commenters out of 91 commenters favor the targeting option whereby EPA would establish Phase II requirements for State NPDES storm water programs to identify additional sources. 5 oppose this option.

Those supporting this option believe that States and local entities (not EPA) should be identifying additional sources for Phase II permitting, adding that EPA should somehow direct the States and municipalities to develop programs appropriate to their unique requirements and monitor the progress of these programs. As far as EPA's exact role in this process, some commenters assert that EPA should establish baseline effluent limitations for particular industries and then establish control measures for these industries. Other commenters believe that such determinations should be made by the State, with EPA maintaining its important role as an information and guidance clearinghouse. One State agency writes that "minimum criteria in the area of funding levels and educational requirements seems appropriate." These commenters indicate that this approach is preferable as it establishes consistent criteria for the development of State storm water programs.

B. Options for Targeting Phase II Industrial Sources

	Yes	No
■ Geographic Targeting: Designate additional individual sources in watersheds of concern (those not meeting designated water uses) and in specific rainfall zones [1.e/1.g.i]	48	5
■ Focus on high-risk polluters and exempt facilities that don't pollute. [1.d/1.g.ii]	39	3
■ Rely on Phase I MS4s to target industrial sources that discharge through their system. [1.c]	9	11

■ **Geographic Targeting: Designate additional individual sources in watersheds of concern (those not meeting designated water uses) and in specific rainfall zones. [1.e./1.g.i]**

Almost half of the 91 commenters (45 commenters) support targeting sensitive watersheds, i.e., those that have high pollutant loadings and/or those not meeting designated uses. These commenters argue that such an approach is the most cost-effective way to improve the quality of the Nation's water. (Please note that within this category, more commenters support permitting watersheds under the NPDES program than under State nonpoint source programs). Commenters suggested that this approach should be coupled with identifying the industry "bad actors" within watersheds of concern. (Identification of "bad actors" is discussed in the following section).

A number of commenters believe that watersheds should be prioritized based on criteria such as threats to high quality resources or significant degradation. One industry offered the following suggestions for a watershed strategy: "1) Conduct a survey of receiving watersheds and rank them based upon their designated uses and level of contamination; 2) Identify and prioritize major sources of pollutant loadings; 3) Analyze the control measures to control these pollutant sources and prioritize them based on cost effectiveness." Some commenters stress the importance of developing national criteria for evaluating watersheds so as to avoid inconsistencies among different regions.

In terms of evaluating watersheds, commenters suggest using the following CWA mechanisms: Section 303(d) which prioritizes a ranking of waters, section 305(b) which describes water quality of all navigable waters in the State, section 319 watershed listings, and section 304(l) which lists waters not expected to meet water quality standards. Some commenters suggest that sampling data from Phase I cities be used to generate regionalized watershed loading criteria.

Regarding costs, a number of commenters agree that targeting watersheds would be more cost-effective for both industries and States than current targeting strategies. However, some States express concern over the cost of gathering watershed-specific information in a timely manner. One State argues that "entirely too much effort would need to be invested to determine what waters have been negatively impacted by storm water runoff. Using the lists from 305(b) reports is not sufficient nor acceptable."

As far as designating specific sources by rainfall zone, there was some scattered support for this measure. However, most commenters agreed that it could be difficult and costly to generate timely, meaningful data that could justify variances or special conditions between regions.

- **Focus on high-risk polluters and exempt facilities that don't pollute. [1.d/1.g.ii]**

Nearly half of the commenters (39 commenters) supported targeting high-risk industrial polluters. Only three commenters opposed the option. As discussed above, many commenters believe that targeting of "bad actors" should be linked to the targeting of sensitive watersheds.

In general, commenters feel that the Phase I targeting of industries based on SIC codes was not cost-effective. In addition, many commenters believe that a number of the big industrial polluters were not included under Phase I of the storm water program. Commenters unanimously agree that bad actors who are contributing to water quality degradation should be targeted for Phase II permitting, while those "good actors" who don't pollute should be exempted. This approach, commenters say, would reduce the regulatory burden on all those facilities that are not contributing to water quality problems.

One State agency stressed that determinations of "bad actors" must be done on a State or local basis, not by EPA. "Controlling activities that are specifically designated by EPA could be a significant waste of time and resources if a particular jurisdiction has other activities that contribute to higher pollutant loads." This commenter suggested using data gleaned from municipal applications to determine Regional water quality information.

As far a which particular "bad actors" should be targeted under Phase II, commenters suggested the following industries: gas/auto service, State highways, large parking lots (malls), tank farms, commercial activities with industrial components, and construction activities of less than five acres. Please note, however, that a number of trade organizations representing the above industries submitted lengthy comments outlining why their industries do not pose environmental risks.

Those commenters opposing the option (3 commenters) claim that focusing on "bad actors" is a reactive strategy rather than a preventative one. Further, one commenter argues that using impairment would be imprudent as States (after more than a decade) still have not completed inventories of their waters. The commenter further states that agricultural runoff and irrigation return flows, which are exempted under the CWA, constitute some of the worst pollution in the country. One commenter suggests the continued use of SIC codes but with exemptions provided for those who have proven that they don't pollute.

- **Rely on Phase I MS4s to target industrial sources that discharge through their system. [1.c]**

11 commenters opposed the targeting option whereby Phase I MS4s would target industrial sources discharging through their systems; 9 commenters supported the option.

Those commenters opposing this option feel that the burden of regulating Phase II industrial dischargers would be too great, and that this role rightfully belongs to the State. Further, commenters believe that water quality problems are not confined to individual municipalities, but rather they span entire watersheds. These commenters argue that standards would not be uniform--or efforts might not be coordinated--between different municipalities and, therefore, regulation through State or EPA would be more equitable. Municipalities indicate a willingness to assist States in targeting Phase II sources, for example, by providing a list of potentially high-risk industries. Commenters supporting this option believe that because Phase I municipalities already have their storm water management plans in place, they are the most appropriate entity to identify additional sources under Phase II.

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C. Options for Targeting Phase II Municipalities

	Yes	No
■ Identify MS4s based on population, population density, and or population growth. [1.b]	20	20
■ Geographic Targeting: Designate additional municipal sources impacting watersheds of concern (those not meeting designated water uses) and in specific rainfall zones [1.e/1.g.i]	48	5
■ Permit small municipalities but establish simplified application requirements. [1.g.iii]	15	1

- **Identify MS4s based on population, population density, and/or population growth. [1.b]**

Commenters are split evenly (20 in favor, 20 against) Phase II MS4s being targeted on the basis of population, population density and/or population growth.

Commenters in support of this approach argue that municipalities having particularly dense populations and those experiencing intense population growth due to new development should be of primary concern under Phase II of the storm water program. One commenter also notes that MS4s could be targeted on the basis of watershed population. At any rate, numerous commenters agree that effective Phase II storm water programs must be coordinated on a regional basis [perhaps in conjunction with those already established under Phase I]. This would allow for the development/implementation of regional policies and regional BMPs, and would facilitate addressing specific issues such as land use, structural controls and construction activities. As discussed later, the majority of commenters supporting this approach also advocate the establishment of simplified permit application requirements.

The majority of the comments opposing this option are from small municipalities. Approximately half of these commenters believe that municipal storm water management should be conducted on a watershed basis rather than by determining population density and/or growth. The other half opposes Phase II regulation of small municipalities altogether. "Phase II regulations will have a very significant impact on municipal budgets if implemented similar to Phase I," 11 municipalities wrote. "These will entail increased staff levels, testing, consulting fees and other costs which are unduly burdensome, particularly where there is no Phase I documentation to show that environmental quality is enhanced." Of primary concern among municipal commenters is the astronomical cost associated with completing municipal storm water permit applications. They argue that funds do not exist to implement the storm water program and that political pressures would prevent them from securing storm water utilities.

- **Geographic Targeting: Designate municipalities impacting watersheds of concern (those not meeting designated water uses) and in specific rainfall zones. [1.e./1.g.i]**

As discussed under the "Industrial Targeting" section, nearly half of the 91 commenters (45 commenters) support targeting sensitive watersheds, i.e., those that have high pollutant loadings and/or those not meeting designated uses. While targeting these watersheds can help identify significant industrial polluters, many commenters also believe that this approach is useful in identifying MS4s for storm water permitting.

These commenters argue that since watersheds are oftentimes a patchwork of rural, suburban and urban lands comprised of incorporated and unincorporated areas, storm water permits should apply to the jurisdiction as a whole, not just to individual municipalities within the watershed. Commenters note that in watersheds of concern, all Phase II municipalities could become co-permittees with Phase I municipalities. Where it is determined that watersheds are not polluted, Phase II municipalities would not be required to obtain a storm water permit. This option provides opportunities for municipalities to reduce administrative burdens, consolidate efforts to study or evaluate approaches, and greatly reduce costs of program development and implementation. Although a great deal of regional coordination would be required, commenters believe that such an approach would yield the greatest environmental benefit.

(Please refer to the "Industrial Targeting" section for a summary of options for targeting on a watershed basis).

- **Permit small municipalities but establish simplified application requirements. [1.g.iii]**

15 commenters support the idea of permitting small municipalities but establishing simplified application requirements. Arguing that Phase I municipal permit application requirements (particularly Part 2 requirements) were burdensome and overly costly, these commenters suggest that Phase II municipalities be covered under a simplified general permit that requires a storm water management plan and flexible watershed-specific monitoring requirements. One commenter suggests the following components of a Phase II municipal program: 1) *Sediment and Erosion Control*:

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Applicants incorporate erosion control into the development review and local permitting process; 2) *Storm Water Quality Control*: Applicants incorporate storm water BMPs into the municipal development review and approval process and into municipal operations; and 3) *Illicit Discharges*: Applicant prohibits illicit connections and improper dumping, he/she develops a spill prevention and response plan.

II. Control Strategies

A. General Control Strategies for Both Municipalities and Industries

	Yes	No
■ Continue to rely on NPDES programs; use NPDES general permits that focus on BMPs. [2.a/2.d.I]	32	4
■ Rely on nonpoint source programs administered under section 319 of the CWA and section 6217 of CZARA. [2.b]	20	3
■ Establish mandatory national Phase II performance standards without a permit. [2.c]	14	10

■ **Continue to rely on NPDES programs; use NPDES general permits that focus on BMPs [2.a.]**

Approximately 32 commenters favor the continued use of NPDES programs to regulate storm water discharges. 19 commenters prefer reliance on State nonpoint source programs under section 319. Most commenters state that it would be inefficient to discontinue the current program, and, as one commenter notes, displacing the NPDES program would "create a significant amount of confusion among authorized NPDES States and the regulated community." Additionally, the NPDES storm water permit program is in the initial stages of development and results may not be realized for at least two years. The majority of the commenters who support reliance on the NPDES program encourage use of general permits, for an "emphasis on the development of effective programs, not on lengthy and expensive application processes." Most commenters believe that BMPs are a more effective control strategy and a better allocation of resources than monitoring and numeric effluent limitations. BMPs utilized should be those which proved cost effective for Phase I sources.

- **Rely on nonpoint source programs administered under section 319 of the CWA and section 6217 of CZARA. [2.b.]**

Approximately 21 commenters favor the use of State nonpoint source programs and/or section 6127 of CZARA to regulate Phase II storm water discharges. Many of these commenters assert that storm water runoff is a nonpoint source rather than a point source and therefore should be regulated under section 319. Moreover, State nonpoint source programs are already developed and utilizing them would lessen the repetition of water quality programs. Several commenters emphasize, however, that if State nonpoint source programs were expanded to include storm water runoff, additional funding would be essential. Those commenters that supported the use of section 319 see it beneficial in that the program encourages flexibility through voluntary control measures, pollution prevention, and watershed planning. Several commenters express some trepidation that nonpoint sources may be moved under the NPDES program, and assert that nonpoint sources should continue to be covered under section 319, not NPDES.

- **Establish mandatory national Phase II control strategies without requiring a permit. [2.c.]**

Commenters are fairly divided on whether EPA should establish national control strategies for Phase II sources. Various statements from the 12 commenters who support mandatory guidelines indicate that this approach would be cost-effective and would alleviate the administrative burdens of permit applications. A few commenters also state that, in order to be most effective, the guidelines and management practices should be industry-specific. A model that is mentioned by several commenters is the Puget Sound Water Quality Management Plan and the Washington State Department of Ecology's Stormwater manual for the Puget Sound Basin. These commenters suggest that all States adopt a similar storm water management plan which would be required to at least meet a national standard; all municipalities within the State would have to adhere to the plan.

11 of the commenters who address this control strategy oppose mandatory national control guidelines for Phase II activities. Several commenters believe it would be difficult to effectively notify and educate the general population concerning the details of such a program. Other commenters express concern that the diversity in climate and topography throughout the country requires more flexibility than national standards would provide.

B. Key Elements of a Control Strategy

		Yes	No
■	Focus on education for public and affected industry. [2.d.ii]	18	0
■	Emphasize pollution prevention incentives and BMPs, particularly for new development. [2.d.iii]	17	0
■	Establish correlation between severity of pollution and controls required, using fines to aid implementation. [2.d.iv]	3	0

- **Focus on education for public and affected industry. [2.d.ii]**

  14 commenters state that education needs to be a primary focus of the Phase II program. One commenter notes that EPA should "keep it simple," particularly on issues on coverage, since Phase II dischargers may be smaller and less familiar with environmental regulations than Phase I dischargers. Commenters unanimously stress the importance of public education and outreach. They urge that EPA/States 1) distribute guidance documents and fact sheets prior to implementing the rule, 2) provide examples of pollution prevention programs, 3) conduct workshops, 4) prepare video presentations for distribution, and 5) launch public education campaigns geared towards explaining water quality problems associated with storm water.

- **Emphasize pollution prevention incentives and BMPs, particularly for new development. [2.d.iii]**

  14 commenters support an emphasis on voluntary pollution prevention programs. This approach is favored because of its cost-effectiveness, flexibility, and reduction in regulatory burden. Additionally, several commenters indicate that it would establish a 'partnership' between the regulated community and regulatory agencies by encouraging dialogue and guidance concerning pollution prevention techniques. One State notes that the voluntary measures in its nonpoint source program have proven very successful in improving water quality, and that similar practices could be implemented for storm water runoff. The State recommends, however, that voluntary approaches be used in conjunction with mandatory approaches and that "provisions be included for requirements placed on 'bad actors' if cooperation is not attained through the voluntary programs." Numerous commenters point out that education would need to be far-reaching if the voluntary programs were implemented.

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- **Establish correlation between severity of pollution and controls required, using fines to aid implementation. [2.d.iv.]**

Only 3 commenters address this control strategy, and all 3 support a correlation between severity of pollution and controls required. One commenter writes that, "market based incentives structured to incorporate true economic externalities associated with pollution can be a valuable tool in helping society balance economic growth and levels of pollution." Another commenter notes that State agencies should administer the fine/implementation system, as States can adjust their controls based on the types of pollutant sources and sensitivity of the watersheds in a particular region.

III. Deadlines

A. Options for Program Deadlines [3]

	Yes	No
■ October 1, 1995 or later	12	
■ Prioritize sources; establish phased deadlines	3	
■ Eliminate Phase II; no deadlines	1	
■ Pending thorough review of Phase I	20	
■ H.R. 6167 deadlines satisfactory	3	
■ Before October 1, 1994	3	

Commenters unanimously feel that Phase II should not be implemented until a thorough review of Phase I has been completed. A number of these commenters indicated that Phase II regulations should not be published before October 1, 1995.

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IV. Costs/Regulatory Burden

A. Issues associated with costs and regulatory burden

■	Balancing the need to protect the environment with the cost-effectiveness of the program [III.A.2]
■	Examining the impacts of the storm water program on small businesses and communities [III.A.7]
■	Assessing the regulatory burden on permittees and regulators [III.A.3/III.A.4]

General Cost/Benefit Concerns

Nearly a third of the commenters (26 commenters) express concern over the costs associated with implementing the storm water program, and whether these costs justify the need to protect the environment.

Municipalities, in particular, voice concern over the costs associated with completing municipal permit applications and implementing storm water management programs. One commenter argues that while cities across the nation have spent over $1 trillion dollars to implementing the program, water quality is not significantly improving because of upstream discharges not regulated under the CWA. This commenter further states that since urban runoff affects only 11% of river impairment and 29% of lake impairment, the price tag of implementing storm water management programs is not justified. (Please note that a number of commenters question EPA's methodology in 305(b) reports as it pertains to assessing "designated uses" for waterbodies).

Comments indicate that across the board--among cities, small business owners, and trade associations--the storm water program is viewed as a major financial burden on communities and industries. Of particular concern for cities (and especially small cities) is the number of growing number of projects/regulations that need to be supported by shrinking municipal budgets. Generating a storm water utility to support the program has proven politically difficult in a number of cities. On the industrial side of the program, there are equally as many concerns over costs and benefits. In particular, commenters argue that a number of small industries which pose little risk to the environment were required to apply for a storm water permit under Phase I, while "higher risk" industries such as oil and gas, agriculture, and retail gasoline facilities were not covered by the rule. A number of small industries claim that sampling is cost-prohibitive and that the quantitative data generated are oftentimes inaccurate/meaningless. Regarding Phase II, one construction operator

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argues that inclusion of construction operations under 5 acres would render these small-scale activities cost-prohibitive.

Strategies for Phase II

In closing, commenters offer the following suggestions for maximizing cost-effectiveness and environmental benefit under Phase II:

- Phase I of the storm water program must be thoroughly assessed in terms of dollars spent and environmental benefits gained before launching into Phase II.
- EPA and/or States must incorporate a more realistic benefit/cost analysis of Phase II, particularly for the municipal side of the program.
- Under Phase II, emphasize storm water management and pollution prevention rather than sample gathering and analysis. (A number of the quantitative requirements under Part 2 of the municipal permit application were viewed as unnecessary and overly costly)
- EPA and States should use data generated from Phase I of the program so as to make Phase II more cost-effective and environmentally beneficial.
- Rely more heavily on State or local entities for storm water program administration.

V. General Concerns/Issues Related to the Storm Water Program [4]

■ Lack of adequate outreach/public education/timely guidance during Phase I resulted in confusion about: • Which facilities are subject to regulation (use of SIC codes viewed as confusing, inappropriate) • The types of permit application options available • Deadlines • The relationship between the industrial and municipal programs • The overall relevance of the program
■ Confusion resulted from different requirements in different States (i.e., those with approved NPDES programs and those without) particularly in regards to the group application process.

- **Lack of adequate outreach/public education/timely guidance during Phase I resulted in confusion over a number of issues, including:**

  Use of SIC codes. A number of commenters indicated that there was widespread confusion during Phase I over which facilities were subject to regulation. In particular, the use of SIC codes to determine regulatory status was viewed as confusing. Multiple activities commonly occur at a single facility and people were frequently unclear as to how they are classified under the SIC code system. Due to this excessive confusion, commenters generally feel that SIC codes are an ineffective way of targeting facilities for regulation under the storm water program.

  Application Options. Commenters complained that the storm water permit application options were not spelled out clearly in the beginning of the program. In particular, some expressed anger over the group application process. One commenter notes that while the group application option seemed preferable a year ago, it became clear that this option was problematic given that certain States are not accepting group applications as legal coverage. In addition, a number of group applicants would have opted for coverage under the general permit had that option been available in the first place. Commenters resented that it was oftentimes necessary to hire expensive consultants simply to understand the regulations and stay informed of their application options.

  Deadlines. Commenters indicate that there was confusion surrounding permit application deadlines. In the future, this could be alleviated by improved outreach and public education.

The relationship between the industrial and municipal programs. One commenter recommends separating municipalities and industries into two distinct rules so as to avoid confusion over the differences between the two programs.

The "Big Picture" of the storm water program. As discussed throughout this report, commenters seem frustrated over the fact that huge costs are being incurred to implement the storm water program without a clear indication that environmental benefits are being achieved. Commenters write that it essential for EPA to step up public education and outreach efforts in the future.

- **Confusion resulted from different requirements in different States (i.e., those with approved NPDES programs and those without) particularly in regards to the group application process.**

Numerous commenters state that the conflicting time frames between States and EPA in developing and issuing the permits created enormous confusion for the regulated community. As discussed above, this situation was particularly frustrating members of group applications.

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APPENDIX K

SELECTED MANAGEMENT MEASURES DEVELOPED UNDER SECTION 6217 OF CZARA

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SELECTED MANAGEMENT MEASURES DEVELOPED UNDER SECTION 6217 OF CZARA[1]

MANAGEMENT MEASURES FOR URBAN AREAS (Chapter 4 of CZARA guidance)

I. INTRODUCTION

II. URBAN RUNOFF

A. New Development Management Measure

(1) By design or performance:

(a) After construction has been completed and the site is permanently stabilized, reduce the average annual total suspended solid (TSS) loadings by 80 percent. For the purposes of this measure, an 80 percent TSS reduction is to be determined on an average annual basis,[2] or

(b) Reduce the postdevelopment loadings of TSS so that the average annual TSS loadings are no greater than predevelopment loadings, and

(2) To the extent practicable, maintain postdevelopment peak runoff rate and average volume at levels that are similar to predevelopment levels.

Sound watershed management requires that both structural and nonstructural measures be employed to mitigate the adverse impacts of storm water. Nonstructural Management Measures for new development (B&C) can be effectively used in conjunction with this Management Measure reduce both the short-and long-term costs of meeting the treatment goals of this management measure.

B. Watershed Protection Management Measure

Develop a watershed protection program to:

(1) Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss;

[1] See "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters," January 1993, U.S. EPA, 840-B-92-002.

[2] Based on the average annual TSS loadings from all storms less than or equal to the 2-year/24-hour storm. TSS loadings from storms greater than the 2-year/24-hour storm are not expected to be included in the calculation of the average annual TSS loadings.

(2) Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota; and

(3) Site development, including roads, highways, and bridges, to protect to the extent practicable the natural integrity of waterbodies and natural drainage systems.

C. Site Development Management Measure

Plan, design, and develop sites to:

(1) Protect areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;

(2) Limit increases of impervious areas, except where necessary;

(3) Limit land disturbance activities such as clearing and grading, and cut and fill to reduce erosion and sediment loss; and

(4) Limit disturbance of natural drainage features and vegetation.

III. CONSTRUCTION ACTIVITIES

A. Construction Site Erosion and Sediment Control Management Measure

(1) Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction, and

(2) Prior to land disturbance, prepare and implement an approved erosion and sediment control plan or similar administrative document that contains erosion and sediment control provisions.

B. Construction Site Chemical Control Management Measure

(1) Limit application, generation, and migration of toxic substances;

(2) Ensure the proper storage and disposal of toxic materials; and

(3) Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface waters.

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IV. EXISTING DEVELOPMENT

A. Existing Development Management Measure

Develop and implement watershed management programs to reduce runoff pollutant concentrations and volumes from existing development:

(1) Identify priority local and/or regional watershed pollutant reduction opportunities, e.g., improvements to existing urban runoff control structures;

(2) Contain a schedule for implementing appropriate controls;

(3) Limit destruction of natural conveyance systems; and

(4) Where appropriate, preserve, enhance, or establish buffers along surface waterbodies and their tributaries.

V. ONSITE DISPOSAL SYSTEMS

A. New Onsite Disposal Systems Management Measures

(1) Ensure that new Onsite Disposal Systems (OSDS) are located, designed, installed, operated, inspected, and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives: (a) discourage the installation of garbage disposals to reduce hydraulic and nutrient loadings; and (b) where low-volume plumbing fixtures have not bee installed in new developments or redevelopments, reduce total hydraulic loadings to the OSDS by 25 percent. Implement OSDS inspection schedules for preconstruction, construction, and postconstruction.

(2) Direct placement of OSDS away from unsuitable areas. Where OSDS placement is unsuitable areas is not practicable, ensure that the OSDS is designed or sited at a density so as not to adversely affect surface waters or ground water that is closely hydrologically connected to surface water. Unsuitable areas include, but are not limited to, areas with poorly or excessively drained soils; areas with shallow water tables or areas with high seasonal water table; areas overlaying fractured bedrock that drain directly to ground water; areas within floodplains; or areas where nutrient and/or pathogen concentrations in the effluent cannot be sufficiently treated or reduced before the effluent reaches sensitive waterbodies;

(3) Establish protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative OSDS. The lateral setbacks should be based on soil type, slope, hydrologic factors, and type of OSDS. Where uniform protective

setbacks cannot be achieved, site development with OSDS so as not to adversely affect waterbodies and/or contribute to a public health nuisance;

(4) Establish protective separation distances between OSDS system components and groundwater which is closely hydrologically connected to surface waters. The separation distances should be based on soil type, distance to ground water, hydrologic factors, and type of OSDS;

(5) Where conditions indicate that nitrogen-limited surface waters may be adversely affected by excess nitrogen loadings from ground water, require the installation of OSDS that reduce total nitrogen loadings by 50 percent to ground water that is closely hydrologically connected to surface water.

B. Operating Onsite Disposal Systems Management Measure

(1) Establish and implement policies and systems to ensure that existing OSDS are operated and maintained to prevent the discharge of pollutants to the surface of the ground and to the extent practicable reduce the discharge of pollutants into ground waters that are closely hydrologically connected to surface waters. Where necessary to meet these objectives encourage the reduced use of garbage disposals, encourage the use of low-volume plumbing fixtures, and reduce total phosphorus loadings to the OSDS by 15 percent (if the use of low-level phosphate detergents has not been required or widely adopted by OSDS users). Establish and implement policies that require an OSDS to be repaired, replace, or modified where the OSDS fails, or threatens or impairs surface waters;

(2) Inspect OSDS at a frequency adequate to ascertain whether OSDS are failing;

(3) Consider replacing or upgrading OSDS to treat influent so that total nitrogen loadings in the effluent are reduced by 50 percent. This provision applies only:

(a) where conditions indicate that nitrogen-limited surface waters may be adversely affected by significant ground water nitrogen loadings from OSDS, and

(o) where nitrogen loadings from OSDS are delivered to ground water that is closely hydrologically connected to surface water.

VI. POLLUTION PREVENTION

A. Pollution Prevention Management Measure

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities, where applicable:

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- The improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, solvents, etc.;
- Lawn and garden activities, including the application and disposal of lawn and garden care products, and the improper disposal of leaves and yard trimmings;
- Turf management on golf courses, parks, and recreational areas;
- Improper operation and maintenance of onsite disposal systems;
- Discharge of pollutants into storm drains including floatable, waste oil, and litter;
- Commercial activities including parking lots, gas stations, and other entities not under NPDES purview, and
- Improper disposal of pet excrement.

VII. ROADS, HIGHWAYS, AND BRIDGES

A. Management Measure for Planning, Siting, and Developing Roads and Highways

Plan, site, and develop roads and highways to:

(1) Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss;

(2) Limit land disturbance such as clearing and grading and cut and fill to reduce erosion and sediment loss; and

(3) Limit disturbance of natural drainage features and vegetation.

B. Management Measure for Bridges

Site, design, and maintain bridge structures so that sensitive and valuable aquatic ecosystems and areas providing important water quality benefits are protected from adverse effects.

C. Management Measure for Construction Projects

(1) Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction and

(2) Prior to land disturbance, prepare and implement an approved erosion control plan or similar administrative document that contains erosion and sediment control provisions.

D. Management Measure for Construction Site Chemical Control

(1) Limit the application, generation, and migration of toxic substance;

(2) Ensure the proper storage and disposal of toxic materials; and

(3) Apply nutrients at rates necessary to establish and maintain vegetation without causing significant nutrient runoff to surface water.

E. Management Measure for Operation and Maintenance

Incorporate pollution prevention procedures into the operation and maintenance of roads, highways, and bridges to reduce pollutant loadings to surface waters.

F. Management Measure for Road, Highway, and Bridge Runoff Systems

Develop and implement runoff management systems for existing roads, highways, and bridges to reduce runoff pollutant concentrations and volumes entering surface waters.

(1) Identify priority and watershed pollutant reduction opportunities (e.g., improvements to existing urban runoff control structures; and

(2) Establish schedules for implementing appropriate controls.

MANAGEMENT MEASURES FOR ANIMAL FEEDLOTS (Chapter 2.II.B of CZARA guidance)

B1. Management Measures for Facility Wastewater and Runoff from Confined Animal Facility Management (Large Units not subject to NPDES permit requirements)

Limit the discharge from the confined animal facility to surface waters by:

(1) Storing both the facility wastewater and the runoff from confined animal facilities that is caused by storms up to and including a 25-year, 24-hour frequency storm. Storage structures should:

(a) Have an earthen lining or plastic membrane lining, or
(b) Be constructed with concrete, or
(c) Be a storage tank;

and

(2) Managing stored runoff and accumulated solids from the facility through an appropriate waste utilization system.

B2. Management Measures for Facility Wastewater and Runoff from Confined Animal Facility Management (Small Units not subject to NPDES permit requirements)

Design and implement systems that collect solids, reduce contaminant concentrations, and reduce runoff to minimize the discharge of contaminants in both facility wastewater and in runoff that is caused by storms up to and including a 25-year, 24-hour frequency storm. Implement these systems to substantially reduce significant increases in pollutant loadings to ground water.

Manage stored runoff and accumulated solids from the facility through an appropriate waste utilization system.

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APPENDIX L

PRESIDENT CLINTON'S CLEAN WATER INITIATIVE (PORTIONS RELATED TO STORM WATER PROGRAM)

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STORM WATER PROGRAMS

ISSUE:

How should CWA storm water requirements be revised to strengthen and facilitate implementation of storm water controls?

BACKGROUND:

States report that approximately 30 percent of remaining surface water quality impairment is attributable to storm water discharges. Significant sources of storm water discharges include urban runoff, industrial activity, construction, and resource extraction (mining). For example, in urban areas, loadings from storm water runoff for heavy metals, sediment, bacteria, polycyclic aromatic hydrocarbons (PAHs), acidity, and floatables are higher than those from POTWs.

To address these environmental risks, Congress established in 1987 a two-phased storm water program under CWA §402(p). Phase I applies to municipal storm sewer systems serving a population over 100,000, as well as storm water discharges associated with industrial activity.

In November of 1990, EPA issued regulations that identified 220 municipalities whose separate storm sewer systems are subject to Phase I of the NPDES program. States and EPA have designated an additional 550 municipalities as part of the Phase I program. The Agency estimates that the Phase I municipalities have a population of over 90 million people (about 36 percent of the total U.S. population). EPA and authorized States have received comprehensive permit applications from many of the municipalities, and are in the process of developing and issuing permits for these dischargers.

In addition, the Phase I regulations established regulation of over 100,000 industrial facilities in eleven categories, including manufacturing, mining, waste management, construction, and transportation. Permits for storm water discharges from Phase I industries generally were required to be issued by October 1, 1993. The Ninth Circuit struck down EPA's exemption from Phase I regulations of construction sites under 5 acres and light industrial activities "with no exposure" to rain water.

Phase II applies to all remaining light industrial, commercial, retail, and residential facilities with storm water discharges that are not in Phase I. Preliminary estimates indicate that millions of facilities are not addressed by Phase I. Phase II is potentially ten times larger in scope than Phase I, and could address a large number of municipalities without significant urban populations. EPA was required to issue Phase II regulations by October 1, 1993, which would designate classes of Phase II storm water discharges to be regulated to protect water quality. Phase II sources are required to obtain a permit by October 1, 1994. EPA did not meet the October 1993 deadline for Phase II regulations.

Municipal Compliance with Standards

Municipal separate storm sewer systems (or "MS4"--those municipal systems that are covered by the storm water program) have stated that it is both technologically and financially impossible to establish treatment or management practices that can ensure that urban storm water runoff complies with water quality standards. They have indicated that it is highly uncertain whether feasible storm water control measures (source controls, traditional structural controls, and best management practices) will ensure that storm water discharges will meet water quality standards. They further argue that the only other alternative, collecting and treating essentially all of the storm water from widespread urbanized areas, would be infeasible and result in significant destruction of urban streams and wetlands.

Under the existing CWA, §402(p)(3)(B)(iii), a statutory standard exists that NPDES storm water discharge permits issued to municipal separate storm sewer systems require controls to reduce the discharge of pollutants in storm water to the "maximum extent practicable" (MEP). The statutory standard can include management practices, control techniques, and system design and engineering methods and other such provisions that the Administrator or State determines are necessary for the control of such pollutants. Because of the lack of a more specific definition of the statutory standard of MEP, municipalities, permitting authorities, and members of the public are uncertain as to the extent of storm water control requirements a municipality must implement in its storm water management program.

Provisions for Facilities with No Exposure

EPA attempted to exempt from storm water control requirements certain industrial facilities that had no exposure of materials, equipment, or wastes to storm water. However, this exemption of facilities without storm water exposure was overturned by the Ninth Circuit. Such an exemption, if reinstated through legislation, would create a strong incentive for facilities to implement pollution prevention. It would simultaneously accomplish environmental objectives (reducing pollutants in storm water) and greatly reduce administrative burdens for EPA, States, and industries.

Deadline Extensions for Phase II

EPA is presently required to issue Phase II regulations designating sources for permitting and establishing deadlines by October 1, 1993. In the absence of new regulations, Phase II sources are required to have permits after October 1, 1994. Given the scope and complexity of Phase II, EPA was unable to meet the October 1, 1993 regulatory deadline. Furthermore, EPA and authorized States will not be able to issue permits to all Phase II sources by October 1, 1994. This may expose unpermitted dischargers, including many small municipalities or commercial enterprises posing small risks, to litigation for discharging without a permit. In addition, potential Phase II municipalities need additional time to develop the financial capabilities and institutional frameworks needed to comply with storm water requirements.

Phase II Storm Water Requirements

Phase II regulations must be reasonable in scope and establish a workable program that will focus on sources of storm water discharges that pose the highest risk. The Bureau of Census has designated 396 urbanized areas which represent the most widespread and dense urban development. These urbanized areas occupy less than 2 percent of the total land area of the United States but contain 165 million people, or about 65 percent of the total population of the United States. In addition, most new development occurs in or adjacent to these urbanized areas. Between 1980 and 1990, over 75 percent of the national increase in population occurred in these urbanized areas. However, over 5,000 municipal entities in urbanized areas are not in Phase I of the NPDES storm water program.

Authorize Municipalities to Directly Regulate Storm Water Facilities Within Their Jurisdiction

Under current CWA provisions, the storm water program requires permits for industrial activities even if they are discharging to municipal separate storm sewer systems which also must obtain storm water permits. Municipalities argue that this is redundant and inefficient, and also undercuts their effectiveness in directly dealing with an industrial facility.

Inactive and Abandoned Mines

It is estimated that there are in the range of 400,000 or more inactive and abandoned mine sites (IAMs) on Federal lands. The environmental damages posed by these sites can vary significantly. While many sites are relatively benign, releases from other sites result in significant environmental degradation, even decades after active operations have ceased. A major administrative challenge is to (1) prioritize these sites that cause environmental problems so that the United States can address them in a rational environmentally protective manner, and (2) effectively protect water resource quality by addressing these sites according to the prioritized order. Another major challenge is to target control measures so as to achieve the greatest improvement in environmental quality for the limited Federal resources that may be available. Although the estimates of total costs of mitigating water resource quality impacts from IAMs vary significantly, they range into the many tens of billions of dollars without such cost-effective, risk-based prioritization.

A significant number of IAMs on Federal lands are believed to have point source discharges of pollutants, as defined under current statute and regulation, to waters of the United States subject to regulation under the NPDES permit program. Given the large number of IAMs and the costs of mitigating sites causing environmental impacts, there is a need for a phased, cost-effective, risk-based prioritized approach to mitigating these sources.

RECOMMENDATIONS:

The Administration recommends that the CWA be amended to do the following--

<u>Municipal Compliance with Standards</u>

- Establish a phased permit compliance approach that requires best management practices in first-round municipal storm water permits, and through improved best management practices in second-round permits, where necessary, to move towards compliance with water quality standards. In later permits, compliance with water quality standards will occur using water quality based effluent limits, where necessary. This would give EPA and municipalities additional time to evaluate the technical feasibility of establishing numeric effluent limits to meet water quality standards and give States time to develop specific water quality standards appropriate for storm water discharges, if necessary.

- The Administration supports clarifying authority under section 402(p)(3)(B) concerning "maximum extent practicable" (MEP). In contrast to best available technology economically achievable (BAT) and best conventional pollutant control technology (BCT) that are applicable for storm water discharges associated with industrial activities, under MEP, storm water management programs can be implemented in a site-specific and flexible manner to address the storm water management concerns in the municipality. It should be made clear that MEP allows for the consideration of different factors including: (1) the severity of the impairment caused by the source, (2) the effectiveness of alternative approaches at reducing storm water discharges, and (3) the cost of control measures. Under MEP, a storm water management program can target controls based on differences in the type and size of sources, climate, geography, and water quality concerns. Based on a statutory clarification, EPA will then issue guidance on the best methods by which to implement MEP in NPDES permits.

- The Administration supports encouraging States to review and revise their designated uses and water quality standards implementation procedures, as they develop water quality-based permits, to reflect the episodic nature of storm water runoff, the varying loadings during storm water events, and the potential resilience of natural ecosystems to some infrequent, temporary incremental loadings.

Provisions for Facilities with No Exposure

- Authorize EPA to exempt from individual storm water permitting requirements facilities that can certify that there is no nor will be exposure of industrial or other activities or significant materials to rain water and snow melt. This change would ensure that several hundred thousand low-risk facilities are not subject to NPDES requirements, allowing allocation of resources to more critical areas. This would also effectively create incentives for facilities to eliminate contamination of storm water.

Deadline Extensions for Phase II

- Extend the Phase II deadline for EPA issue to regulations to October 1, 1997. Also, extend the deadline to obtain a permit to October 1, 1999. These extensions are necessary to allow EPA to work with States and municipalities in developing workable, effective regulations. Extending the deadline for permits would give municipalities an opportunity to begin to build institutional frameworks and provide the funding necessary to implement storm water management programs. It would also allow permits to be issued to Phase II municipalities at the same time Phase I permits are expiring. This will promote regional and watershed-wide permitting by allowing different municipalities to be co-applicants and coordinate their storm water programs.

Phase II Storm Water Requirements

- Focus Phase II requirements on system-wide permits for municipal separate storm sewer systems in Census-designated urbanized areas with a population of 50,000 or more.

- Target storm water management programs for municipal separate storm water systems (MS4) in the 138 Phase II urbanized areas associated with a Phase I permitted MS4 to address, at a minimum, non-storm water discharges into storm sewers and storm water runoff from growth and development and significant redevelopment. The CWA should encourage NPDES permitting authorities as part of a watershed approach to implement a more comprehensive municipal storm water management program where appropriate based on water quality impairments or other factors for the MS4s in these urbanized areas. In the remaining 258 Phase II urbanized areas, storm water management programs would be required which focus only on controlling non-storm water discharges into storm sewers and storm water runoff from growth and development and significant redevelopment activities.

- Under Phase II for those MS4s required to implement a storm water management program targeted to growth, development and significant redevelopment and illicit connections, the municipal program will control those Phase II storm water sources, including discharges from construction of less than 5 acres, which are part of growth, development, and significant redevelopment activities and may address, where appropriate, subject to the MEP standard, those Phase II sources causing water quality impairment. For those municipal separate storm sewer systems required by the NPDES permitting authority to implement a more comprehensive storm water management program, Phase II light industrial, commercial, retail, and institutional storm water sources would be addressed through the program under the municipality's NPDES storm water permit, which meets the MEP standard. Phase II sources not addressed through a municipal program would not be covered by the NDPES program.

- Do not directly regulate Phase II light industrial, commercial, retail, and institutional storm water discharges, and municipalities outside of Census-designated urbanized areas under the NPDES program, unless otherwise designated by the permitting authority for inclusion in the NPDES program under §402(p)(2)(E) of the CWA. (EPA does not expect that this designation process would be used, except in highly-unusual circumstances, to require an NPDES permit for a typical homeowner.) Rather, such discharges could be addressed by NPS program, if they were a targeted source.

<u>Authorize Municipalities to Directly Phase I Industrial Regulate Storm Water Facilities Within Their Jurisdiction Under the NPDES Program</u>

- Allow EPA and authorized States to authorize municipalities to establish programs for Phase I industrial storm water permit issuance and controls, where it has the appropriate authority, and is willing to commit to implement Federal requirements. EPA does not envision Federal funding to be available to municipalities to perform this function. This recommendation is similar to the industrial pretreatment program currently authorized under the CWA. As in the industrial pretreatment program, storm water permits and controls that are issued by municipalities in an EPA-approved program would be Federally enforceable.

<u>Inactive and Abandoned Mines</u>

- The Administration recommends that the CWA be amended to make the following changes to the NPDES permitting program to target control measures so as to achieve the greatest improvement in environmental quality for the limited Federal resources available for inactive and abandoned mine sites (IAMs) without an operator present:

- The Administration supports clarifying authority to issue NPDES permits on a State-wide basis for IAMs within resource management units (e.g., one permit per State for the National Forest Service, National Park System, Bureau of Land Management, or Fish and Wildlife Service resource areas). This would allow Federal land managers to establish State-wide priorities based on impairment or threats to water resource quality and the most effective use of the available resources. Such priorities could allow some sites not to be controlled or be subject to relatively less stringent controls.

- The Administration supports an amendment to substitute, for existing technology-based requirements under the NPDES program for IAMs on Federal lands, the authority for Federal land managers to identify water resource quality that is threatened or impaired by IAMs and to implement targeted controls for such sites, similar to existing authority for permits for municipal separate storm sewer systems contained in section 402(p)(3)(B).

- The Administration further supports allowing, in general, no more than up to ten years to meet appropriate water quality standards within a resource management unit, as defined in the language above, from the date of issuance of an NPDES permit to the Federal land manager. The Federal land manager would be expected during this period to 1) strive to achieve water quality standards as expeditiously as possible, 2) continue to assess the water resource quality impacts of IAMs where they are currently unknown, and 3) continue to implement targeted controls for those sites causing impairments or threats once identified. This provision should not apply to IAMs which were permitted under the NPDES program prior to the date of enactment.

- The Administration supports encouraging States to review and revise their designated uses and water quality standards implementation procedures, as they develop water quality-based permits, to reflect the episodic nature of storm water runoff, the varying loadings during storm water events, and the potential resilience of natural ecosystems to some infrequent, temporary incremental loadings.

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4.0 Storm Water

EPA's current Phase I storm water program requires NPDES permits of cities and counties with municipal separate storm sewer systems (MS4s) serving populations of 100,000 or more and "storm water discharges associated with significant industrial activity." The Phase II program, currently suspended due to a Congressional moratorium, could require permits for all private sources of storm water (commercial, industrial, retail, and institutional) and all MS4s serving all populations that have the potential to affect water quality. In the Initiative, EPA has addressed the potentially high costs of the Phase II program while still providing protection from private sources and additional MS4s.

The "worse case" scenario for storm water permitting reflects the most inclusive option of all potential options that EPA would consider in proposing rules for the types of facilities covered under Phase II. If EPA were to propose regulations for permitting Phase II facilities, EPA may propose to cover only a portion of these facilities, based on consideration of costs incurred and environmental benefits gained. EPA could propose regulations covering the same facilities to the same extent as suggested in the Initiative.

The Initiative's Phase II program will focus on system-wide permits for MS4s in Census-designated urbanized areas--i.e., areas with a population of 50,000 or more and a population density of 1,000 persons per square mile. The Census Bureau has identified 396 such urbanized areas nationwide. Phase II MS4s will be required to implement storm water management programs that are subject to a "maximum extent practicable" (MEP) standard. These programs will, at a minimum, address: (1) nonstorm water discharges to their systems (i.e., illicit connections) and (2) storm water runoff from growth and development and significant redevelopment activities (including discharges from construction of less than 5 acres) and, where appropriate, those Phase II sources causing water quality impairment.

Where the NPDES authority deems it necessary, MS4s in the 138 urbanized areas associated with a Phase I permitted MS4 may be required to have a more comprehensive storm water management program (consistent with the Phase I storm water requirements). The comprehensive storm water management programs would cover Phase II light industrial, commercial, retail, and institutional storm water sources under a municipality's storm water permit. The NPDES program would not cover Phase II sources not addressed through a municipal program. Such discharges could be addressed by the NPS program if they were a targeted source.

4.1 Private Sources

Under a stringent interpretation of the CWA, the current Phase I program is estimated to cost industrial permittees $3.99 billion per year, while Phase II under a similarly stringent interpretation could cost as much as $16.23 billion in annual costs.

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To account for the uncertainty in estimating the potential costs, EPA has developed ranges. These ranges account for variations in both the number of sources affected and the costs incurred. The Initiative's Phase II plan would reduce these impacts on commercial, service, and institutional facilities considerably, imposing costs of between $0.34 billion and $1.67 billion per year, as follows:

	Low	High
10,000 facilities x $22,340/facility	$0.22 billion	
28,000 facilities x $34,700/facility		$0.97 billion
96,000 facilities x $630/facility	$0.06 billion	
269,000 facilities x $1,885/facility		$0.51 billion
100,000 sites x $630/site	$0.06 billion	
100,000 sites x $1,885/site		$0.19 billion
TOTAL	**$0.34 billion**	**$1.67 billion**

From a universe of 1.1 million significant sources, EPA has identified 100,000 that are similar to Phase I industrial sources while the remaining 1.0 million are retail, commercial, and institutional. Of the 100,000 industrial sources, approximately 60 percent or 60,000 have no storm water exposure. Of the remaining 40,000 sources, EPA has assumed that municipalities will require between 25 and 70 percent of the facilities to install storm water controls. To further account for the uncertainty inherent in projecting costs, EPA has used $22,340 per facility at the low end and $34,700 per facility at the high end of the estimated cost to comply (EPA, 1994c). The total cost for industrial look-a-likes is estimated to be between $0.22 billion and $0.97 billion per year.

Of the remaining 1.0 million sources, 60 percent are located in urbanized areas and may be addressed under storm water management programs for the urbanized areas. As above, 36 percent, or 216,000 sources, are estimated to have no storm water exposure. Of the remaining 384,000 sources, or 64 percent, the low-end number of facilities (96,000 sources or 25 percent) could incur costs as low as $630 per facility, while the high-end number of facilities (269,000 sources or 70 percent) could incur costs as high as $1,884 per facility.

In addition, 40 percent of the private sources that are not covered by a municipal program would be covered by the NPS program. Under the NPS program, only the sites located in impaired watersheds would need controls. EPA believes roughly 25 percent of these sites are in impaired watersheds. At a range of $630 and $1,885 per site and 100,000 sites, the annual costs will be between $0.06 billion and $0.19 billion.

Based on these estimates, the Initiative's total cost on private sources is between $0.34 billion and $1.67 billion. Compared to EPA's best interpretation of current law and assuming that the moratorium will expire, the Initiative will avoid costs (or yield a cost savings) of between $14.6 billion and $15.9 billion.

The Initiative may also result in potential cost savings for those facilities currently or soon to be permitted under the existing storm water Phase I regulations. About 60 percent of existing permitted industrial sources and 100 percent of potentially permitted light industrial sources will not require NPDES permits under the Initiative's provisions. In addition, small (less than 5 acre) construction sites will be considered Phase II sources, and this would result in additional cost savings of $70 million per year. As a result, additional cost savings to private sources from Phase I requirements will be between $1.1 billion and $1.6 billion.

The above estimates are derived in EPA, 1994c, and are summarized here. Based on a stringent interpretation of the current law, the overall cost savings (or costs avoided) to private sources from these provisions would be in the range of $15.7 billion and $17.5 billion, as shown in Table 21.

4.2 Municipalities

Costs for the current Phase I program for municipal sources are estimated at between $1.6 billion and $2.6 billion annually, based on a covered population of 69.3 million people and per person costs of between $23.91 and $37.00 per person.[8]

If the Phase II moratorium expires, EPA could be required to promulgate regulations covering an additional population of at least 74.1 million people (25.3 million in 138 urbanized areas associated with Phase I MS4s, 29 million in 258 additional urbanized areas between the population of 50,000 and 100,000, and potentially 19.8 million in other MS4s). EPA's best interpretation of the current law is that it would not include these additional 28 million in other MS4s. Using the same unit costs ($23.91 to $37.00), the existing Phase II program could cost between $1.8 and $2.7 billion per year.

To account for the uncertainty of the impact in terms of the number of municipalities affected and the costs incurred, EPA has estimated a range of costs for the Phase II provision in the Initiative. The following estimates are derived in EPA, 1994c, and are summarized here. About 25.3 million people live in 138 urbanized areas (UAs) with growth and development and illicit discharge. Costs range from a low of $15.33 per capita to a high of $23.72 per capita. The range of total costs for these urbanized areas is between $0.39 billion and $0.60 billion. Next, EPA assumed that between 25 and 70 percent of the population in these UAs will be covered by a comprehensive program based in part on the percentage of impaired urban waters. The population affected will be between 6.33 million and 17.7 million. The additional cost of

[8] Population estimates for the municipal storm water costs are from the draft "Report to Congress on Storm Water Dischargers Not Regulated Under Phase I of the NPDES Storm Water Program" (EPA, 1993d). Average costs are from the draft EPA report "Review of Program Costs in Part 2 NPDES Municipal Storm Water Permit Applications" (EPA, 1993c).

a comprehensive plan above the cost of addressing growth and development and illicit discharges will be in the range of $8.58 and $13.28 per capita. The total cost of the comprehensive coverage will vary from a low of $0.05 billion to a high of $0.24 billion.

EPA identified 29 million people in another 258 UAs who will be affected by the Phase II provisions. The cost of compliance will vary from $15.33 per capita to $23.72 per capita. The total cost of this coverage will be in the range of $0.44 billion and $0.69 billion. The final element of this cost on municipalities is the cost of addressing private sources and industrial look-a-likes that impact water quality in areas without the comprehensive program and in areas with combine sewers. At a per capita cost of $2.00, EPA estimates that about 75.7 million people will incur $0.15 billion. At a per capita cost of $5.00, the upper-end cost would be $0.38 billion.

	Low	High
25.3 million population x $15.33 per capita	$0.39 billion	
25.3 million population x $23.72 per capita		$0.60 billion
6.33 million population x $8.58 per capita	$0.05 billion	
17.7 million population x $13.28 per capita		$0.24 billion
29.0 million population x $15.33 per capita	$0.44 billion	
29.0 million population x $23.72 per capita		$0.69 billion
75.7 million population x $2.00 per capita	$0.15 billion	
75.7 million population x $5.00 per capita		$0.38 billion
TOTAL	**$1.03 billion**	**$1.91 billion**

The total cost to the municipalities of the proposed Phase II requirements is between $1.03 billion and $1.91 billion, as shown in Table 20.

Compared with the cost of Phase II requirements under a stringent interpretation of the current law, total savings to municipalities will be between $755 million and $850 million per year.

4.3 State Water Programs

The impacts of the Phase II storm water provisions on states have not been estimated but are expected to be minimal.

4.4 Federal Agencies

Additional costs of the storm water provisions on federal agencies will total $19 million per year. EPA will account for $2 million per year of this cost, and DOI will account for $17 million per year.

4.5 Benefits[9]

The benefits of storm water control as proposed in the Initiative are based on numerous case studies and are summarized as follows:

- 75 to 80 percent reduced loadings in urbanized areas prior to and during development,
- 15 to 25 percent reduced loadings in areas already developed,
- Greater environmental protection at lower cost,
- Improved water resource quality, habitat, and aquatic life; reduced flooding; improved recreational opportunities; increased commercial fishing; improved human health; and increased employment.

(Note that more cost-effective and institutionally feasible prevention and management methods are available for new development than for areas that have already been developed.)

Case Studies[10]

Bellevue, Washington (see longer summary in Appendix B)

Bellevue has a population of nearly 87,000 and covers a 30-square mile area that contains five lakes and over 50 miles of open streams. The city established a storm water utility in 1974 to maintain a hydrologic balance, prevent property damage, and protect water quality.

The city requires newly developing areas to include on-site storm water management that provides protection for 24-hour, 100-year storm events.

Examples of program benefits:

- Flood control. One of the most successful aspects of the program is flood control, which relies on eight remote-controlled regional detention basins along major stream corridors to monitor rainfall, stream flow, and water levels. This helps ensure that flood gates control peak flows. Small detention basins reduce peak flow rates up to 60 percent, providing flood and stream-bank erosion control and protecting stream-side property.

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[9] See also the EPA (1994e) background paper "CWA Benefits of Storm Water Controls," January 1994.

[10] Costs for these case studies were not available and hence are not included here.

– Reduced property damage. As a result of storm water controls over the previous 10 years, property damages were avoided during a 100-year storm in January 1986.

– Reduced pollutant loadings. Runoff concentrations of lead and total solids were reduced by 10 to 25 percent through biannual cleaning of storm drainage inlet pumps and catch basins; oxygen demanding substances, nutrients, and zinc concentrations were reduced by 5 to 10 percent. Conventional street-sweeping operations reduced toxic loadings by 5 to 10 percent. Installation and maintenance of oil/water separators reduced floatables in the drainage system.

– Reduced illegal dumping. Dumping of motor oil and debris in storm drains was significantly reduced through increasing public awareness of storm water issues and volunteer stenciling of storm drains. A recent survey indicates that 85 percent of area residents dispose of used oil at a recycling facility.

– Increased recreational opportunities. Clean-up of Mercer Slough (a 325-acre wetland) along with stream and wildlife enhancement of the park resulted in increased canoeing on the slough and increased visitation to the park's trails.

Murray City, Utah

Murray City (population 31,000) worked with the Utah Department of Transportation (DOT) to develop a storm water control system for runoff from a 4.5-mile stretch of highway in conjunction with the construction of an 18-hole, 135-acre municipal golf course.

Storm water runoff from the highway and subsurface waters is collected and routed through a series of streams and wetlands into four ponds on the golf course.

Examples of program benefits:

– Reduction in pollutant loadings. The pond system removes approximately 90 percent of the sediment, oil and grease, and dissolved materials from the highway runoff.

– Flood control. The system successfully handled the runoff from two 25-year storms.

– Savings in irrigation water costs. The detention ponds provide 7 acres of flood retention area and created nearly 11 acres of wetlands. The ponds also provide water to irrigate the golf course, which saves nearly $80,000 per year in watering costs.

– Savings in highway construction costs. Because runoff was diverted to irrigate the golf course, DOT saved $300,000 in land acquisition and storm water piping costs by eliminating the need to construct a separate storm water discharge system for the highway.

Orlando, Florida

The city of Orlando (population 160,000) receives over 50 inches of rain annually, over half of which converts to storm water runoff and flows into the city's 83 lakes. One example of a project to manage storm water is the creation of the Greenwood Urban Wetland, which consists of several ponds in a series.

Examples of program benefits:

- Increased property values. Overall, whenever Orlando constructs a storm water control lake, property values in that area increase.

- A savings was realized in construction of the Greenwood Urban Storm Water Control Wetland with the sale of fill dirt that was excavated ($5/cubic yard).

- Creation of a natural park. The Greenwood Urban Wetland created a natural park atmosphere (with footbridges, walking paths, picnic areas, and opportunities for observing wetland wildlife) in an urbanized area.

- Irrigation and drinking water supply. Cleansed storm water is used to irrigate the upland areas of the park, which conserves the drinking water supply.

Santa Clara Valley, California

Santa Clara Valley has a municipal storm water permit covering 15 co-permittees (14 municipal entities and one water control district). Three of the municipalities have populations over 100,000, four are between 50,000 and 100,000, and seven are less than 50,000.

Transportation activities have been identified as potentially the most significant source of storm water pollutants. Copper and zinc have been identified as significant contaminants in the storm water runoff into south San Francisco Bay. These metal are carried by suspended particles. Brake pad dust is believed to be a major source of the copper.

Examples of program benefits:

- Significant reduction in copper loadings. Street sweeping activities clean 19,000 miles per month and have prevented 2,500 pounds of copper and 46,000 cubic yards of material throughout the area from entering storm sewers.

- Reduction in floatables. Cleaning 34,000 catch basins has removed 1,000 cubic

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yards of material. Inspection and cleaning of 160 miles of conveyances has removed 400 cubic yards of material.

-- Identification of illegal dumping activities. The co-permittees identified 867 cases of illegal dumping, of which 700 have been resolved.

Tulsa, Oklahoma

The city of Tulsa (population 367,000) has been recognized as having an effective storm water management program. EPA recently issued a draft municipal storm water permit for Tulsa.

Discharges from Tulsa's storm sewer collection system were identified as a source of pollutant loadings in the Zinc Lake portion of the Arkansas River. The storm sewer's discharges showed a high concentration of bacteria.

Examples of program benefits:

-- Removal of suspended solids. Tulsa estimates that its construction site storm water controls average 70 percent effectiveness in removing total suspended solids from storm water runoff. In addition, the city estimates that its street sweeping and structural operation and maintenance reduce suspended solids by up to 50 percent; metals by up to 10 percent; total solids and lead by 10 to 25 percent; and oxygen demanding substances, nutrients, and zinc by 5 to 10 percent.

-- Improved Water Quality in the Arkansas River. The city identified 35 illicit storm sewer connections drained into Zinc Lake and the Arkansas River. Tulsa removed these discharges from the storm sewer system and states that water resource quality has improved as a result.

APPENDIX B

STORM AND SURFACE WATER UTILITY
BELLEVUE, WASHINGTON

Bellevue, Washington, is a suburban community located in the Puget Sound area east of Lake Washington in the Seattle metropolitan area. The city experienced substantial population growth during the last 30 years and particularly rapid growth over the last 20 years. When Bellevue incorporated as a city in 1953, the population was approximately 6,000 and the city limits covered five square miles. By 1990, Bellevue had grown to a population of 86,000 and an area that covered 30 square miles, making it the fourth largest city in Washington State. Recent estimates indicate that the watershed is over 90 percent developed, primarily with residential units and commercial and light industrial uses.

Rapid growth and development created storm water runoff problems in most of the natural streams draining the area. The city's 30-square mile area contains over 50 miles of open streams and five lakes. Much of the average annual rainfall of 42 inches is carried by existing streams into the following receiving waters: Kelsey Creek, Meydenbauer Bay and the Lake Washington East Channel, Yarrow Bay on Lake Washington, Lake Sammamish, and Coal Creek. Of these, Lake Washington is considered the primary receiving water body. The types of storm water runoff problems documented in the Bellevue area include increased flooding and streambank erosion; property damage; stream sedimentation/siltation; diminished salmon runs; water quality degradation by discharges of nutrients, heavy metals, pesticides, and oil; and illicit connections.

In response to citizen concerns about environmental degradation caused by storm water runoff, the city of Bellevue established a storm water utility in 1974. The mission of Bellevue's Storm and Surface Water Utility (SSWU) is to manage the storm and surface water system in Bellevue, to maintain a hydrologic balance, to prevent property damage, and to protect water quality for the safety and enjoyment of citizens and the preservation and enhancement of wildlife habitat.

STORM AND SURFACE WATER UTILITY PROGRAMS

When first established, Bellevue's utility focused on examining various solutions to control flooding and preserve waterways. The utility selected an "open stream concept" using streams as the main conveyance system for storm water runoff. This system uses regional, in-stream flood control facilities to attenuate peak flows for older development. The utility also manages the municipal storm drainage system. In addition, regulations require developers to provide erosion and sedimentation controls at all construction sites and on-site storm water controls for new development. With successful flood control systems in place, the focus has recently shifted to water quality controls, including requirements mandated by the federal Clean Water Act. For the most part, SSWU's comprehensive effort to solve storm water quality problems is preventive in nature, but the utility also recognizes the need for retrofitting and new capital improvements for treatment.

Management of Bellevue's storm drainage system and open streams involves five major programs: a capital improvement program, operations and maintenance, water quality control, public education, and administration. Activities conducted under each of the major programs are summarized below.

- **Capital improvement program.** SSWU's capital improvement program (CIP) involves planning, design, property acquisition, flood control construction, water quality treatment, and stream enhancement projects. The utility constructed a series of 11 in-stream flood control facilities (detention basins) within the Bellevue stream system to provide protection for the 24-hour, 100-year storm event. SSWU also improves stream passages for carrying capacity, stability, wildlife habitat, and migratory fish passage.

- **Operations and maintenance.** The operations and maintenance (O&M) program involves those functions typically associated with urban drainage, such as repair and minor replacement of SSWU's structural facilities. Bellevue's O&M program also includes operation of structures for flood control, including a telemetry control system for structures and an emergency storm response program, a drainage system inventory, and advice to private citizens on private drainage concerns.

- **Water quality control.** Activities conducted for water control include drainage system cleaning, routine monitoring of receiving waters, investigative monitoring of pollution events and sources, emergency response for water pollution events, coordination with other water quality control agencies, participation in lake restoration studies and projects, a private maintenance inspection program, and a streams enhancement program.

- **Public education.** SSWU's public education efforts focus on available services and the environment. Specific activities include articles in local publications about SSWU services and the effects of human practices on the environment, the Stream Team Program (includes a water quality newsletter, workshops, and citizen activities), City Hall's "Mini Salmon Hatchery" and annual salmon release, storm drain stenciling projects, and a business water quality program.

- **Administration.** Administrative programs for SSWU include financial management, rate administration, comprehensive drainage planning, general administration, and support for the City Council and Storm and Surface Water Advisory Commission. SSWU assures quality control of utility services by tracking all service requests through an automated Customer Action Request system.

UTILITY FINANCING

The city decided that the most equitable system of drainage service charges entails basing changes on the estimated amount of runoff that individual properties contribute to the surface water system. All properties are classified according to their intensity of development. Each classification is assigned a rate (per 2,000 square feet of property area), with current rates set as follows: undeveloped ($0.17), light development ($0.99), moderate development ($1.23), heavy development ($1.83), and very heavy development ($2.46). Wetlands are also a class; however, wetlands are not charged due to their value in water quantity and quality control. The classification combined with the total square footage of the property determines the service charge, which is billed every two months.

Revenues grew slowly until rates were raised to fund the adopted Capital Improvement Program, which was initiated by issuance of $10 million in revenue bonds. Three major rate increases occurred in 1980 (70 percent), 1982 (90 percent), and 1986 (35 percent), and subsequent rate increases have remained in the single-digit category largely to cover inflation. Although the majority of SSWU revenue is from service charges, other revenue sources include clearing and grading permit fees, general facilities charges, and interest on fund accounts. Revenues from the utility service charges and these other sources cover the full costs of Bellevue's storm and surface water management program.

Single-family customers make up 92 percent of the 24,000 accounts and contribute 45 percent of the revenue. An average single-family household pays $16.44 every two months ($98 per year) for 10,000 to 12,000 square feet of property with a typical home. Tax-exempt properties are not exempt from the utility charges. (Washington State highways and Bellevue streets are the SSWU's two biggest ratepayers.)

BENEFITS OF THE STORM AND SURFACE WATER PROGRAM

One of the most successful of SSWU's programs is flood control, and several different approaches to managing storm water discharges are achieving water quality improvements. In addition, Bellevue's reputation as a well-planned, environmentally sensitive city is enhanced through SSWU programs that preserve the city's numerous streams.

Reductions in Peak Flows

- Bellevue's use of the natural stream system to manage storm water preserves the environment and reduces costs. Bellevue's storm water management activities to address flooding and stream erosion problems range from four to ten times less costly than traditional storm sewer improvements.

- Small detention basins (detention times of 30 minutes or less) reduced peak flow rates by up to 60 percent, providing flood and streambank erosion control that protects streamside property.

- With a computerized remote control system, maximum flood protection along major stream corridors is achieved through eight regional detention basins. The remote control system monitors rainfall, stream flow, and water levels to ensure optimal operation of flood gates to control peak flows.

- During a 100-year storm experienced by the Bellevue area in January 1986, property damages occurred only where planned improvements were not yet constructed. Capital improvements totalling $15 million and constructed over the previous 10 years reduced flooding and streambank erosion, thereby avoiding property damages.

- Calls for emergency service during storm events continue to decrease, indicating that SSWU's flood control system has significantly reduced hazards to life and property.

Reductions in Pollutant Loadings/Discharges

- Runoff concentrations of lead and total solids were reduced by between 10 to 25 percent over a two-year period through biannual cleaning of storm drainage inlet sumps and catch basins. Chemical oxygen demand (COD), nutrient, and zinc concentrations were reduced by between 5 to 10 percent over a two-year period.

- Toxic loadings were reduced by between 5 and 10 percent by conventional street-sweeping operations.

- Introduction of floatables to the drainage system was reduced by the installation and maintenance of oil/water separators, some of which have the capability of reducing oil and grease during oil spill events to levels generally associated with background levels in urban storm water.

- Dumping of motor oil and debris in storm drains was significantly reduced by increasing public awareness of storm water issues through SSWU's Stream Team Program and volunteer stenciling of storm drains. A recent survey indicates that 85 percent of area residents dispose of used oil at a recycling facility.

- Dumping of motor oil and household chemicals was also reduced through SSWU's Oil Recycling and Hazardous Waste Program. SSWU collected 2,100 gallons of petroleum products at a recycling event in October 1993.

- Total solids in urban runoff originating from residential yards were reduced by increasing public awareness of practices such as pet waste and litter control.

- A wide variety of local businesses work with SSWU water quality staff to prevent storm water pollution at the source through an innovative program called Business

Partners for Clean Water.

Protection or Restoration of Ecological Resources

- Volunteers have planted thousands of native trees and shrubs along 10 miles of Bellevue's open streams to shade stream waters and enhance fish habitat. Other stream enhancement projects conducted through the Stream Team Program have reduced streambank erosion which also lowered water temperatures and provided shade to enhance fish habitat.

- Kelsey Creek's salmon fishery was enhanced through installation of regional detention basins that help mitigate peak flows and habitat improvements from streambank revegetation projects. Previously, this salmon fishery was limited and unhealthy because of high peak flows from urban runoff that altered the stream channel and carried pollutants.

- Anadramous fish populations are enhanced because SSWU's flood control system is designed to provide maximum flood protection with minimum impact on fisheries and fish migration. During salmon spawning season, flood control gates remain open until significant heavy rainfall occurs.

- Sensitive areas (floodplains, wetlands, and steep slopes) are protected through the city's Natural Determinants Regulations, which prohibit development of designated areas, including 740 acres of wetlands.

- The city is restoring Phantom and Larsen Lakes in partnership with the Washington Department of Ecology. Restoration measures for Phantom Lake over a two-year period reduced annual internal phosphorus loading to the lake by approximately 75 percent and reduced annual external phosphorus loading by 39 to 54 percent. The trophic status of Phantom Lake improved substantially after implementation of restoration measures, although it remains a eutrophic lake.

- Ecological and aesthetic features of the natural environment are preserved through regulation of new development under city codes and a Comprehensive Plan to reflect the philosophy that development should be integrated naturally with the environment and preserve rather than overcome natural features.

Recreation Activity

- Kelsey Creek, a natural water channel that was developed to convey storm water from the city of Bellevue to Lake Washington, provides recreational opportunities such as canoeing, birdwatching, and hiking.

- Cleanup of Mercer Slough (a 325-acre wetland), along with stream and wildlife enhancement in Mercer Slough Nature Park, resulted in increased canoeing on the slough and increased visitation to the park's interpretive trail.

- Phantom and Larsen Lakes furnish recreational opportunities such as fishing and educational opportunities for school children, who visit the lakes for environmental education projects.

Economic Activity

- Clean water in Bellevue and the surrounding Puget Sound area is important for drinking, food sources, recreation, and industry.

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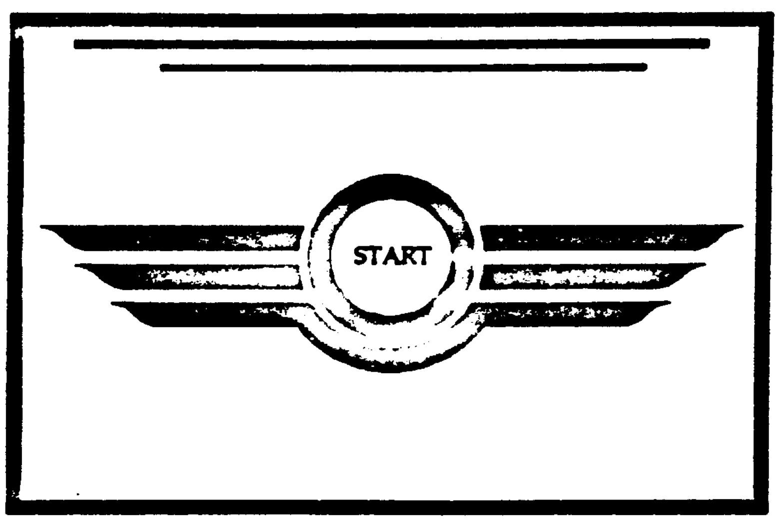
United States
Environmental Protection
Agency

Office Of Water
(EN-336)

EPA 833-B-92-001
July 1992

EPA

NPDES Storm Water Sampling Guidance Document



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NPDES STORM WATER SAMPLING GUIDANCE DOCUMENT

1. INTRODUCTION

The 1972 Federal Water Pollution Control Act [(FWPCA), also referred to as the Clean Water Act (CWA)] prohibits the discharge of any pollutant to waters of the U.S. from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Efforts to improve water quality under the NPDES program have focused traditionally on reducing pollutants in industrial process wastewater discharges and from municipal sewage treatment plants. Past efforts to address storm water discharges, in particular through the NPDES program, have generally been limited to certain industrial categories, using effluent limitations for storm water as a permit condition.

Recognizing the need for more comprehensive control of storm waters discharges, Congress amended the CWA in 1987 and established a two-phase program. In Phase I, Congress required the U.S. Environmental Protection Agency (EPA) to establish NPDES requirements for certain classes of storm water discharges.

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- A storm water discharge for which a permit has been issued prior to February 4, 1987
- A storm water discharge associated with industrial activity
- A storm water discharge from a municipal separate storm sewer system serving a population of 250,000 or more (large system)
- A storm water discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000 (medium system)
- A discharge for which the Administrator or the State determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States.

To implement these requirements, EPA published on November 16, 1990 (55 Fed. Reg. 47990), permit application requirements that include storm water sampling. EPA and the States will subsequently issue NPDES storm water permits based on these applications, and many of these permits will require storm water sampling. Congress intended for EPA to address all other point source discharges of storm water in Phase II of the program.

1.1 PURPOSE OF THIS MANUAL

This manual is for operators of facilities that discharge storm water associated with industrial activity and operators of large and medium municipal separate storm sewer systems. Storm water sampling is sometimes difficult due to the unpredictability of storm events and the variable nature of storm water discharges. This manual is primarily designed to assist operators/owners in planning for and fulfilling the NPDES storm water discharge sampling requirements for permit applications as well as for other storm water sampling needs.

It is assumed that applicants already have a basic understanding of the storm water permit application requirements. This document is designed to supplement existing storm water application guidance by focusing on the technical aspects of sampling. Since many industrial storm water permits and all municipal storm water permits will require regular storm water sampling, many of the concepts in this guidance may be applicable to sampling requirements contained in NPDES storm water permits.

The information in this manual pertains specifically to individual industrial storm water applications, group storm water applications (Part 2), and municipal Part 2 storm water permit applications for storm water discharges. For information on other storm water application requirements for industrial facilities and large and medium municipal separate storm sewer systems, see EPA's Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity (EPA-505/8-91-002, April 1991), and EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems (EPA-505/8-91-003A, April 1991), respectively. These manuals can be requested by calling the Storm Water Hotline [(703) 821-4823] or the National Technical Information Service (NTIS) [(703) 487-4650]. Additional background documents for further information are listed in Technical Appendix D.

1.2 ORGANIZATION OF THIS MANUAL

This manual explains the basic requirements of storm water sampling and provides procedural guidance on sampling for permit applications. Chapter 2 discusses background information (i.e., a

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summary of permit application requirements, who must sample, when and where to sample, and staffing considerations). Chapter 3 presents the fundamentals of sampling (i.e., types of sampling, obtaining flow data, handling samples, and sending them to the laboratory). Chapter 4 presents analytical considerations, including the storm water pollutants that must be analyzed under the regulations. Chapter 5 discusses regulatory flexibility with respect to storm water sampling, and Chapter 6 includes health and safety considerations.

Technical Appendices provide information as follows:

- Technical Appendix A—Forms 2F and 1
- Technical Appendix B—NOAA Weather Radio Information
- Technical Appendix C—Required Containers, Preservation Techniques, Holding Times and 40 Code of Federal Regulations (CFR) Part 136
- Technical Appendix D—References
- Technical Appendix E—Glossary
- Technical Appendix F—Acronyms.

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2. BACKGROUND FOR STORM WATER SAMPLING

This chapter presents background information, definitions, and a description of the fundamentals of sampling. Specifically, it covers the following areas:

- The benefits of sampling
- A summary of storm water application regulations
- Who must sample
- When sampling is required
- Where to sample
- Staffing considerations

In response to the 1987 Water Quality Act amendments to the CWA, EPA published the storm water final rule on November 16, 1990. In this rule, EPA established the initial scope of the storm water program by defining the phrase "storm water discharge associated with industrial activity" in terms of 11 categories of industrial activity and the phrase "large and medium municipal separate storm sewer systems" to include municipal systems serving a population greater than 100,000. These terms are discussed in greater detail in Section 2.6, "Who Must Sample."

In addition to defining the initial scope of the storm water program, the final rule established permit application requirements, including requirements for storm water sampling. Sampling data gathered for the application will be used to characterize storm water discharges, and will serve as a basis for establishing requirements in NPDES storm water permits. It is important to note that the applicant must report data that are representative of the storm water discharge, and that the intentional misrepresentation of discharge characteristics is unlawful.

2.1 BENEFITS OF SAMPLING

Data that characterize storm water discharges are valuable to permitting authorities and permittees for several reasons. First, storm water sampling provides a means for evaluating the environmental risk of the storm water discharge by identifying the types and amounts of pollutants present. Evaluating these data helps to determine the relative potential for the storm water discharge to contribute to water quality impacts or water quality standard violations. And, storm water sampling

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data can be used to identify potential sources of pollutants. These sources can then be either eliminated or controlled more specifically by the permit.

2.2 INDUSTRIAL FACILITY APPLICATION REQUIREMENTS

The storm water permit application regulations provide operators of facilities (including those owned by the government) that have storm water discharges associated with industrial activity with three application options: (1) submit an individual application; (2) participate in a group application (a two-part application); or (3) submit a Notice of Intent (NOI) to be covered by a general permit where general permits are available. This guidance focuses on sampling requirements for individual applications and Part 2 of group applications. Sampling data generally will not be required for an NOI, however, the general permit may require sampling during the term of the permit. State permitting authorities may also require sampling information for an NOI at their discretion, and should, therefore, be consulted prior to submittal.

Industrial facilities submitting individual applications must submit sampling data on a completed application Form 2F (entitled "Application for Permit to Discharge Storm Water Discharges Associated with Industrial Activity"). Facilities selected to be part of the sampling subgroup for a group application must submit sampling data with Part 2 of the application. Members of the sampling subgroup must complete only the quantitative data portions of Form 2F, including Sections VII, VIII, IX, and the certification in Section X. Exhibit 2-1 details the types of information required for each section of Form 2F. Exhibit 2-2 describes what sampling information must be provided in Part 2 of the group application. It should be noted that States may require the use of different forms and submittal of additional documentation.

Form 1 must also be submitted with Form 2F by applicants submitting individual permit applications. General information about the facility is provided on Form 1 (i.e., addresses, operators, etc.); it does not request sampling data. Forms 1 and 2F are reproduced in Technical Appendix A.

Facilities with unpermitted combined discharges of storm water and process or nonprocess wastewater must submit Form 2C or 2E, respectively, in addition to Forms 1 and 2F. Facilities with storm water discharges combined with new sources or new discharges of process wastewater must submit Form 2D as well as Forms 1 and 2F.

EXHIBIT [illegible] REQUIREMENTS

Section	Requirement
2F-I	Outfall location(s), including longitude and latitude and receiving water(s)
2F-II	Facility improvements which may affect the discharges described in the application
2F-III	Site drainage map
2F-IVA	Estimates of impervious area within each outfall drainage area
2F-IVB	A narrative description of pollutant sources (i.e., onsite materials which may come in contact with storm water runoff)
2F-IVC	Location and description of existing structural and nonstructural pollutant control measures
2F-VA	Certification that outfalls have been tested or evaluated for non-storm water discharges
2F-VB	Description of method used for testing/evaluating presence of non-storm water discharges
2F-VI	History of significant leaks or spills of toxic or hazardous pollutants at the facility within the last 3 years
2F-VII	Discharge characterization for all required pollutants
2F-VIII	Statement of whether biological testing for acute or chronic toxicity was performed and list of pollutants it was performed for
2F-IX	Information on contract laboratories or consulting firms
2F-X	Certification that information supplied is accurate and complete

Note: See Form 2F and the instructions for more detail on application requirements.

2.3 MUNICIPALITIES' APPLICATION REQUIREMENTS

Operators of large and medium municipal separate storm sewer systems are required to submit a two-part application. Both parts contain sampling requirements: Part 1 requires information characterizing discharges from the separate storm sewer system, including field screening sample data for identifying illicit/illegal connections; Part 2 requires sampling at representative locations and estimates of pollutant loadings for those sites. These sampling data are to be used to design a long-term storm water monitoring plan that will be implemented during the term of the permit. The sampling data that must be submitted in Parts 1 and 2 of municipal applications are listed in Exhibit 2-3. There is no standard application form for municipalities.

Quantitative Testing Data

- For groups with 4 to 20 members, 50 percent of the facilities must submit data; for groups with 21 to 99 members, a minimum of 10 dischargers must submit quantitative data; for groups with 100 to 1,000 members, a minimum of 10 percent of the facilities must submit data; for groups with greater than 1,000 members, no more than 100 facilities must submit data; there must be 2 dischargers from each precipitation zone in which 10 or more members of the group are located, or 1 discharger from each precipitation zone in which 9 or fewer members are located.
- Sampling and analysis requirements are described in 40 Code of Federal Regulations (CFR) 122.26(c)(1)(i)(E) and 40 CFR 122.21(g)(7). Pollutants to be analyzed depend on the type(s) of industries applying as a group.
- Sampling subgroup must provide all quantitative discharge information required in Form 2F Sections VII-IX plus the certification in Section X.
- The group application sampling subgroup must collect grab samples during the first 30 minutes of the storm event and flow-weighted composite samples as required in 40 CFR 122.21(g)(7).

2.4 APPLICATION SUBMITTAL DEADLINES

Deadlines for submitting permit applications and associated sampling requirements are presented in Exhibit 2-4 for individual and group industrial applications and for municipal applications.

2.5 WHERE TO SUBMIT APPLICATIONS

Storm water discharge permit applications are generally submitted directly to the permit-issuing authority. The appropriate authority is the State, where the State has been granted the authority to issue NPDES permits, or the EPA Regional office, where the State does not have NPDES authorization. Exhibit 2-5 indicates which States have approved NPDES permitting programs. It also provides contact names and addresses where applications should be submitted for each State or EPA Regional Office (depending on who the permitting authority is in each case). It should be noted, however, that both parts of a group application must instead be submitted to EPA Headquarters. Group applications must be sent to: Director, Office of Wastewater Enforcement and Compliance, Attention Mr. William Swietlik, U.S. EPA, EN-336, 401 M Street, SW, Washington, DC 20640.

[illegible]

Part 1

- Monthly mean rainfall and snowfall estimates
- Existing quantitative data on the depth and quality of storm water discharges
- A list of receiving water bodies and existing information concerning known water quality impacts
- Field screening analysis for illicit connections and illegal dumping
- Identification of representative outfalls for further sampling in Part 2

Part 2

- Quantitative data from 5 to 10 representative locations in approved sampling plans
- Estimates of the annual pollutant load and event mean concentration (EMC) of system discharges
- Proposed schedule to provide estimates of seasonal pollutant loads and the EMC for certain detected constituents in a representative storm event during the term of the permit
- Proposed monitoring program for representative data collection during the term of the permit

Applications submitted by industrial facilities must be certified by a responsible corporate officer as described in 40 CFR 122.22 (e.g., president, secretary, treasurer, vice president of the corporation in charge of a principal business function). Applications submitted by municipalities must be certified by a principal executive officer or ranking elected official as described in 40 CFR 122.22.

2.6 WHO MUST SAMPLE

Operators of facilities that have storm water discharges associated with industrial activity and operators of large and medium municipalities are required to conduct storm water sampling as part of their NPDES permit applications. Specifically, the following types of industries and municipalities must sample storm water discharges:

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	Date	Sampling Requirement
Industrial*		
Individual	October 1, 1992	Sampling data due
Group • Part 1 • Part 2	September 30, 1991 October 1, 1992	Sampling subgroup identified Sampling data due
Municipal		
Large Municipalities • Part 1 • Part 2	November 18, 1991 November 16, 1992	Illicit connection screening due and identification of sampling points Effluent characterization due Monitoring management program identified
Medium Municipalities • Part 1 • Part 2	May 18, 1992 May 17, 1993	Illicit connection screening due and identification of sampling points Effluent characterization due Monitoring management program identified

*NOI under a general permit is due on October 1, 1992 or the date specified in the permit, whichever comes first.

- Storm Water Discharges Associated With Industrial Activities - Under Phase I, the storm water permit application regulations identify, by Standard Industrial Classification (SIC) code and narrative description, 11 categories of facilities considered to be "engaging in industrial activity" for the purposes of storm water permit application requirements. Those facilities included in 40 CFR 122.26(b)(14)(i) through (xi) of the storm water permit application regulations with storm water point source discharges to waters of the U.S. or separate storm sewers and those designated under Section 402(p)(2)(E) of the CWA are required to apply for storm water permit coverage by October 1, 1992. Industrial facilities include those that are Federally, State, or municipally owned or operated. Exhibit 2-6 lists these industrial facilities. The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain industrial activities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water discharge permit applications for only airports, power plants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority.

- Municipal Separate Storm Sewer Systems - Under Phase I, those municipalities with separate storm sewer systems serving 100,000 people or more are required to submit an application for discharges from the system. (Only the part of the population served by municipal separate storm sewers is to be included in the 100,000 count, not the part served by combined sewers.) Regulated municipalities are listed in Appendices F through I in the November 16, 1990, final rule or have been designated by their permitting authority.

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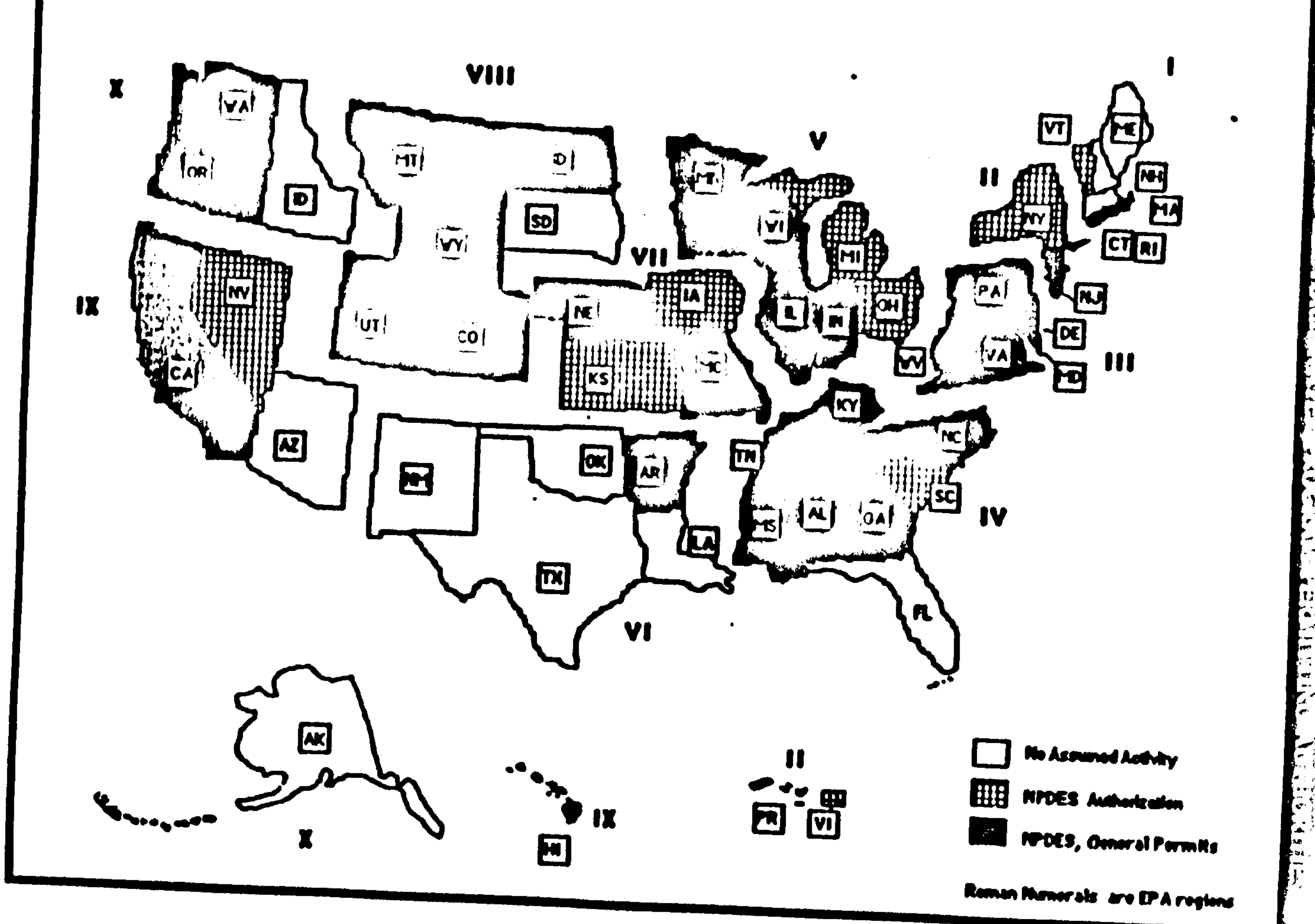
NPDES AUTHORITY AS OF MARCH 1992



[illegible]

State	Permitting Authority	Contact	State	Permitting Authority	Contact
Alabama	yes	Aubrey White Water Division 1751 Dickinson Dr. Montgomery, AL 36130 (205) 271-7811	Alaska	no	Steve Bubnick U.S. EPA Region 10 1200 6th Ave. WD-134 Seattle, WA 98101 (206) 553-8399
Arizona	no	Eugene Bromley U.S. EPA Region 9 75 Hawthorne St. W-5-1 San Francisco, CA 94105 (415) 744-1906	Arkansas	yes	Marysia Jastrzebski 8001 National Dr. P.O. Box 8913 Little Rock, AR 72219-8913 (501) 562-7444
California	yes	Archie Matthews Storm Water Research Control Board Water Quality 901 P St. Sacramento, CA 95814 (916) 657-1110	Colorado	yes	Patricia Nelson Dept. of Health Water Quality Control 4210 E. 11th Ave. Denver, CO 80220 (303) 331-4590
Connecticut	yes	Dick Mason Dept. of Environmental Protection Water Management Bureau Water Discharge Management 165 Capitol Ave. Hartford, CT 06106 (203) 566-7167	Delaware	yes	Sarah Cooksey Dept. of Natural Resources Surface Water Management 89 Kings Highway P.O. Box 1401 Dover, DE 19903 (302) 739-5731
Florida	no	Chris Thomas U.S. EPA Region 4 345 Courtland St. N.E. 4WM-FP Atlanta, GA 30365 (404) 347-3633	Georgia	yes	Mike Creason Dept. of Natural Resources Environmental Protection 205 Butler St. S.E. Room 1070 Atlanta, GA 30334 (404) 656-4887
Hawaii	yes	Steve Chang Dept. of Health Clean Water Branch Five Water Front Plaza #500 Ala-Moana Blvd. Honolulu, HI 96813 (808) 586-4309	Idaho	no	Steve Bubnick U.S. EPA Region 10 1200 6th Ave. WD-134 Seattle, WA 98101 (206) 553-8399
Illinois	yes	Tim Kluge EPA Water Pollution Control 2200 Churchill Rd. P.O. Box 19276 Springfield, IL 62794-9276 (217) 782-0610	Indiana	yes	Lonnie Brumfield Dept. of Environmental Management NPDES Permits Group 105 S. Meridian St. P.O. Box 6015 Indianapolis, IN 46206 (317) 232-8705
Iowa	yes	Monica Wnuk Department of Natural Resources Wallace State Building 900 E. Grand St. Des Moines, IA 50319-0034 (515) 281-7017	Kansas	yes	Don Carlson Dept. of Environment Water Bureau Forbes Field, Building 740 Topeka, KS 66620 (913) 296-5555

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State	Permitting Authority	Contact
Kentucky	yes	Douglas Allgeier Dept. of Environmental Protection Water Division 18 Reilly Road Frankfort, KY 40601 (502) 564-3410
Maine	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Massachusetts	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Minnesota	yes	Scott Thompson Pollution Control Agency 520 Lafayette Rd. St. Paul, MN 55155-3898 (612) 296-7203
Missouri	yes	Bob Hentges Dept. of Natural Resources Water Pollution Control Program 205 Jefferson St. P.O. Box 176 Jefferson City, MO 65102 (314) 751-6825
Nebraska	yes	Clark Smith Environmental Control Water Quality Division P.O. Box 98922 Lincoln, NE 68509 (402) 471-4239
New Hampshire	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
New Mexico	no	Brent Larson U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Louisiana	no	Brent Larson U.S. EPA Region 6 1455 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Maryland	yes	Edward Gertler MD Dept. of Environment Industrial Discharge Program 2500 Broening Highway Baltimore, MD 21224 (410) 631-3323
Michigan	yes	Gary Boersen Dept. of Natural Resources Surface Water Division P.O. Box 30028 Lansing, MI 48909 (517) 373-1982
Mississippi	yes	Jerry Cain Dept. of Environmental Quality Office of Pollution Control Industrial Waste Water Branch P.O. Box 10385 Jackson, MS 39289-0385 (601) 961-5171
Montana	yes	Fred Shewman Water Quality Bureau Cogswell Building Helena, MT 59620 (406) 444-2406
Nevada	yes	Rob Saunders Conservation and Natural Resources Environmental Protection 123 W. Nye Lane Carson City, NV 89710 (702) 687-4670
New Jersey	yes	Sandra Cohen NJ DEPE Office of Regulatory Policy CN029 Trenton, NJ 08625-0029 NJ Hotline: (609) 633-7021
New York	yes	Ken Stevens Wastewater Facilities Design NY State DEC 50 Wolf Road Albany, NY 12233 (518) 457-1157

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State	Permitting Authority	Contact
Kentucky	yes	Douglas Allgeier Dept. of Environmental Protection Water Division 18 Reilly Road Frankfort, KY 40601 (502) 564-3410
Maine	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Massachusetts	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Minnesota	yes	Scott Thompson Pollution Control Agency 520 Lafayette Rd. St. Paul, MN 55155-3898 (612) 296-7203
Missouri	yes	Bob Hentges Dept. of Natural Resources Water Pollution Control Program 205 Jefferson St. P.O. Box 176 Jefferson City, MO 65102 (314) 751-6825
Nebraska	yes	Clark Smith Environmental Control Water Quality Division P.O. Box 98922 Lincoln, NE 68509 (402) 471-4239
New Hampshire	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
New Mexico	no	Brent Larson U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
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Michigan	yes	Gary Boersen Dept. of Natural Resources Surface Water Division P.O. Box 30028 Lansing, MI 48909 (517) 373-1982
Mississippi	yes	Jerry Cain Dept. of Environmental Quality Office of Pollution Control Industrial Waste Water Branch P.O. Box 10385 Jackson, MS 39289-0385 (601) 961-5171
Montana	yes	Fred Shewman Water Quality Bureau Cogswell Building Helena, MT 59620 (406) 444-2406
Nevada	yes	Rob Saunders Conservation and Natural Resources Environmental Protection 123 W. Nye Lane Carson City, NV 89710 (702) 687-4670
New Jersey	yes	Sandra Cohen NJ DEPE Office of Regulatory Policy CN029 Trenton, NJ 08625-0029 NJ Hotline: (609) 633-7021
New York	yes	Ken Stevens Wastewater Facilities Design NY State DEC 50 Wolf Road Albany, NY 12233 (518) 457-1157

State	Permitting Authority	Contact
North Carolina	yes	Coleen Sullins Environmental Management Water Quality Planning P.O. Box 29535 Raleigh, NC 27626-0535 (919) 733-5083
Ohio	yes	Bob Phelps OEPA Water Pollution Control P.O. Box 1049 1800 Watermark Columbus, OH 43266 (614) 644-2034
Oregon	yes	Ranei Nomura DEQ-Water Quality 811 SW 6th St. Portland, OR 97204 (503) 229-5256
Puerto Rico	no	José Rivera U.S. EPA Region 2 Water Permits & Compliance Branch 26 Federal Plaza, Room 845 New York, NY 10278 (212) 264-2911
South Carolina	yes	Birgot McDade Dept. of Health & Env. Ctrl. Industry and Agriculture Waste Water Division 2600 Bull St. Columbia, SC 29201 (803) 734-5241
Tennessee	yes	Robert Halsy Dept. of Environment Water Pollution Control 150 9th Ave. N., 4th Floor Nashville, TN 37243-1534 (615) 741-2275
Utah	yes	Harry Campbell Dept. of Environmental Quality P.O. Box 16690 Salt Lake City, UT 84116 (801) 538-6146
North Dakota	yes	Sheila McClenathan Dept. of Health Water Quality Division 1200 Missouri Ave. P.O. Box 5520 Bismarck, ND 58502-5520 (701) 221-5210
Oklahoma	no	Brent Larsen U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Pennsylvania	yes	R.B. Patel Environmental Resources Water Quality Management P.O. Box 2063 Harrisburg, PA 17120 (717) 787-8184
Rhode Island	yes	Angela Liberti Division of Water Resources 291 Promenade St. Providence, RI 02908 (401) 277-6519
South Dakota	no	Vern Berry U.S. EPA Region 8 999 18th St. 8-WM-C Denver, CO 80202-2466 (303) 293-1630
Texas	no	Brent Larsen U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Vermont	yes	Brian Kolker Environmental Conservation Permits and Compliance 103 S. Main St. Annex Building Waterbury, VT 05671-0405 (802) 244-5674

[illegible]

State	Permitting Authority	Contact
Virgin Islands	yes	Marc Pacifico Dept. of Planning & Natural Resources 1118 Watergut Project Christiansted St. Croix, VI 00820-5065 (809) 773-0565
Washington	yes	Gary Kruger Dept. of Ecology Water Quality Division P.O. Box 47600 Olympia, WA 98504-7600 (206) 438-7529
West Virginia	yes	Jerry Ray Division of Water Resources 1201 Greenbriar St. Charleston, WV 25311 (304) 348-0375
Wyoming	yes	John Wagner Dept. of Environmental Quality Herschler Building, 4th Floor Cheyenne, WY 82002 (307) 777-7082
Virginia	yes	Burton Tuxford Water Control Board Permits Section P.O. Box 11143 Richmond, VA 23230-1143 (804) 527-5083
Washington D.C.	no	Kevin Magerr U.S. EPA Region 3 841 Chestnut Bldg. 3WM53 Philadelphia, PA 19107 (215) 597-1651
Wisconsin	yes	Anne Manel Dept. of Natural Resources Wastewater Management P.O. Box 7921 Madison, WI 53707 (608) 267-7364

2.7 WHEN SAMPLING IS REQUIRED

Industrial individual and group applicants must include sampling data from at least one representative storm event. Operators of large or medium municipal separate storm sewer systems must submit sampling data from three different representative storm events. How to determine "representativeness" and other considerations for when to sample are presented below.

2.7.1 STORM EVENT CRITERIA

Storm water discharge permit application requirements establish specific criteria for the type of storm event that must be sampled:

- The depth of the storm must be greater than 0.1 inch accumulation
- The storm must be preceded by at least 72 hours of dry weather
- Where feasible, the depth of rain and duration of the event should not vary by more than 50 percent from the average depth and duration.

[illegible]

40 CFR 122.26(b)(14) Subpart	Description
(i)	Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutants effluent standards under 40 CFR, Subchapter N [except facilities which are exempt under category (xi)].
(ii)	Facilities classified as: SIC 24 (except 2434) ...... Lumber and Wood Products SIC 26 (except 265 and 267) . Paper and Allied Products SIC 28 (except 283 and 285) . Chemicals and Allied Products SIC 29 .... Petroleum and Coal Products SIC 311 .... Leather Tanning and Finishing SIC 32 (except 323) ...... Stone, Clay and Glass Products SIC 33 .... Primary Metal Industries SIC 3441 .... Fabricated Structural Metal SIC 373 .... Ship and Boat Building and Repairing
(iii)	Facilities classified as SIC 10 through 14, including active or inactive mining operations and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts, or waste products located on the site of such operations. SIC 10 .... Metal Mining SIC 11 .... Anthracite Mining SIC 12 .... Coal Mining SIC 13 .... Oil and Gas Extraction SIC 14 .... Nonmetallic Minerals, except Fuels
(iv)	Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA).
(v)	Landfills, land application sites, and open dumps that receive or have received any industrial wastes including those that are subject to regulation under subtitle D or RCRA.
(vi)	Facilities involved in the recycling of material, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as: SIC 5015 .... Motor Vehicle Parts, Used SIC 5093 .... Scrap and Waste Materials
(vii)	Steam electric power generating facilities, including coal handling sites.
(viii)	Transportation facilities which have vehicle maintenance shops, equipment cleaning operations, or airport de-icing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fuelling, and lubrication), equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category, are included. SIC 40 .... Railroad Transportation SIC 41 .... Local and Suburban Transit SIC 42 (except 4221-25) .... Motor Freight and Warehousing SIC 43 .... U.S. Postal Service SIC 44 .... Water Transportation SIC 45 .... Transportation by Air SIC 5171 .... Petroleum Bulk Stations and Terminals

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[illegible] STORM WATER PERMITS [illegible]

40 CFR 122.26(b)(14) Subpart	Description
(ix)	Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including lands dedicated to the disposal of the sewage sludge that are located within the confines of the facility, with a design flow of 1.0 million gallons per day or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA.
(x)	Construction activity including clearing, grading, and excavation activities except operations that result in the disturbance of less than 5 acres of total land area and those that are not part of a larger common plan of development or sale.*
(xi)	Facilities under the following SICs [which are not otherwise included in categories (ii)-(x)], including only storm water discharges where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to storm water.* SIC 20 .... Food and Kindred Products SIC 21 .... Tobacco Products SIC 22 .... Textile Mill Products SIC 23 .... Apparel and Other Textile Products SIC 2434 .... Wood Kitchen Cabinets SIC 25 .... Furniture and Fixtures SIC 265 .... Paperboard Containers and Boxes SIC 267 .... Converted Paper and Paper Board Products (except containers and boxes) SIC 27 .... Printing and Publishing SIC 283 .... Drugs SIC 285 .... Paints, Varnishes, Lacquer, Enamels SIC 30 .... Rubber and Misc. Plastics Products SIC 31 (except 311) ...... Leather and Leather Products SIC 323 .... Products of Purchased Glass SIC 34 (except 3441) ...... Fabricated Metal Products SIC 35 .... Industrial Machinery and Equipment, except Electrical SIC 36 .... Electronic and Other Electric Equipment SIC 37 (except 373) ...... Transportation Equipment SIC 38 .... Instruments and Related Products SIC 39 .... Miscellaneous Manufacturing Industries SIC 4221 .... Farm Products Warehousing and Storage SIC 4222 .... Refrigerated Warehousing and Storage SIC 4225 .... General Warehousing and Storage

Source: Federal Register, Vol. 55, No. 222, p. 48065, November 16, 1990.
*On June 11, 1992, the U.S. Court of Appeals for the Ninth Circuit remanded the exemption for construction sites of less than five acres in category (x) and for manufacturing facilities in category (xi) which do not have materials or activities exposed to storm water to the EPA for further rulemaking. (Nos. 90-70671 & 91-70200).

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These criteria were established to: (1) ensure that adequate flow would be discharged; (2) allow some build-up of pollutants during the dry weather intervals; and (3) ensure that the storm would be "representative," (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria ensures that the resulting data will accurately portray the most common conditions for each site. However, the permitting authority is authorized to approve modifications of this definition (especially for applicants in arid areas where there are few representative events). Section 5.1 of Chapter 5 discusses general protocol for requesting modifications to application requirements, including the definition of "representative storm."

In determining whether a storm is representative, there are two important steps to take. First, data on local weather patterns should be collected and analyzed to determine the range of representative storms for a particular area. Second, these results should be compared to measurements of duration, intensity, and depth to ensure that the storm to be sampled fits the representativeness criteria.

2.7.2 OBTAINING RAINFALL DATA

Several sources provide accurate local weather information for both: (1) determining what a representative storm event is for a particular area; and (2) assessing expected storm events to determine whether a predicted rainfall will be "representative," and thus, meet the requirements for storm water sampling. The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center's (NCDC's) Climate Services Branch is responsible for collecting precipitation data. Data on hourly, daily, and monthly precipitation for each measuring station (with latitude and longitude) are available to the public on computer diskette, microfiche, or hard copy. Orders can be placed by calling (704) 259-0682, by fax at (704) 259-0876, or by writing to NCDC, Climate Services Branch, The Federal Building, Asheville, North Carolina 28071-2733.

The National Weather Service (NWS) of NOAA can also provide information on historic, current, and future weather conditions. Local NWS telephone numbers can be obtained from the NWS Public Affairs Office at (301) 713-0622. Telephone numbers are also usually in local phone directory listings under "National Weather Service" or "Weather." In addition, NOAA runs the NOAA NWS

Weather Radio, which provides continuous broadcasts of the most current weather information. This broadcast can be accessed with a radio that has a weather band feature. Approximately 90 percent of the United States population is within listening range of the 380 NWS stations. Technical Appendix B presents additional information on NOAA Weather Radio, including radio frequencies for specific locations and a listing of weather band radio manufacturers. Telephone recordings of weather conditions are also provided by most NWS offices.

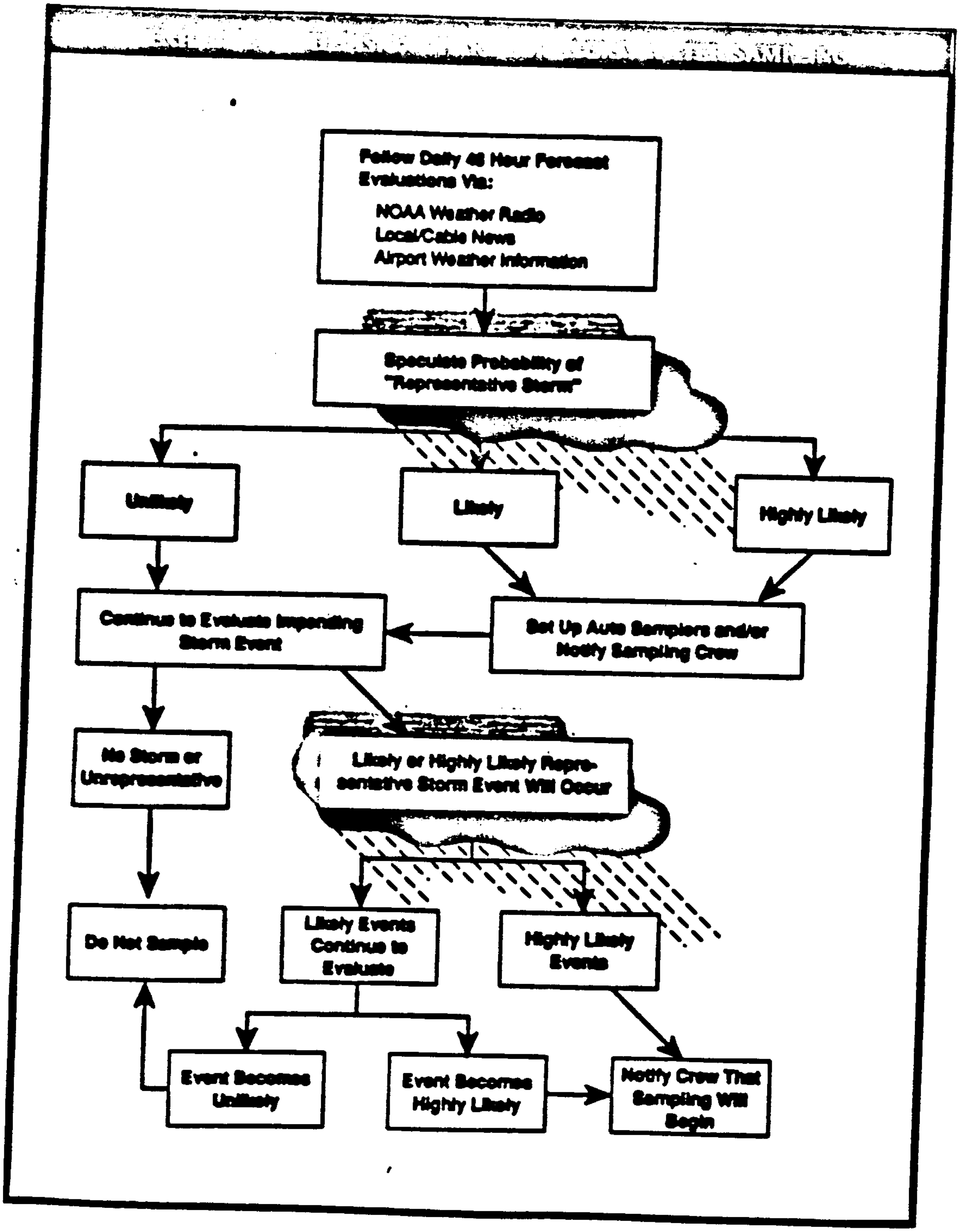
Cable TV weather stations and local airports can also provide weather information. Weather information provided by the local newspaper or TV stations should be used only if more accurate data (as described above) are unavailable, since weather forecasts can change drastically within several hours.

Someone should be designated at the facility to follow current weather conditions by listening to NOAA Weather Radio, calling the local NWS offices, and watching cable TV weather news. Exhibit 2-7 presents a storm water sampling decision chart for mobilizing field personnel for a probable storm event.

Annual rainfall statistics can also be used to evaluate representativeness of storm events. For example, Exhibit 2-8 presents fifteen rain zones in the United States and related storm event statistics. (These rain zones are not those shown in 40 CFR Part 122 Appendix E.) To determine typical values of annual storm events for a particular facility, identify the zone in which the facility is located. The tabulated information lists the annual average number of storms and precipitation as well as the average duration, intensity, and depth of independent storm events for each zone. Care must be taken, however, in using annual rainfall statistics for determining representativeness of storm events, since the annual rainfall statistic may not be representative of seasonal rainfall events. If rainfall data is available at or close to a particular facility, it is preferable to use this data for determining average storm event statistics.

Rainfall data tabulated from NOAA precipitation data indicate for Alaska (not shown in Exhibit 2-8) that average storm events last from 14 to 24 hours in duration and are 0.6 to 1.05 inches in depth. Average storm event data for Hawaii are 9 to 11 hours in duration and from 0.6 to 1.6 inches in depth.

CHAPTER 2 - BACKGROUND FOR STORM WATER SAMPLING



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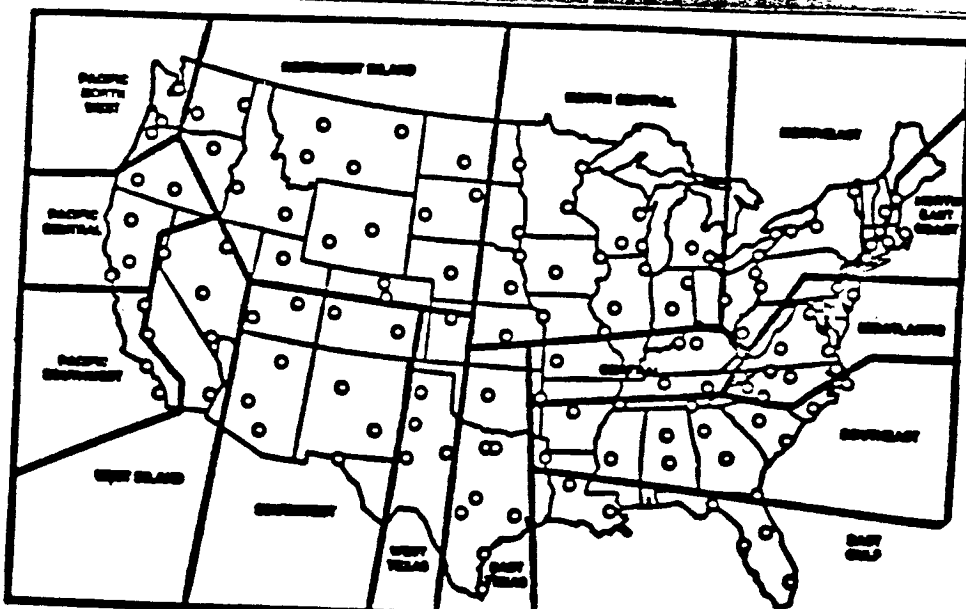

RAIN ZONE	Annual Statistics: No. of Storms Avg	No. of Storms COV	Precip. Avg (in)	Precip. COV	Independent Storm Event Statistics: Duration Avg (hr)	Duration COV	Intensity Avg (in/hr)	Intensity COV	Volume Avg (in)	Volume COV	DELTA Avg (hr)	DELTA COV
NORTH EAST	70	0.13	34.6	0.18	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
NORTH EAST-COASTAL	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.66	1.05	140	0.87
MIDATLANTIC	62	0.13	39.5	0.18	10.1	0.84	0.092	1.20	0.64	1.08	143	0.97
CENTRAL	68	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
NORTH CENTRAL	55	0.16	29.9	0.22	9.5	0.83	0.087	1.20	0.55	1.01	167	1.17
SOUTHEAST	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.30	136	1.03
EAST GULF	68	0.17	53.7	0.23	6.4	1.05	0.178	1.08	0.80	1.19	130	1.25
EAST TEXAS	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.18	213	1.28
WEST TEXAS	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
SOUTHWEST	20	0.30	7.4	0.37	7.8	0.88	0.079	1.16	0.37	0.88	473	1.46
WEST INLAND	14	0.38	4.9	0.43	9.4	0.75	0.055	1.06	0.36	0.87	786	1.54
PACIFIC SOUTH	19	0.36	10.2	0.42	11.6	0.78	0.054	0.76	0.54	0.98	476	2.09
NORTHWEST INLAND	31	0.23	11.5	0.29	10.4	0.82	0.057	1.20	0.37	0.93	304	1.43
PACIFIC CENTRAL	32	0.25	18.4	0.33	13.7	0.80	0.048	0.85	0.58	1.05	265	2.00
PACIFIC NORTHWEST	71	0.15	35.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV = Coefficient of Variation = Standard Deviation/Mean
DELTA = Interval Between Storm Midpoints
o = Rain Gauge Stations

Source: Urban Targeting and BMP Selection, U.S. EPA Region 5, November 1990.

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The NWS should be consulted for proper procedures for collecting and interpolating rainfall data if the applicant elects to collect the data rather than use existing data.

2.7.3 DETERMINING REPRESENTATIVENESS

An example of how to determine whether a rainfall event varies by more than 50 percent (i.e., is not representative) is shown in Exhibit 2-9.

[illegible] RAINFALL

Event Type	Duration (hrs.)	Depth (in.)
Average event	5.2	0.43
50 percent average event	2.6	0.22
150 percent average event	7.8	0.65

Once the information on an average duration and depth storm event is obtained for a specific location, multiply these numbers by 0.5 to get the 50 percent average event numbers and multiply by 1.5 to get the 150 percent average event numbers.

A representative storm in both duration and depth for a specific area will fall between the shaded numbers above (i.e., between 2.6 and 7.8 hours in duration and 0.22 and 0.65 inches in depth).

Snowmelt creates runoff which may result in point source discharges very similar to that from other storm events. Pollutants accumulate in snow, and when a thaw occurs, the pollutants will be discharged to receiving waters much like during a rain storm event. Snowmelt may be sampled as long as the applicant works closely with the permitting authority to determine the proper sampling strategy, i.e., sampling procedures, techniques, and pollutant analyses.

For snowmelt, the sampling strategy should be developed depending on the drainage area being monitored for storm flow. The strategy should consider (1) snow removal or clearing practices, e.g., direct dumping into water bodies, plowing, and the creation of snow mounds (whether in a line along a roadway or in piles on parking lots, etc.), and (2) the melting process.

It is also important to consider what happens to snowmounds as they melt and evaporate, which can alter the pollutant concentration in the resulting runoff. In addition, pollutants from the surrounding air and pavement can build up on snow mound surfaces in a crust or cake-like manner eventually leaving a residue (including previously dissolved solids that become a remaining solids residue) which is later left to be washed off by rainfall, manual flushing or other mechanisms.

The sampling of snow mounds, undisturbed snow itself, and hard pack requires a carefully thought out strategy. Given the complexities associated with snowmelt sampling, applicants should have proposed sampling strategies reviewed by the permitting authority before attempting to conduct sampling.

2.7.4 LOGISTICAL PROBLEMS WITH WHEN TO SAMPLE

Applicants may encounter weather conditions that may not meet minimum "representative" storm criteria; these conditions may prevent adequate collection of storm water samples prior to application submission deadlines. For instance, sampling may be problematic in parts of the country that experience drought or near-drought conditions or areas that are under adverse weather conditions such as freezing and flooding. Events with false starts and events with stop/start rains can also cause problems. Solutions for sampling under these circumstances are discussed below.

Where the timing of storm event sampling poses a problem, it may be appropriate for the applicant to petition the permitting authority for a sampling protocol/procedure modification either prior to sampling or after sampling is conducted (if the storm event is not acceptable). When the applicant requests a sampling protocol/procedure modification, a narrative justification should be attached. This justification should be certified by a corporate official (for industrial facilities) or the principle executive officer or ranking official (for municipalities), as per 40 CFR 122.22. Section 5.1 of Chapter 5 discusses protocol/procedure modifications.

<u>Arid Areas</u>

For arid or drought-stricken areas where a storm event does not occur prior to the time the applicant must sample and submit data with the application form, the applicant should submit the application, complete to the extent possible, with a detailed explanation of why sampling data are not provided and an appraisal of when sampling will be conducted. This explanation must be certified by the appropriate party (as described above). The applicant should also contact the permitting authority air and pavement can build up on snow mound surfaces in a crust or cake-like manner eventually leaving a residue (including previously dissolved solids that become a remaining solids residue) which is later left to be washed off by rainfall, manual flushing or other mechanisms.

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for further direction. Where the applicant can anticipate such problems, approval for an extension to submit sampling data should be acquired prior to the deadline.

Adverse Weather Conditions

The applicant should never conduct storm water sampling during unsafe conditions. It is likely that, in areas that experience flooding, lightening storms, high winds, etc., another representative storm event will occur for which sampling conditions will be much safer. (For further information on safety issues, see Chapter 6.) If no other storm event occurs, the applicant should submit a justification as to why the event was not sampled. This information should be certified by the appropriate official.

False Starts and Stop/Start Rains

False start and stop/start rains can also cause problems. False starts may occur when weather conditions are unpredictable and it appears that a storm event may be representative, collection begins, and then the rain stops before an adequate sample volume is obtained. (Necessary sample volumes are discussed in Section 3.6.) Some latitude may be given for the 0.1-inch rainfall requirement as long as the sample volume is adequate; the permitting authority may accept the results with applicant justification and certification. Again, see Chapter 5 for information on requesting protocol/procedure modifications to storm water sampling requirements.

During stop/start rains (those in which rainfall is intermittent), samples should be taken until an adequate sample volume is obtained. Exhibit 2-10 summarizes logistical problems of storm water sampling and presents solutions to the problems identified.

2.7.5 WHEN INDUSTRIAL FACILITIES MUST SAMPLE

Industrial applicants must generally collect two types of storm water samples: (1) grab samples collected during the first 30 minutes of discharge; and (2) flow-weighted composite samples collected during the first 3 hours of discharge (or the entire discharge, if it is less than 3 hours). Information from both types of samples is critical to fully evaluate the types and concentrations of pollutants present in the storm water discharge.

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EXHIBIT 2-10. LOGISTICAL PROBLEMS OF STORM WATER SAMPLING	
Problem:	Arid/drought areas
Solution:	Submit a petition requesting a modification to the protocol if problems are anticipated and, if it is approved, submit the application without sampling data by the application due date with a certified explanation. Provide sampling data to the permitting authority as soon as possible.
Problem:	Adverse weather conditions such as freezing, flooding, winds, tornadoes, electrical storms, and gully washes
Solution:	Sample another, less hazardous event or submit a certified justification of why the event was not sampled. Provide sampling data to the permitting authority as soon as possible.
Problem:	False starts
Solution:	Discard the sample if the volume is inadequate. If the volume is adequate, submit the sampling data with a certified explanation that the sample is from a non-representative event. Continue to monitor weather conditions and attempt to resample as soon as possible.
Problem:	Stop/start rains
Solution:	Continue to sample in case the storm event turns out to be representative and adequate sample volumes are obtained. If sample volumes are inadequate, continue to monitor weather conditions and attempt to resample as soon as possible.

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The grab samples taken during the first 30 minutes of a storm event will generally contain higher concentrations of pollutants, since they pick up pollutants that have accumulated on drainage surfaces since the last storm event.

Composite samples characterize the average quality of the entire storm water discharge. Flow-weighted composite samples provide for the most accurate determination of mass load. The flow-weighted composite sample must be taken for either the first 3 hours or for the entire discharge (if the event is less than 3 hours long). Additional information on how to collect grab and composite samples is presented in Sections 3.3 and 3.4, respectively.

Industrial applicants are required at a minimum to sample only one storm event. However, if samples from more than one storm are analyzed and the results are representative of the discharge, the data representing each event must be reported. The facility must provide a description of each storm event tested. The average of all values within the last year must be determined and the concentration, mass, and total number of storm events sampled must be reported on Form 2F. Furthermore, sampling should be conducted during normal operating procedures (day or night), and, not when the facility has been closed for a period of time.

Industrial applicants must certify, as a separate requirement, that all outfalls have been tested or evaluated to determine whether non-storm water discharges are present (e.g., process wastewater, sanitary wastes, cooling water, or rinse water) or whether illegal/illicit connections are occurring in the system. This testing should be conducted during dry weather to avoid any flows of storm water through the conveyance.

A checklist that can be used to conduct dry weather evaluations is provided in Exhibit 2-11. A narrative description of the method used to conduct dry weather evaluations and the date and the drainage points must be included in Section V.A of Form 2F. This statement must be certified by the appropriate party as described in Section 2.7.4.

A dry weather visual inspection is the simplest way to screen for illicit discharges. If one or more of the items on the checklist in Exhibit 2-11 are answered affirmatively, or if there are other reasons to believe that illicit connections exist, more detailed investigations (such as dye tests, smoke tests, evaluation of piping designs, and TV line monitoring) may be necessary. Dye testing involves releasing fluorescent, nontoxic dye into the suspected source of non-storm water, (e.g., a drain, sink, toilet, or pipe) and checking to see whether the dye shows up in the storm water outfall. Smoke testing involves pumping smoke into a storm sewer and viewing the facility to see if smoke escapes through unknown openings or storm sewer inlets. The presence of smoke indicates that storm water may enter the sewer through these openings or inlets. However, smoke testing may prove ineffective at finding non-storm water discharges to separate storm sewers. Smoke passage may be blocked due to line traps that are intended to block sewer gas.

TV line monitoring is a technique whereby a small video camera is placed in the storm sewer and a video image of the sewer is viewed on a monitor at the surface to identify illicit connections. The camera can be moved through the sewer by remote control. For more information on smoke and dye testing and TV line monitoring, consult EPA's Guidance Manual for the Preparation of NPDES

EXHIBIT 2-1[illegible] CHECKLIST FOR CONDUCTING DRY WEATHER EVALUATIONS

1. Date of inspection: ____________
2. Facility name and address: ____________
3. Date of last rain event: ____________
4. Inspector name: ____________
5. Type of outfall

☐ Concrete ☐ Pipe ☐ Grassed ☐ Rock ☐ Other ____________

6. Is there visible flow from the pipe? ☐ Yes ☐ No
If yes, check all that apply. If no, go to number 7.

☐ Colored water (describe) ____________ ☐ Oily sheen
☐ Odor* (describe) ____________ ☐ Sludge present
☐ Murky ☐ Clear water
☐ Floating objects (describe) ____________ ☐ Stains on conveyance
☐ Absence of plant life surrounding conveyance ☐ Notable difference in plant life surrounding conveyance
☐ Scum ☐ Suds ☐ Other: ____________

*e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.

Estimate the flow either visually or by describing the width, height, and shape of the conveyance and the approximate percentage of the conveyance where flow is present or the approximate depth of the flow. Describe your estimate.

7. Is there standing water present? ☐ Yes ☐ No
If yes, check all that apply. If no, go to number 8.

☐ Colored water (describe) ____________ ☐ Oily sheen
☐ Odor* (describe) ____________ ☐ Sludge present
☐ Murky ☐ Clear water
☐ Floating objects (describe) ____________ ☐ Stains on conveyance
☐ Absence of plant life surrounding conveyance ☐ Notable difference in plant life surrounding conveyance
☐ Suds ☐ Scum ☐ Other: ____________
☐ Absence of plant life surrounding conveyance

*e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.

8. From the inspection locations, can you see any unusual piping or ditches that drain to the storm water conveyance? ☐ Yes ☐ No
9. Is there any overland flow visible from the discharge location? ☐ Yes ☐ No
10. Are there dead animals present? ☐ Yes ☐ No

Signature:

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Permit Applications for Storm Water Discharges Associated with Industrial Activity (EPA-505/8-91-002, April 1991).

A problem with the dry weather evaluation process is that the presence of a dry weather/non-storm water discharge may be caused by infiltration of ground or surface waters through cracks in the storm water drainage system. In this situation, all other possible sources of the non-storm water discharge should be examined and ruled out. If no sources are found, the physical structure of the conveyance system should be inspected for deterioration.

The applicant should make every attempt to halt non-storm water discharges to the storm sewer system unless the discharge is covered by an NPDES permit. If it is not feasible to halt the discharge of non-storm water to the storm sewer system, and the discharge is not authorized by a process wastewater or storm water permit, the applicant must submit either Form 2C (for a process water discharge) or Form 2E (for a nonprocess water discharge), and check with state officials to see if alternate forms are required.

2.7.6 WHEN MUNICIPAL FACILITIES MUST SAMPLE

Municipal applicants are required to conduct sampling for both Parts 1 and 2 of their applications. In Part 1, municipalities must conduct a field screening analysis to detect illicit connections and illegal dumping into their storm sewer system. Where flow is observed during dry weather, two grab samples must be collected during a 24-hour period with a minimum of 4 hours between samples. These samples must be analyzed for pH, total chlorine, total copper, total phenol, and detergents (surfactants). Note that these are dry weather samples, rather than storm water samples. EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems presents a description of conducting field screening sampling and provides a data sheet.

For Part 2 of the application, municipalities must submit grab (for certain pollutants) and flow-weighted sampling data from selected sites (5 to 10 outfalls) for 3 representative storm events at least 1 month apart. The flow-weighted composite sample must be taken for either the entire discharge or the first 3 hours (if the event lasts longer than 3 hours). Municipal facilities are not required to collect grab samples within the first 30 minutes of a storm event.

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In addition to submitting quantitative data for the application, municipalities must also develop programs for future sampling activities that specify sampling locations, frequency, pollutants to be analyzed, and sampling equipment. Where necessary (as determined by the municipality or if required by the permitting authority), responsibilities may also include monitoring industries connected to the municipality's storm sewers for compliance with their facility-specific NPDES permits. Refer to EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems for information on how to develop municipal sampling programs.

2.7.7 USE OF HISTORICAL DATA

Data from storm water samples analyzed in the past can be submitted with applications in lieu of new sampling data if:

- All data requirements in Form 2F are met
- Sampling was performed no longer than 3 years prior to submission of the permit application
- All water quality data are representative of the present discharge.

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The historical data may be unacceptable if there have been significant changes since the time of that storm event in production level, raw materials, processes, or final products. Significant changes which may also impact storm water runoff include construction or installation of treatment or sedimentation/erosion control devices, buildings, roadways, or parking lots. Applicants should assess any such changes to determine whether they altered storm water runoff since the time of the storm event chosen for use in the permit application. Historical data can be used only in applications. Historical data cannot be used for fulfilling permit requirements.

2.8 WHERE TO SAMPLE STORM WATER DISCHARGES

Storm water samples should be taken at a storm water point source. A "point source" is defined as any discernible, confined, and discrete conveyance, including (but not limited to) any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged (as per 40 CFR 122.2). Included in the definition of storm water "point sources" is storm water from an industrial facility that enters, and is discharged through, a municipal separate storm sewer. In short, most storm water discharges can be defined as "point source" discharges, since they ultimately flow into some kind of conveyance (e.g., a channel or swale).

2.8.1 INDUSTRIAL FACILITIES

Industrial applicants submitting individual applications must collect and analyze a grab sample taken within the first 30 minutes of the storm event and flow-weighted composite samples from each of the industrial storm water "point source" outfalls identified on the site drainage map submitted for Section III of Form 2F. Applicants submitting quantitative data for Part 2 of the group application must also collect samples for each outfall discharging storm water associated with industrial activity. All outfalls should be sampled during the same representative storm event if possible. If this is not feasible, outfalls may be sampled during different representative storm events upon approval by the permitting authority. Descriptions of each storm event and which outfalls were sampled during each event must be included in the application. Storm water runoff from employee parking lots, administration buildings, and landscaped areas that is not mixed with storm water associated with industrial activity, or storm water discharges to municipal sanitary sewers, do not need to be sampled.

<u>Outfalls With Substantially Identical Effluents—Industrial Facilities</u>

If an applicant has two or more outfalls with "substantially identical effluents," the facility may petition the permitting authority to sample and analyze only one of the identical outfalls and submit the results as representative of the other. "Substantially identical effluents" are defined as discharges from drainage areas undergoing similar activities where the discharges are expected to be of similar quantity and quality, and indistinguishable in expected composition. Chapter 5 presents an example of a petition for substantially identical effluents and discusses this process in more detail.

2.8.2 MUNICIPALITIES

Large and medium municipalities are required to sample storm water discharges from 5 to 10 outfalls or field screening points that were proposed in Part 1 of the application. The final decision on the number and location of sampling points will be determined by the permitting authority and will depend on site-specific conditions such as land use or drainage area and results of data collected during the field screening analysis process for Part 1 of the application.

2.8.3 LOGISTICS OF WHERE TO SAMPLE

The ideal sampling location would be the lowest point in the drainage area where a conveyance discharges storm water to waters of the U.S. or to a municipal separate storm sewer system. A sample point also should be easily accessible on foot in a location that will not cause hazardous sampling conditions. Ideally, the sampling site should be on the applicant's property or within the municipality's easement; if not, the field personnel should obtain permission from the owner of the property where the discharge outfall is located. Typical sampling locations may include the discharge at the end of a pipe, a ditch, or a channel.

However, logistical problems with sample locations may arise (e.g., nonpoint discharges, inaccessibility of discharge point, etc.). Logistical problems with sample locations and suggested solutions are described in Exhibit 2-12. In many cases, it may be necessary to locate a sampling point further upstream of the discharge point (e.g., in a manhole or inlet). If the storm water at a selected location is not representative of a facility's total runoff, the facility may have to sample at several locations to best characterize the total runoff from the site. In situations where discharge points are difficult to sample for various reasons, the applicant should take the best sample possible and explain the conditions in the application. A discussion on sampling at retention ponds appears in Section 3.1.2.

2.9 STAFFING CONSIDERATIONS

Staffing needs for sampling must be determined by the applicant. Factors in making the determination include the number of sample locations, the size of the area to be sampled, how far apart the locations are, the type of sampling required, the technique to be used, the number of samples to be taken (depending on how many parameters must be analyzed), and safety considerations.

Training sampling personnel is important to the success of storm water discharge characterization. Training can be done using this manual. Sampling conducted by untrained personnel may result in

EXHIBIT 2-12 SOLUTIONS TO SAMPLE LOCATION PROBLEMS

Problem:	Sampling where storm water commingles with process or non-process water
Solution:	Attempt to sample the storm water discharge before it mixes with the non-storm water discharge. If this is impossible, sample the discharge both during dry and wet weather and present both sets of data to the permitting authority. This will provide an indication of the contribution of pollutants from each source.
Problem:	Numerous small point discharges
Solution:	Impound channel or join together flow by building a weir or digging a ditch to collect discharge at a low point for sampling purposes. This artificial collection point should be lined with plastic to prevent infiltration and/or high levels of sediment. Or, sample at several locations to represent total site runoff.
Problem:	Inaccessible discharge point [examples include underwater discharges or unreachable discharges (e.g., out of a cliff)]
Solution:	Go up the pipe to sample (i.e., to the nearest manhole or inspection point). If these are not available, tap into the pipe or sample at several locations to best represent total site runoff.
Problem:	Managing multiple sampling sites to collect grab samples during the first 30 minutes (industrial facilities only)
Solution:	Have a sampling crew ready for mobilization when forecasts indicate that a representative storm will occur or sample several different representative events. Also, for most parameters, automatic samplers may be used to collect samples within the first 30 minutes triggered by the amount of rainfall, the depth of flow, flow volume or time.
Problem:	Commingling of parking lot runoff with discharge associated with industrial activity
Solution:	The combined runoff must be sampled at the discharge point as near as possible to the receiving water or the parking lot drain inlet if there is one.
Problem:	Sampling in manholes
Solution:	Sample in manholes only when necessary. See Chapter 6 for safety information. Sampling in manholes requires training on confined space entry.
Problem:	Runon from other property
Solution:	If possible, estimate the volume of offsite runon contributions and offsite runon sources of pollutants to perform a mass balance calculation. Include this information in the permit application. If this estimation is not possible, provide a narrative discussion of the upstream site (e.g., is it developed, if so the type of facility, the types of pollutants that may be present on the site, etc.).

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data that is unrepresentative of the facility's storm water discharge. This data might be rejected by the permitting authority, who would then require another sampling effort.

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3. FUNDAMENTALS OF SAMPLING

Because of the variable nature of storm water flows during a rainfall event and different analytical considerations for certain pollutants, the storm water regulations establish specific requirements for sample collection techniques. The quality of storm water discharges and logistical needs for sampling will be different for industrial applicants and municipal applicants. Therefore, specific sampling requirements vary. After a brief review of sampling fundamentals and special sampling requirements for storm water permit applications, the following sections are intended to teach applicants how to sample to meet these requirements.

The applicant should carefully plan his/her sampling strategy prior to the actual sampling event, e.g., walk the site to determine appropriate sampling locations, become familiarized with local rainfall patterns, train sampling staff in procedures and safety, consult with laboratory, and collect supplies.

3.1 TYPES AND TECHNIQUES OF SAMPLING

There are three basic aspects of sampling:

- Sample type (i.e., grab versus composite)
- Sample technique (i.e., manual versus automatic)
- Flow measurement methods.

These topics will be discussed in relation to requirements of an NPDES storm water discharge permit application. Once these aspects are addressed, step-by-step instructions on sampling procedures are presented. The sections below define and describe the types of storm water samples that must be collected and methods or techniques for collecting them. In addition, special sampling requirements for certain pollutants are discussed.

3.1.1 SAMPLE TYPE VERSUS SAMPLE TECHNIQUE

It is important to understand the difference between sample type and technique. "Sample type" refers to the kind of sample that must be collected -- either a grab or a composite. "Sample technique" refers to the method by which a grab or composite sample is actually collected -- either manually or by automatic sampler. A generalized relationship between sample type and sample technique is presented in Exhibit 3-1. Sections 3.1.2 and 3.1.3 further explain the significance of these terms as they relate to storm water sampling requirements.

EXHIBIT 3-1. SAMPLE TYPE VS. SAMPLE TECHNIQUE

Sample Type	Sample Technique
Grab	Manual Automatic sampling system
Composite	Manual with manual compositing Automatic system or automatic sampling with manual compositing

3.1.2 SAMPLE TYPE: GRAB AND COMPOSITE SAMPLES

To comply with storm water application requirements, the sample type (grab or composite) must be collected in accordance with 40 CFR 122.21(g)(7) and 40 CFR Part 136. The storm water application requirements clearly specify which pollutants must be analyzed by grab sample, and which by composite sample. Although the requirements in 40 CFR 122.21(g)(7) do not explicitly specify either manual or automatic sampling techniques, the approved analytical methods contained in 40 CFR Part 136 direct that grab samples must be collected manually for certain pollutants. Sections 3.3 and 3.4 clarify which pollutants must be grabbed, which ones must be grabbed manually, and which ones must be flow-weighted composites.

The two types of storm water samples required by the regulations, grab and composite samples, are described below.

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Grab Samples

A grab sample is a discrete, individual sample taken within a short period of time (usually less than 15 minutes). Analysis of grab samples characterizes the quality of a storm water discharge at a given time of the discharge.

Composite Samples

A composite sample is a mixed or combined sample that is formed by combining a series of individual and discrete samples of specific volumes at specified intervals. Although these intervals can be time-weighted or flow-weighted, the storm water regulations require the collection of flow-weighted composite samples. This means that discrete aliquots, or samples, are collected and combined in proportion to flow rather than time. Composite samples characterize the quality of a storm water discharge over a longer period of time, such as the duration of a storm event.

Application Requirements

Both types of samples must be collected and analyzed for storm water discharge permit applications. Grab samples must be collected for the following conditions:

- For storm water discharges associated with industrial activity, a grab sample must be obtained during the first 30 minutes of a discharge. This requirement is in addition to the composite sampling requirements. These samples are intended to characterize the maximum concentration of a pollutant that may occur in the discharge and/or may indicate intermingling of non-storm water discharges.

- For storm water discharges from large and medium municipal separate storm sewers, grab samples are required for Part 1 of the application if a discharge is noted during dry weather field screening. Two grab samples must be collected during a 24-hour period with a minimum of 4 hours between samples. These samples are intended to assist in the identification of illicit connections or illegal dumping. In Part 2, grab samples may be required for the analysis of certain pollutants for which municipalities are required to sample.

Flow-weighted composite samples must be collected during the first 3 hours of discharge or the entire discharge (if it is less than 3 hours) for both industrial and municipal applicants.

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Pollutant-specific Requirements

The regulations at 40 CFR 122.21(g)(7) identify certain pollutants for which grab sampling is required:

- Monitoring by grab sample must be conducted for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease (O&G), fecal coliform, and fecal streptococcus. Composite samples are not appropriate for these parameters due to their tendency to transform to different substances or change in concentration after a short period of time. Such transformations may be particularly likely in the presence of other reactive pollutants.

Sampling At Retention Ponds

Retention ponds with greater than a 24-hour holding time for a representative storm event may be sampled by grab sample. Composite sampling is not necessary. The rationale for this is that, because the water is held for at least 24 hours, a thorough mixing occurs within the pond. Therefore, a single grab sample of the effluent from the discharge point of the pond accurately represents a composite of the storm water contained in the pond. If the pond does not thoroughly mix the discharge, thereby compositing the sample, then a regular grab and composite sample should be taken at the inflow to the pond. Since each pond may vary in its capability to "composite" a sample, applicants must carefully evaluate whether the pond is thoroughly mixing the discharge. Such factors as pond design and maintenance are important in making this evaluation. Poor pond design, for example, where the outfall and inflow points are too closely situated, may cause short-circuiting and inadequate mixing. In addition, poor maintenance may lead to excessive re-suspension of any deposited silt and sediment during heavy inflows. Because of factors such as these, the applicant should determine the best location to sample the pond (e.g., at the outfall, at the outfall structure, in the pond) to ensure that a representative composite sample is taken. If adequate compositing is not occurring within the pond, the applicant should conduct routine grab and flow-weighted composite sampling.

A grab sample <u>and</u> a flow-weighted sample must be taken for storm water discharges collected in holding ponds with less than a 24-hour retention period. The applicant must sample the discharge in the same manner as for any storm water discharge [as described in 40 CFR 122.21(g)(7)]. In effect, the applicant must take one grab sample within the first 30 minutes of discharge, or as soon as possible. The applicant must also collect a flow-weighted composite sample for at least the first 3 hours of the discharge, or for the event's entire duration (if it is less than 3 hours). The flow-weighted composite sample may be taken using a continuous sampler or as a combination of at least three sample aliquots taken during each hour of the discharge, with a minimum of 15 minutes between each aliquot. If the applicant does not know what retention period the pond is designed for, the design engineer of the pond should be consulted.

3.1.3 SAMPLE TECHNIQUE: MANUAL VERSUS AUTOMATIC SAMPLING

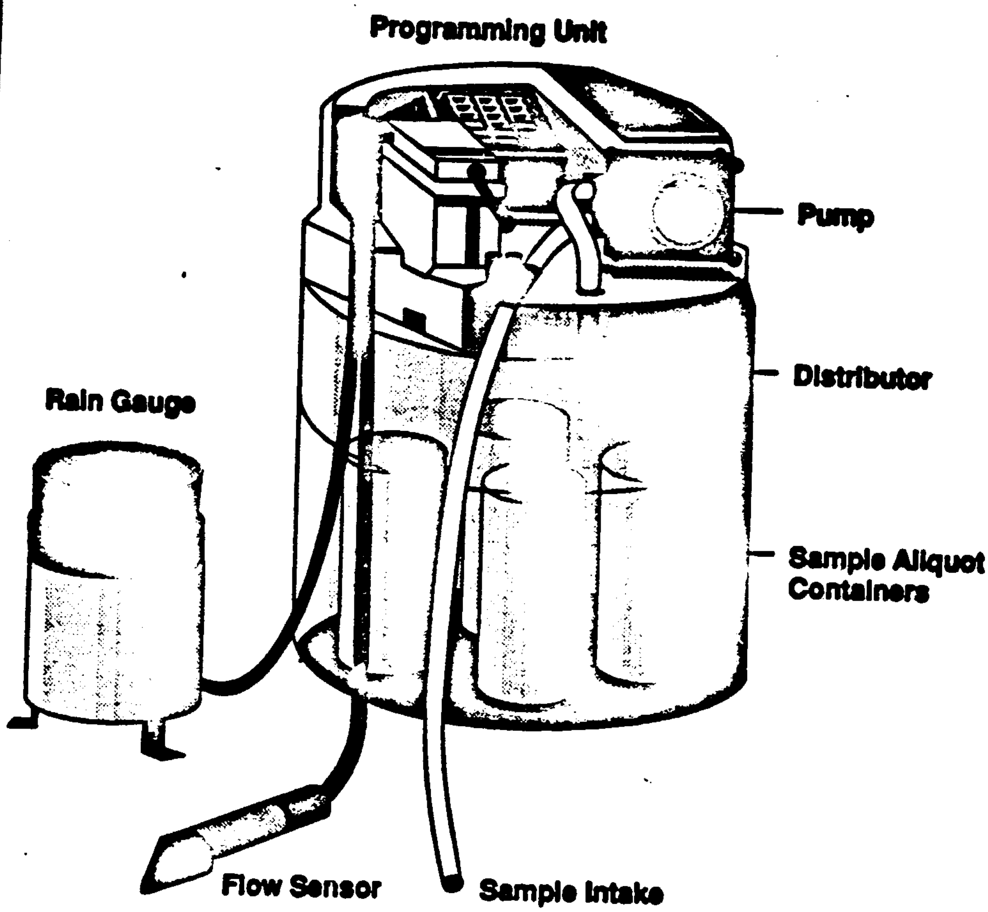
As previously discussed, manual and automatic sampling techniques are methods by which both grab and composite samples can be collected. Manual samples are simply samples collected by hand. Automatic samplers are powered devices that collect samples according to preprogrammed criteria. A typical automatic sampler configuration is shown in Exhibit 3-2.

For most pollutants, either manual or automatic sample collection will conform with 40 CFR Part 136. However, one case in which automatic samplers cannot be used is for the collection of volatile organic compound (VOC) samples because VOCs will likely volatilize as a result of agitation during automatic sampler collection. Samples collected for VOC analysis should be filled until a reverse meniscus is found over the top of the collection bottle and capped immediately to leave no air space. Automatic samplers do not perform this function. Special requirements for VOC sampling are discussed in Section 3.5.2.

Although both collection techniques are available, several other pollutants may not be amenable to collection by an automatic sampler, for example fecal streptococcus, fecal coliform and chlorine have very short holding times (i.e., 6 hours), pH and temperature need to be analyzed immediately and oil and grease requires teflon coated equipment to prevent adherence to the sampling equipment.

Other restrictions on sample collection techniques (such as container type and preservation) should be determined by consulting the approved analytical methods listed in 40 CFR Part 136. Section 3.5 and Technical Appendix C provide additional information on sample handling, holding times, and preservation methods.

EXHIBIT 3-2 AUTOMATIC SAMPLER



Manual and automatic techniques have advantages and disadvantages that the applicant should consider in relation to the sampling program. The main advantage of manual sampling is that it can be less costly than purchasing or renting automatic samplers. Automatic samplers, however, can be often more convenient. Exhibit 3-3 presents a matrix of advantages and disadvantages associated with each technique. Ultimately, the best technique to use will depend on each applicant's situation.

3.2 OBTAINING FLOW DATA

In addition to collecting samples of storm water discharges, applicants must collect data characterizing the flow rate and flow volume for each storm water discharge sampled. Flow rate is the quantity of storm water discharged from an outfall per unit of time. Total flow is a measure of the total volume of storm water runoff discharged during a rain event. Flow rates and volumes can either be measured specifically or can be estimated (based on rainfall measurements, velocities, and depth of flows). To collect flow-weighted composite samples, flow rate data is necessary to combine proportional volumes of individually collected aliquots. Applicants must also report the mass of pollutants contained in storm water discharges (see Section 3.2.5). To determine mass loadings of pollutants, applicants must measure both discharge flow rate and pollutant concentration. This section presents methods for obtaining flow data.

3.2.1 MEASURING FLOW RATES

Flow rates for storm water discharges are most accurately measured using either primary or secondary flow measurement devices. Facilities should use these devices to characterize their discharge as precisely as possible. Where flow measurement devices are not already installed, portable devices should be considered. There are many permanent and portable types of flow measurement devices available. This discussion is limited to the most common flow measurement devices. To purchase flow measurement devices and rain gauges, pertinent engineering journals can be consulted for equipment vendor listings. Proper analysis of site discharge conditions must be conducted prior to purchase and installment of flow measurement devices.

<u>Primary Flow Measurement Devices</u>

A primary flow measurement device is a man-made flow control structure which, when inserted into an open channel, creates a geometric relationship between the depth of the flow and the rate of the

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EXHIBIT [illegible]. COMPARISON OF MANUAL AND AUTOMATIC SAMPLING TECHNIQUES

Sample Method	Advantages	Disadvantages
Manual Grabs	• Appropriate for all pollutants • Minimum equipment required	• Labor-intensive • Environment possibly dangerous to field personnel • May be difficult to get personnel and equipment to the storm water outfall within the 30 minute requirement • Possible human error
Manual Flow-Weighted Composites (multiple grabs)	• Appropriate for all pollutants • Minimum equipment required	• Labor-intensive • Environment possibly dangerous to field personnel • Human error may have significant impact on sample representativeness • Requires flow measurements taken during sampling
Automatic Grabs	• Minimizes labor requirements • Low risk of human error • Reduced personnel exposure to unsafe conditions • Sampling may be triggered remotely or initiated according to present conditions	• Samples collected for O&G may not be representative • Automatic samplers cannot properly collect samples for VOCs analysis • Costly if numerous sampling sites require the purchase of equipment • Requires equipment installation and maintenance • Requires operator training • May not be appropriate for pH and temperature • May not be appropriate for parameters with short holding times (e.g., fecal streptococcus, fecal coliform, chlorine) • Cross-contamination of aliquot if tubing/bottles not washed
Automatic Flow-Weighted Composites	• Minimizes labor requirements • Low risk of human error • Reduced personnel exposure to unsafe conditions • May eliminate the need for manual compositing of aliquots • Sampling may be triggered remotely or initiated according to on-site conditions	• Not acceptable for VOCs sampling • Costly if numerous sampling sites require the purchase of equipment • Requires equipment installation and maintenance, may malfunction • Requires initial operator training • Requires accurate flow measurement equipment tied to sampler • Cross-contamination of aliquot if tubing/bottles not washed

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flow. The depth of the flow, referred to as the head (H), can then be measured at the respective reference point/area with a ruler or other staff gauge. When substituted into a formula, which mathematically describes the relationship between depth and discharge for the primary devices, the head measurement can be used to calculate a flow rate (Q). The most common primary flow measurement devices are weirs and flumes. Weirs and flumes are flow structures designed to provide a known, repeatable relationship between flow and depth.

Weirs

Weirs consist of a crest located across the width of an open channel (at a right angle to the direction of the flow). The flow of water is impeded, causing water to overflow the crest. Diagrams and formulas of some typically found weirs are provided in Exhibit 3-4. Weirs are inexpensive and particularly valuable in measuring flow in natural or man-made swales because they are easily installed in irregularly shaped channels.

Weirs can only provide accurate flow measurements when head measurements are appropriately taken. When flow exceeds the capacity of the weir and water overtops the weir crest, flow depth actually diminishes as the water approaches the weir, as shown in Exhibit 3-5. Therefore, measuring the depth at the weir crest will result in an inaccurate measurement of the actual head. Under these circumstances, the head should be measured upstream, at a point determined by the type of weir and the estimated amount of flow. A staff gauge can be installed at a nonturbulent point upstream of the weir crest to provide accurate and convenient measurements.

Flumes

Flumes are structures which force water through a narrow channel. They consist of a converging section, a throat, and a diverging section. Exhibit 3-6 portrays the most common type of flume, the Parshall flume, and also provides formulas for calculating appropriate flow rates.

Parshall flumes have fixed specifications relating to geometric shape. They vary only in throat width. Due to these geometric constraints, Parshall flumes may be expensive to install. They are typically used in permanent flow measurement points and are most commonly placed in concrete-lined channels. However, Parshall flumes can also be used in temporary points. Parshall flumes provide accurate measurements for a relatively wide range of flow rates. The flow rate through the Parshall flume (see Exhibit 3-6) is calculated from the depth (H_a) of flow measured in the converging

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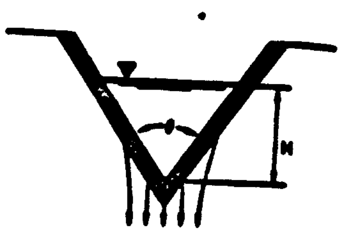
EXHIBIT 3-[illegible] WEIRS

V-Notch



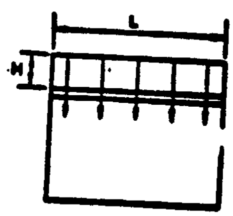
$Q = 2.5\ H^{2.5}$ (90°)
$Q = 1.443\ H^{2.5}$ (60°)
$Q = 1.035\ H^{2.5}$ (45°)
$Q = 0.676\ H^{2.5}$ (30°)
$Q = 0.497\ H^{2.5}$ (22½°)

Q = Flow Rate

H = Depth of flow (Head)

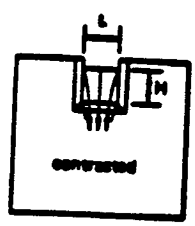
Rectangular (without contractions)

$Q = 3.33\ L\ H^{1.5}$



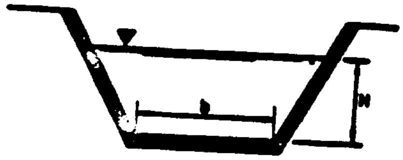
Rectangular (with contractions)

$Q = 3.33\ (L - 0.2\ H)^{1.5}$



Cipolleti (trapezoidal)

$Q = 3.367\ b\ H^{1.5}$



Source: Civil Engineering Reference Manual, 5th Edition, by Michael R. Lindeburg, PE, with permission from the publisher, Professional Publications, Inc., Belmont, California, 1989.

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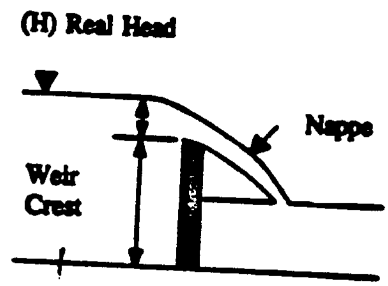
EXHIBIT 3-5: SUPPRESSED FLOW OVER THE WEIR CREST



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section of the flume. The exact location of the depth measurement depends on the specific design of the Parshall flume. Exhibit 3-6 indicates the equations used to calculate flow rate through a typical Parshall flume. These equations are accurate only when the submergence ratio (H_b/H_a) is greater than 0.7. The manufacturers' information should be consulted for the flow rate equation and measuring points for a specific Parshall flume.

Palmer-Bowlus flumes, shown in Exhibit 3-7, are also used at some facilities. Palmer-Bowlus flumes are designed to be installed in an existing circular channel (such as a manhole channel) and are available as portable measurement devices. While Palmer-Bowlus flumes are inexpensive, self cleaning, and easy to install, they can only measure flow rates accurately over a narrow range of flow.

The flow from a Palmer-Bowlus flume is calculated using the height between the floor of the flume portion and the water level, not the total head of the water level. Head measurements are taken at

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EXHIBIT 3-6. FLUMES

Parshall Flume

$$Q = 0.338\ H^{1.55} \quad \text{(1 inch)}$$
$$Q = 0.676\ H^{1.55} \quad \text{(2 inches)}$$
$$Q = 0.992\ H^{1.547} \quad \text{(3 inches)}$$
$$Q = 2.09\ H^{1.58} \quad \text{(6 inches)}$$
$$Q = 3.07\ H^{1.53} \quad \text{(9 inches)}$$
$$Q = 4\ W\ H^{1.522\ W^{0.26}} \quad \text{(1-8 feet)}$$
$$Q = (3.6875\ W + 2.5) H^{1.6} \quad \text{(10-50 feet)}$$

Q = Flow rate

H = Depth of flow (Head)

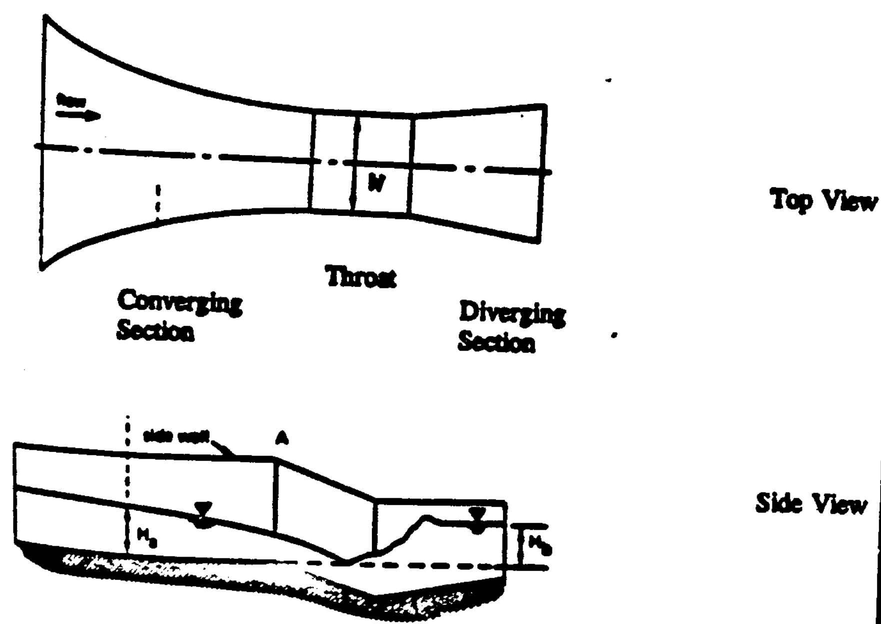

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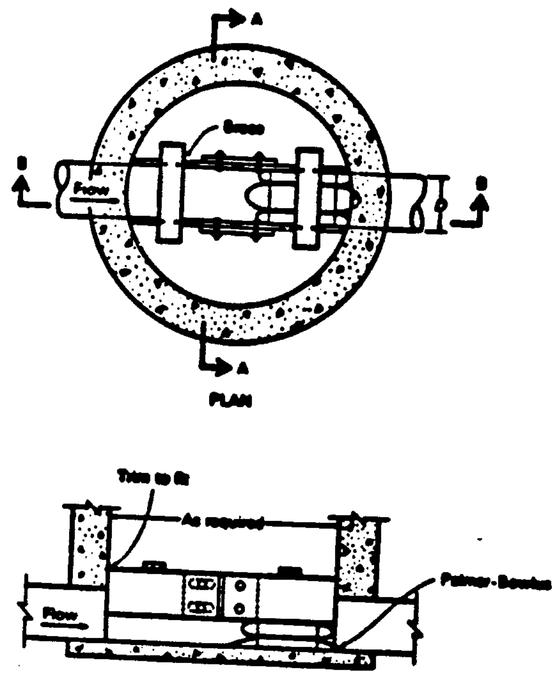
EXHIBIT 3-7 PALMER-BOWLUS FLUME



Source: Wastewater Engineering: Treatment, Disposal, Reuse, 2nd Edition, Metcalf & Eddy, Inc., with permission from the publisher, McGraw-Hill Book Co., New York, 1979.

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a distance from the throat equal to one half the width of the flume. The dimensions of a Palmer-Bowlus flume have been standardized in a generic sense, but the flume shape may vary. Therefore, there are no formulas that can be applied to all Palmer-Bowlus flumes. Device-specific head-flow relationships for each device should be obtained from the manufacturer.

There are a number of other, less common, flow measurement devices available which will not be discussed (see Appendix D for additional references).

Secondary Flow Measurement Devices

Secondary flow measurement devices are automated forms of flow rate and volume measurement. Typically, a secondary device is used in conjunction with a primary device to automatically measure the flow depth or head. This value is then processed, using established mathematical relationships to relate the depth measurement to a corresponding flow rate. The device also may have the capacity to convert this flow rate to a volume. Secondary flow measurement devices include floats, ultrasonic transducers, pressure transducers, and bubblers. The output of the secondary device is transmitted to a display, recorder, and/or totalizer to provide flow rate and volume information. The user manuals for these devices should be consulted for proper usage.

Evaluation of Flow Measurement Devices

To ensure accurate results, facilities should evaluate, via visual observation and routine checks, the design, installation, and operation of flow measurement devices. When evaluating design, select a device which:

- Is accurate over the entire range of expected flow rates
- Can be installed in the channel to be monitored
- Is appropriate to the sampling location (i.e., power setup, submersible, etc.).

When evaluating the installation of flow measurement devices, ensure that:

- There are no leaks and/or bypasses of flow around the measuring device
- The primary device is level and squarely installed
- The secondary device is calibrated.

When evaluating the operation of flow measurement devices, look for:

- Excessive flows which submerge the measuring device
- Flows outside the accuracy range of the device
- Leaks and/or bypasses around the measuring device

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- Turbulent flow through the measuring device
- Corrosion, scaling, or solids accumulation within the measuring device
- Obstructions to the measuring device
- Use of the correct factor or formula to convert head readings to actual flow rate.

Other than ensuring appropriate design and installation, accuracy checks are difficult to accomplish for primary flow measurement devices. Secondary flow measurement devices, on the other hand, may require evaluation of design, installation, and calibration. Applicants should examine the secondary recording devices and their readouts after installation to ensure that they are operating properly. Unusual fluctuations or breaks in flow indicate operational or design flaws.

3.2.2 ESTIMATING FLOW RATES

There are a variety of techniques for estimating flow rates. These methods are not as accurate as the methods described in Section 3.2.1 above, but are suitable for those discharges where primary or secondary devices are not practical or economically feasible. Each of the following methods is suitable for certain types of flow situations, as indicated. For each, the procedure for collecting flow rate data will be given along with a sample calculation.

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Float Methods

Float methods can be used for any discharge where the flow is exposed and/or easily accessible. It is particularly useful for overland flows, gutter flows, and open drain or channel flows. The flow rate is calculated in each of the float methods by estimating the velocity of the flow and the cross-sectional area of the discharge and using the standard flow rate equation:

$$\textit{Flow Rate (cfm)} = \textit{Velocity (ft/min)} \times \textit{Area (ft}^2\textit{)}$$

The velocity is estimated by measuring the time it takes a float to travel between two points (point A and point B) along the flow path. For most accurate results, the two points should be at least 5 feet apart. The cross-sectional area is estimated by measuring the depth of the water and the width of the flow, and multiplying the depth by the width. This assumes a uniform cross-section in the flow path and a geometric cross-section shape. The float method can also be used for any accessible pipe or ditch where the movement of the float can be traced downstream for at least 5 feet. Subsurface storm water flows can be measured with the float method where there are two accessible manholes.

If the flow is overland, the water will need to be directed into a narrow channel or ditch so that the measurements can be taken. The initial preparation for this method requires that a shallow channel or ditch be dug that is 6 feet long or longer and 4 to 12 inches wide. The channel or ditch should be shallow enough to easily obtain flow depths but should be deep enough to carry the flow that will be diverted to it. Boards or other barriers should be placed on the ground above the channel (so that the flow is diverted into the channel) and along the edges of the channel or ditch (flush with the ground surface so that flow does not seep under them).

The procedure for measuring the flow rate by the float method involves measuring the length of the channel between chosen points A and B (which must be 5 feet apart or more). The depth of the water at point B, in the middle of the channel, must be determined, and the width of the water flow must be measured at point B. A float is then placed in the water and timed as it moves from point A to point B. Exhibit 3-8 provides an example of estimating the flow rate using the float method.

For runoff flows from many directions into a drain in a low or flat area where ponding is evident, the float method can also be used. The total flow rate is calculated by measuring flow rates for several points into the drain and adding these values together. Exhibit 3-9 provides an example of estimating the flow rate using the float method in this situation.

<u>Bucket and Stopwatch Method</u>

The bucket and stopwatch method of estimating flow rate is the easiest of all the flow rate estimation procedures. However, it can only be used under certain conditions. The flow or discharge to be measured must be flowing from a small pipe or ditch, and it must be free-flowing. In other words,

EXHIBIT [illegible] EXAMPLE CALCULATION OF FLOAT METHOD FOR UNIMPEDED OPEN CHANNEL FLOW

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken and the length between points A and B (at least 5 feet apart). See columns A, B, and C.

EXAMPLE DATA:

A	B	C	D	E	F	G
Sample Number	Time in Minutes	Distance Between Points A & B (feet)	Time of Travel (A to B) (min)	Depth of Water at Point B (feet)	Width of Flow at Point B (feet)	Calculated Flow Rate (cfm)
1	0	5.0	0.17	0.12	0.5	1.8
2	20	5.0	0.18	0.25	0.5	3.5
3	40	5.0	0.20	0.29	0.5	3.6
4	60	5.0	0.21	0.33	0.5	3.9
5	80	5.0	0.18	0.29	0.5	4.0
6	100	5.0	0.17	0.25	0.5	3.7
7	120	5.0	0.17	0.12	0.5	1.8
8	140	5.0	0.16	0.12	0.5	1.9
9	160	5.0	0.18	0.12	0.5	1.7

Step 2: Place a float in the water flow at point A and time it as it moves from point A to point B. Record the time in minutes. See column D.

Step 3: Measure the depth of the water and the width of the flow at point B. See columns E and F.

Step 4: Calculate the flow rate for each sample time using the common flow rate formula. See column G.

Formulas:

$$\textit{Velocity } (V) = \frac{\text{Length from A to B}}{\text{Time of Travel}}$$

$$\textit{Area } (A) = \textit{Water Depth} \times \textit{Width of Flow}$$

$$\textit{Flow Rate } (Q) = (V) \times (A)$$

Example: For Sample 1

$$V = \frac{5.0\ ft}{0.17\ min} = 29.4\ ft/min$$

$$A = 0.12\ ft \times 0.5\ ft = 0.06\ ft^2$$

$$Q = 29.4\ ft/min \times 0.06\ ft^2 = 1.8\ cfm$$

EXHIBIT [illegible] EXAMPLE CALCULATION OF FLOAT METHOD FOR ESTIMATING DRAIN FLOWRATES

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken. Measure the outer perimeter or edge of the drain where the water flows in. See columns B and C.

Step 2: Designate three evenly spaced points surrounding the drain approximately 3 to 5 feet from the drain. These points will be referred to as points A, B, and C. Record the distance from each point to the edge of the drain. See column D.

EXAMPLE DATA: Assume the drain dimensions are 1 ft x 1 ft square, and flow surrounds drain.

A	B	C	D			E			F			G
Sample Number	Sample Time (min)	Drainage Perimeter (feet)	Distance of Point to Drain (feet)			Time of Travel to Drain (min)			Depth of Water (feet)			Calculated Flow Rate (cfm)
			Pt. A	Pt. B	Pt. C	Pt. A	Pt. B	Pt. C	Pt. A	Pt. B	Pt. C	
1	0	4	3	4	5	0.2	0.3	0.5	0.08	0.08	0.08	4 cfm
2	20	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
3	40	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
4	60	4	3	4	5	0.4	0.5	0.6	0.16	0.17	0.20	6 cfm
5	80	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
6	100	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
7	120	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
8	140	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
9	160	4	3	4	5	0.2	0.3	0.5	0.08	0.08	0.08	4 cfm

Step 3: Place a float at each of the three points and measure the time it takes to reach the drain. Record the times in minutes. See column E.

Step 4: Determine the depth of flow at each place where the float enters the drain from points A, B, and C. Record the depth in feet. See column F.

Step 5: Calculate the flow rate by adding the individual flow rates for points A, B, and C. Record the data in column G.

Formulas:

$$\textit{Velocity } (V) = \frac{\textit{Distance of Point from Drain}}{\textit{Time of Travel}}$$

$$\textit{Area } (A) = \textit{Water Depth} \times \textit{Drainage Perimeter}$$

$$\textit{Flow Rate } (Q) = 1/n \Sigma A_n V_n \textit{ where n equals points A, B, and C}$$

Example: For Sample 1

$$V_A = \frac{3 \textit{ Feet}}{0.2 \textit{ Min}} = 15 \textit{ ft/min}$$

$$A_A = 0.08 \textit{ ft} \times 4 \textit{ ft} = 0.32 \textit{ ft}^2$$

EXHIBIT [illegible] EXAMPLE CALCULATION OF FLOAT METHOD FOR ESTIMATING DRAIN FLOW RATES (Continued)

$$Q_{OPEN} = \tfrac{1}{3}(V_A A_A + V_B A_B + V_C A_C)$$

$$= \tfrac{1}{3}[(15\ ft/min)(0.32\ ft^2) + (13\ ft/min)(0.32\ ft^2) + (10\ ft/min)(0.32\ ft^2)]$$

$$= 4\ cfm$$

the pipe or ditch must be raised above the ground. Also, the flow must be small enough to be captured by a bucket or other suitable container without overflowing. If these conditions are not present, another method must be used. The procedure involves recording the time that each sample is taken, the time it takes for the container to be filled, and the volume of discharge collected. The flow rate is then calculated in gallons per minute (gpm) or in cubic feet per minute (cfm). The basis for the bucket and stopwatch method is the collection of a measured amount of flow over a measured amount of time to determine flow per unit of time (or flow rate) as per the formula below.

$$\textit{Flow Rate Q (gpm)} = \frac{\textit{Volume of Bucket (gal)}}{\textit{Time to Fill (sec)}} \times \frac{60\ sec}{1\ min}$$

Exhibit 3-10 provides an example of estimating flow rates with the bucket and stopwatch method.

<u>Slope and Depth Method</u>

The slope and depth method is also a relatively easy method for estimating flow rates in pipes and ditches. This procedure requires that the slope of the pipe or ditch be known. A survey or engineering design data such as sewer or grading plans may provide the slope or grade of the pipe or ditch. In addition, the flow or effluent to be measured should not fully fill the pipe or ditch from which it is flowing. To measure the depth of the flow at the center of the pipe or ditch at the outfall, the outfall should be accessible. If these conditions are not present, another method should be used. The procedure involves recording the time that each sample is taken and measuring the depth of the flow in the middle of the pipe or ditch. If the flow is coming from a pipe, the inside diameter of the pipe should be recorded. If the effluent is coming from a ditch, the width of the flow in the ditch should be measured. Also, the modified slope of the ditch should be calculated. The flow rate is calculated in cfm using the same formulas for both pipes and ditches. Exhibit 3-11 provides an example of estimating the flow rate with the slope and depth method.

Table [illegible]: EXAMPLE APPLICATION OF BUCKET AND STOPWATCH METHOD FOR ESTIMATING FLOWS

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken. See column B.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	Time (minutes)	Time to Fill Bucket (seconds)	Volume of Bucket (gallons)	Calculated Flow Rate (gpm)	Calculated Flow Rate in (cfm)
1	0	40.0	2.0	3.0	0.4
2	20	26.0	2.0	4.6	0.6
3	40	24.0	2.0	5.0	0.7
4	60	32.0	2.0	3.7	0.5
5	80	45.0	2.0	2.7	0.4
6	.100	31.0	2.0	3.9	0.5
7	120	50.0	2.0	2.4	0.3
8	140	21.0	2.0	5.7	0.8
9	160	28.0	2.0	4.3	0.6
					0.6

Step 2: Put a bucket beneath the flow, while measuring with a stopwatch the time it takes to fill the bucket to a certain level. If the water spills over the sides, the process must be redone. Record the time it took to fill the volume of water. See columns C and D.

Step 3: Calculate the flow rate in gpm and cfm.

Formulas:

$$\textit{Flow Rate, } Q(gpm) = \frac{\text{Volume of bucket (gal)}}{\text{Time to fill (sec)}} \times \frac{60 \text{ sec}}{1 \text{ min}}$$

$$Q(cfm) = Q(gpm) \times 0.1337\ ft^3/gal$$

Example: For Sample 1

$$Q\ (gpm) = \frac{2 \text{ gal}}{40.0 \text{ sec}} \times \frac{60 \text{ sec}}{1 \text{ min}} = 3.0 \text{ gpm}$$

$$Q\ (cfm) = 3.0 \text{ gpm} \times 0.1337\ ft^3/gal = 0.4 \text{ cfm}$$

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EXHIBIT [illegible] EXAMPLE CALCULATION OF SLOPE AND DEPTH METHOD FOR ESTIMATING FLOW RATES

Step 1: Obtain the pipe or ditch channel percent slope from engineering data. Determine the inside diameter if the flow is from a pipe.

EXAMPLE DATA: For purposes of this example, a ditch with a 2 percent slope is assumed.

Step 2: When each sample or aliquot is taken, record the data for the time the sample was taken. See column B.

EXAMPLE DATA:

A	B	C	D	E	F	G
Sample Number	Time (minutes)	Depth of Water (in)	Width of Flow (ditch only) (feet)	"M" Modified Slope (ditch only)	Calculated Flow Rate (cfm Pipe only)	Calculated Flow Rate (cfm ditch only)
1	0	3.6	2.2	3.7	-	246.1
2	20	6.0	3.2	3.2	-	713.6
3	40	7.2	4.0	3.3	-	1,237.3
4	60	8.4	4.2	3.0	-	1,532.9
5	80	7.2	4.0	3.3	-	1,237.3
6	100	6.0	3.2	3.2	-	713.6
7	120	6.0	3.0	3.0	-	624.2
8	140	6.0	2.9	2.9	-	581.8
9	160	4.6	2.5	3.3	-	374.1

Step 3: Measure the depth of the water in the center of the pipe or ditch. Record the data in feet. See column C.

Step 4: Measure the width of the flow only if the flow is in a ditch. Record the data in feet. See column D.

Step 5: Calculate the modified side slope only if the flow is in a ditch (leave column E blank if the flow is in a pipe).

Formula:

$$\textit{Modified slope } (M) = \frac{12.0 \text{ in/ft} \times \text{flow width (ft)}}{2.0 \times \text{water depth (in)}}$$

Example: Sample 1:

$$M = \frac{12.0 \text{ in/ft} \times 2.2 \text{ ft}}{2.0 \times 3.6 \text{ in}} = 3.7$$

Step 6: For pipes, calculate the flow rate and record the data in column F.

$$\textit{Flow Rate } (Q) = 0.004 \times (I.D.)^{1.67} \times D \times \sqrt{S}$$

where Q = flow rate in pipe (cfm), I.D. = inside diameter of pipe (in), D = water depth (in), S = pipe slope (%)

Step 7: For ditches or channels, calculate the flow rate in cfm. Record the flow rate in column G.

Formula:

$$\textit{Flow Rate } (Q) = \frac{0.42M \times (M)^{1.67} \times (D)^{2.67} \times \sqrt{S}}{(M^2 + 1)^{0.33}}$$

where Q = flow rate in ditch (cfm), M = modified slope, D = water depth (in), S = ditch slope (%)

Example: For Sample 1:

$$Q_1 = \frac{0.42\,(3.7) \times (3.7)^{1.67} \times (3.6)^{2.67} \times \sqrt{2}}{[(3.7)^2 + 1]^{0.33}}$$

$$Q = 246.1 \text{ cfm}$$

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Runoff Coefficient Methods

Runoff coefficient methods are the least accurate of all the flow rate estimation methods. These methods should only be used for composite flow-weighted samples if all of the other methods are inappropriate for the site. Although the least accurate, runoff coefficients are the simplest method of estimating runoff rates.

Runoff coefficients represent the fraction of total rainfall that will be transmitted as runoff from the drainage area that flows into the facility outfall. Runoff coefficients consider the ground surface or cover material and determine the amount of storm water flow which may infiltrate or runoff as a discharge. A simple estimate of runoff volume assumes that paved areas and other impervious structures such as roofs have a runoff coefficient of 0.90 (i.e., 90 percent of the rainfall leaves the area as runoff). For unpaved surfaces, a runoff coefficient of 0.50 is normally assumed. A more accurate estimate can be made by using more specific runoff coefficients for different areas of the facility, based on the specific type of ground cover. Commonly used runoff coefficients are listed in Exhibit 3-12.

The average runoff coefficient can be estimated for drainage areas that have both paved and unpaved areas by weighting the coefficients based on their proportion of the total area. An equation for this would be:

$$\textit{Estimated Average Runoff Coef.} = \frac{(\textit{Area A})(\textit{Runoff Coef. A}) + (\textit{Area B})(\textit{Runoff Coef. B})}{\textit{Area A} + \textit{Area B}}$$

The area of the drainage basin can generally be obtained from land surveys conducted at the time of facility purchase or site surveys taken from design documents developed as part of construction planning. If these are not available, the applicant may estimate the drainage areas from a topographic map of the area. The areas used in this calculation should include only those areas drained by the sampled outfall. When determining the basin area that drains through the outfall, some special considerations should be noted: (1) storm water from sources outside an industrial facility's property boundary may contribute to the discharge; and (2) storm water not associated with industrial activity may contribute to the flow volume. Where these conditions occur, the facility should accurately quantify and appropriately address these contributions.

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EXHIBIT [illegible] TYPICAL [illegible] COEFFICIENTS FOR [illegible] 10-YEAR FREQUENCY DESIGN STORMS

Description of Area	Runoff Coefficients
Business	
• Downtown areas	0.70-0.95
• Neighborhood areas	0.50-0.70
Residential	
• Single-family areas	0.30-0.50
• Multiunits (detached)	0.40-0.60
• Multiunits (attached)	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
• Light areas	0.50-0.80
• Heavy areas	0.60-0.90
Parks and cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
• Asphalt	0.70-0.95
• Concrete	0.80-0.95
• Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns - course textured soil (greater than 85 percent sand)	
• Slope: Flat (2 percent)	0.05-0.10
Average (2-7 percent)	0.10-0.15
Steep (7 percent)	0.15-0.20
Lawns - fine textured soil (greater than 40 percent clay)	
• Slope: Flat (2 percent)	0.13-0.17
Average (2-7 percent)	0.18-0.22
Steep (7 percent)	0.25-0.35

Source: *Design and Construction of Sanitary and Storm Sewers*, with permission from the publisher, American Society of Civil Engineers, *Manual of Practice*, page 37, New York, 1960.

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There are two specific methods to estimate flow rate using runoff coefficients. The first method uses depth of flow in a pipe or ditch and an average runoff rate to estimate each of the sample flow rates where the slope/pitch of the pipe or ditch is unknown. Exhibit 3-13 provides an example calculation of estimating flow rates based on depth and runoff coefficients. The second method uses only rainfall accumulation and runoff coefficients to estimate a flow associated with the time the sample was taken. No actual flows or flow depths are measured. Exhibit 3-14 provides an example of estimating the flow rate based on rainfall depth and runoff coefficients.

3.2.3 MEASURING TOTAL FLOW VOLUMES FOR THE SAMPLED RAIN EVENT

Similar to measuring flow rates, flow volumes may be measured using automatic flowmeters or primary/secondary devices as discussed in Section 3.2.1. Measurement of flow volume with these devices provides a reasonably accurate determination of the total flow volume for the entire storm water discharge. In many cases, however, primary or secondary devices have not been installed for storm water flow measurement. Portable flow measurement devices are often expensive. Many of the automatic samplers that are currently on the market can measure flow volumes as well as perform sampling. Where available and when economically feasible, measuring devices should be used to generate data for calculating flow.

3.2.4 ESTIMATING TOTAL FLOW VOLUMES FOR THE SAMPLED RAIN EVENT

Since accurate measurement of total flow volumes is often impracticable due to lack of equipment, total flow volumes are more commonly estimated. The two methods provided in this section require only simple estimated measurements. The first method is based on rainfall depths and runoff coefficients and the second is based on flow rates that can be either measured or estimated.

<u>Runoff Coefficients Methods</u>

Discharge volumes are most easily estimated using the area of the drainage basin contributing to the outfall, the rainfall accumulation, and a runoff coefficient. The total volume of discharge can be estimated using a simple equation that relates the amount of rainfall to the volume of discharge that will leave the site as runoff. The equation is as follows:

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[illegible] DEPTH METHOD FOR ESTIMATING FLOW RATES (Continued)

Step 5: Calculate a depth-weight flow factor and record the data in column D.

Formula:

$$\textit{Factor} = \frac{\textit{Measured Water Depth}}{\textit{Sum of all Water Depths}} \times \textit{Number of Flow Measurements}$$

Example: For Sample 1

$$\textit{Factor} = \frac{(1\ ft) \times 9}{11.0} = 0.82$$

Step 6: Calculate the flow rate. Record the data in column E.

Formula:

$$\textit{Flow Rate, } Q\ (cfm) = \textit{Average Runoff Rate} \times \textit{Depth Factor}$$

Example: For Sample 1

$$Q = 47\ cfm \times 0.82 = 39\ cfm$$

$$V_t = R_t \times [(A_{paved} \times C_{runoff}) + (A_{unpaved} \times C_{runoff})]$$

where: V_t = the total runoff volume in cubic feet
R_t = the total rainfall measured in feet
A_{paved} = the area (sq ft) within the drainage basin that is paved or roofed
$A_{unpaved}$ = the area (sq ft) within the drainage basin that is unpaved
C_{runoff} = a specific runoff coefficient (no units) for the drainage area ground cover

Exhibit 3-15 provides an example calculation of total runoff volume from rainfall data.

Discharge Volumes Estimated Based on Measured Flow Rates

Another method of estimating the total volume of a discharge uses a series of measured or estimated flow rates. The total volume of discharge can be estimated by first multiplying each of the flow rates by the time interval in between flow measurements. This time period represents the portion of the total storm duration that can be associated with the flow rate measurement. Adding all such partial volumes results in a total flow volume. A procedure for calculating the total runoff volume from a set of discrete measurements of flow depth and velocity in a ditch during a storm runoff event is presented in Exhibit 3-16.

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EXHIBIT [illegible] EXAMPLE CALCULATION OF RUNOFF COEFFICIENT/FLOW DEPTH METHOD FOR ESTIMATING FLOW RATES

Step 1: Estimate the runoff coefficient for the drainage area that contributes flow to the sampled outfall (see Section 3.2.2).

EXAMPLE: Assume the drainage area to the outfall is 3 acres. Two of those acres are paved with a runoff coefficient of .90, and 1 is unpaved with a runoff coefficient of .50. Using the equation for estimated runoff coefficient from the text in Section 2.2.2.2:

$$\textit{Est. Run. Coef.} = \frac{(2\ Ac)\ (0.90) + (1\ Ac)\ (0.50)}{2\ Ac + 1\ Ac} = 0.77$$

The runoff coefficient for the entire drainage area is 0.77.

Step 2: Measure the rainfall depth. Record the total rainfall of the storm or the rainfall that occurred in the first 3 hours (if it lasted more than 3 hours). Also record the duration of the rain event.

EXAMPLE: Assume the rainfall depth to be 1.0 inches in 3 hours.

Step 3: Calculate an average runoff rate.

Formula:

$$\textit{Average Runoff Rate} = \frac{\textit{Drainage Area} \times \textit{Runoff Coef.} \times \textit{Rainfall Depth}}{\textit{Rainfall Duration}}$$

Example:

$$\textit{Average Runoff Rate} = \frac{3\ Ac \times .77 \times 1\ in}{3\ hrs} \times \frac{43{,}560\ ft^2}{Ac} \times \frac{ft}{12\ in} \times \frac{hr}{60\ min} = 47\ cfm$$

When each sample or aliquot is taken, record the data for the time the samples were taken and the depth of the water in the center of the ditch or pipe. Record the data in columns B and C.

EXAMPLE DATA:

A	B	C	D	E
Sample Numbers	Time (minutes)	Channel or Ditch Water Depth (feet)	Calculated Depth-Weighted Flow Factor	Flow Rate (cfm)
1	0	1.0	0.82	39
2	20	1.1	0.90	42
3	40	1.2	0.98	46
4	60	1.25	1.02	48
5	80	1.3	1.06	50
6	100	1.25	1.02	48
7	120	1.2	0.98	46
8	140	1.7	1.39	65
9	160	1.0	0.82	39

Step 4: Sum up all the water depths for each sample taken as indicated above in column C.

Sum = 11.0 feet

EXHIBIT [illegible] EXAMPLE [illegible]ION OF RUNOFF COEFFICIENT [illegible] FLOW RATES

Step 1: Estimate the runoff coefficient for the drainage area that contributes flows to the sampled outfall.

EXAMPLE: See Step 1 in Exhibit 3-14. The site for this example will be similar so a coefficient of .77 will be used for the same 3-acre drainage area.

Step 2: When each sample or aliquot is taken, record the data for the time the sample was taken. Record the data in column B.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	Time (minutes)	Total Rainfall Depth (inches)	Time Since Last Sample	Incremental Rainfall (inches) per 20 minutes	Calculated Flow Rate (cfm)
1	0	0.0	0	0.0	–
2	20	0.2	20	0.2	84
3	40	0.3	20	0.1	42
4	60	0.5	20	0.2	84
5	80	0.6	20	0.1	42
6	100	0.8	20	0.2	84
7	120	0.9	20	0.1	42
8	140	1.0	20	0.1	42
9	160	1.1	20	0.1	42

Step 3: Using a rainfall gauge, measure the total rainfall depth (in inches) and record the data in column C.

EXAMPLE: See sample data above.

Step 4: Calculate the incremental time since the last flow measurement and record the data in column D.

EXAMPLE: Samples were taken 20 minutes apart so this increment will be 20 minutes for every sample.

Step 5: Calculate the additional or incremental rainfall that has occurred since the last measurement. Record the data in column E.

Formula:

$$\textit{Incremental Rainfall} = \textit{Total Rainfall Sample 2} - \textit{Total Rainfall Sample 1}$$

Example: For Sample 2

$$\textit{Incremental Rainfall} = .2 - 0 = .2 \textit{ inches}$$

Step 6: Calculate the flow rate. Record the data in column F.

Formula:

$$\textit{Flow Rate (cfm)} = \frac{\textit{(Drainage area)(Runoff coefficient)(Incremental rainfall)}}{\textit{(Incremental time)}}$$

Example:

$$\textit{Flow Rate} = \frac{(3\ Ac)(0.77)(0.2\ in)}{20\ min} \times \frac{(43{,}560\ ft^2)}{Ac} \times \frac{1\ ft}{12\ in} = 84\ cfm$$

[illegible] RAINFALL DATA

Step 1: Determine the area of drainage contributing to the runoff volume at the outfall and convert it to square feet.

Example: Using a land survey, a facility has determined its site encompasses 0.3 acres (13,068 square feet). The entire site is used for industrial activities, and therefore, any storm water discharges from the site will be associated with industrial activity. A berm surrounds the entire site limiting the drainage area to the site itself and preventing any dilution or contamination from other discharges. (Note: To convert acres to square feet, multiply the number of acres by 43,560, which is the conversion factor).

Step 2: Determine the rainfall depth during the event that was sampled to the nearest one-hundredth of an inch and convert it to feet.

Example: From the rain gauge, the rainfall accumulation is measured at 0.6 inches or 0.05 feet (ft). (Note: To convert inches to feet, divide the inches by 12, which is the conversion factor).

Step 3: Determine the runoff coefficients for each area.

Example: The facility has estimated that ⅓ of the site, or 4,356 square feet, is covered by impervious surfaces (i.e., roofs or paved roadways) and ⅔ of the site, or 8,712 square feet, is unpaved.

Step 4: Calculate the volume of flow using the following formula and convert the volume to liters.

Formula: *Total runoff volume in cubic feet (cu ft) = total rainfall (ft) x [facility paved area (sq ft) x 0.90 + facility unpaved area (sq ft) x 0.50]*

Example: *Total runoff volume (cu ft) = 0.05 x [4,356 x 0.90 + 8,712 x 0.50]*

Total runoff volume = 413.8 cu ft or 11,720 liters

(Note: To convert cubic feet to liters, multiply cubic feet by 28.32, which is the conversion factor).

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[illegible] FROM FLOW RATE DATA

Step 1: Measure and tabulate flow depths and velocities every 20 minutes (at the same time that the sample is collected) during at least the first 3 hours of the runoff event.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	Time (minutes)	Flow Velocity (feet per minute)	Flow Depth (feet)	Width (feet)	Calculated Flow Rate (cfm)
1	0	-	-	-	-
2	20	4	0.2	5	4
3	40	8	0.4	5	16
4	60	12	0.4	5	24
5	80	8	0.4	5	16
6	100	4	0.2	5	4
7	120	8	0.2	5	8
8	140	4	0.2	5	4
9	160	4	0.2	5	4

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[illegible] EXAMPLE [illegible] FROM FLOW RATE DATA (Continued)

Step 2: Calculate and tabulate the cross-sectional area of flow for each of the flow depths measured. Calculate the flow rate for each discrete set of measurements.

Formula:

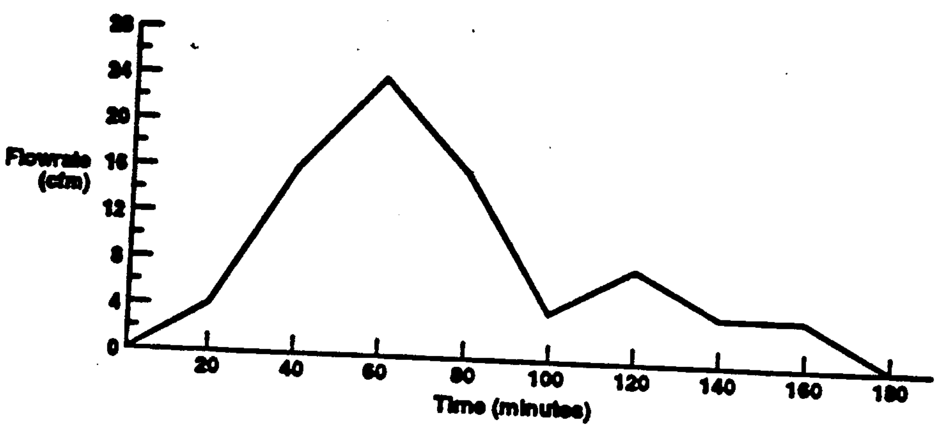
$$\textit{Flow Rate } Q \text{ (cfm)} = \textit{Velocity (ft/min)} \times \textit{Area (sq ft)}$$
$$\textit{Area} = \textit{Depth} \times \textit{Width}$$

Example: For Sample 1

$$\textit{Area} = 0.2 \text{ ft} \times 5 \text{ ft} = 1 \text{ sq ft}$$
$$\textit{Flow Rate} = 4 \text{ ft/min} \times 1 \text{ sq ft} = 4 \text{ cfm}$$

Step 3: Plot the flow rate, Q, versus time. Also, assume that flow drops uniformly from the last calculated flow rate (Q_9) to zero at the time when Q_{10} would have been taken.

Example: The flow rates calculated in Step 3 are plotted against the time between samples.



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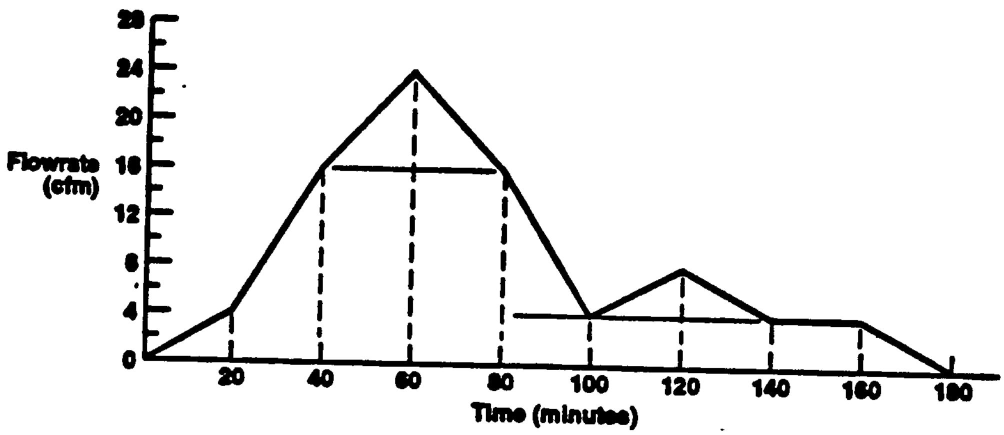
[illegible] EXAMPLE CALCULATION OF [illegible] FROM FLOW RATE DATA (Continued)

Step 4: The total flow volume (V_t) can be calculated by geometrically determining the area under the curve. The summation of the individual volumes per increment of time (V_1 through V_9) is the total flow volume of the event.

Example:



Step 5: Compute the flow volume associated with each observation (V_1, V_2, ..., V_9) by multiplying the measured flow rate by the duration (in this case, 20 minutes). Be sure the units are consistent. For example, if durations are in minutes and flow velocities are in cubic feet per second (cfs), convert the durations to seconds or the velocities to feet per minute.

Example:

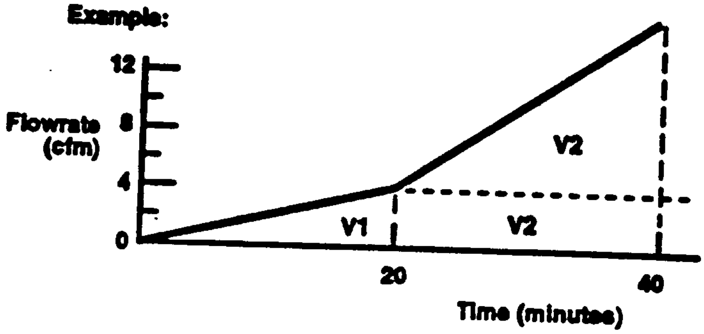


EXHIBIT [illegible] EXAMPLE CALCULATION OF [illegible] FROM FLOW RATE DATA (Continued)

Formula: *Volume (V) = Flow Rate (cfm) x Duration (minutes)*

Example:

$$V_1 = \frac{1}{2}(Q_1 - Q_0)(t_1 - t_0) = \frac{1}{2}(4-0)(20-0) = 40\ ft^3$$

$$V_2 = \frac{1}{2}(Q_2 - Q_1)(t_2 - t_1) + Q_1(t_2 - t_1)$$

$$= \frac{1}{2}(16-4)(40-20) + 4(20)$$

$$= 120 + 80 = 200\ ft^3$$

$V_1 = 40\ ft^3$
$V_2 = 200\ ft^3$
$V_3 = 400\ ft^3$
$V_4 = 400\ ft^3$
$V_5 = 200\ ft^3$
$V_6 = 120\ ft^3$
$V_7 = 120\ ft^3$
$V_8 = 80\ ft^3$
$V_9 = 40\ ft^3$

Step 6: Total the individual volumes calculated in Step 5 to obtain the total runoff volume.
Example:

Total Storm Runoff = 1,600 ft³

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3.2.5 REPORTING STORM WATER DISCHARGE FLOW RATES AND VOLUMES

Form 2F requires applicants to provide quantitative data (reported both as concentration and as total mass) based on flow-weighted samples collected during storm events. In addition, applicants are required to provide flow estimates or flow measurements, as well as an estimate of the total volume of the discharge. The method of flow estimation or measurement must be described in the application. Although EPA only requires flow estimates in Form 2F, accurate flow measurement is necessary for collecting representative flow-weighted composite samples and reporting pollutant mass loadings.

3.2.6 MEASURING RAINFALL

Many types of instruments have been developed to measure the amount and intensity of precipitation. All forms of precipitation are measured on the basis of the depth of the water that would accumulate on a level surface if precipitation remained where it fell. There are two types of rain gauges – standard and recording gauges. A standard rain gauge collects the rainfall so that the amount of rain can be easily measured. The standard gauge for the NWS has a collector which is 8 inches in diameter. Rain flows from the collector into a cylindrical measuring tube inside the overflow can. The measuring tube has a cross-sectional area one tenth the size of the collector so that 0.1 inch of rainfall will fill 1 inch of the measuring tube. While this standard gauge is both accurate and easy to use, any open receptacle with vertical sides can be an effective rain gauge. Standard rain gauges are simple and inexpensive; however, with a standard gauge, there is no way to record changes in the intensity of the rainfall without making frequent observations of the gauge during the storm.

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The second type of gauge is the recording rain gauge, which provides a permanent record of the amount of rainfall which accumulates over time. Three common types of recording gauges are:

- <u>Tipping Bucket Gauge</u> - Water caught in a collector is funneled into a two-compartment bucket; a known quantity of rain fills one compartment, overbalancing the bucket and emptying it into a reservoir. This moves the second bucket into place beneath the funnel. The tipping of the bucket engages an electric circuit, which records the event.

- <u>Weighing Type Gauge</u> - Water is weighed when it falls into a bucket placed on the platform of a spring or lever balance. The weight of the contents is recorded on a chart, showing the accumulation of precipitation.

- <u>Float Recording Gauge</u> - Water is measured by the rise of a float that is placed in the receiver. These gauges may be self-siphoning, or may need to be emptied periodically by hand.

Recording rain gauges provide a permanent record of rainfall, and they can be used to determine variations in rainfall intensity over time without making frequent observations during the storm. But recording gauges are more complicated mechanically than standard gauges, making them more costly, less durable, and more difficult to operate.

Although all gauges are subject to error, most errors can be minimized. To minimize errors, the gauge should be placed on a level surface that is not windswept and is away from trees or buildings that might interfere with the path of rainfall. When taking measurements, other factors contributing to error should also be considered: mistakes in reading the scale, dents in the collector rim (which changes the receiving area), measuring sticks that may retain some of the water, and water lost to evaporation. In the case of tipping bucket gauges, water may not be collected while the bucket is still tipping. The most common source of inaccuracy is changes in data that are attributable to wind. It is possible to assess wind errors by comparing measurements of gauges that are protected from the wind with those that are not.

3.3 GRAB SAMPLE COLLECTION

Section 3.1.2 discussed both the parameters that must be monitored by grab sample and the conditions under which grab sampling is required. This section explains how to collect grab samples. The entire sample is collected at an uninterrupted interval (i.e., grabbed at one time). A grab sample provides information on the characterization of storm water at a given time and may be collected either manually or automatically as discussed below.

3.3.1 HOW TO MANUALLY COLLECT GRAB SAMPLES

A manual grab is collected by inserting a container under or downcurrent of a discharge with the container opening facing upstream. Generally, simplified equipment and procedures can be used. In most cases, the sample container itself may be used to collect the sample. Less accessible outfalls may require the use of poles and buckets to collect grab samples. To ensure that manual grab samples are representative of the storm water discharged, the procedures set forth in Exhibit 3-17 should be followed.

EXHIBIT [illegible] RECOMMENDED OPERATING PROCEDURES FOR TAKING GRAB SAMPLES

- Label sample containers before sampling event
- Take a cooler with ice to the sampling point
- Take the grab from the horizontal and vertical center of the channel
- Avoid stirring up bottom sediments in the channel
- Hold the container so the opening faces upstream
- Avoid touching the inside of the container to prevent contamination
- Keep the sample free from uncharacteristic floating debris
- Transfer samples into proper containers (e.g., from bucket to sample container), however, fecal coliform, fecal streptococcus, phenols and O&G should remain in original containers
- If taking numerous grabs, keep the samples separate and labelled clearly
- Use safety precautions (see Chapter 6)

Specialized equipment and procedures may be needed, particularly in situations where storm water discharges are inaccessible or where certain parameters are monitored. For example:

- When sampling for O&G and VOCs, equipment that safely and securely houses O&G bottles or VOC vials should be used. This may be necessary because: (1) O&G will adhere to containers and thus should not be transferred from one container to another; and (2) excessive aeration during sampling may result in the partial escape of VOCs.
- Since facilities sometimes use sample bottles that already contain preservatives (as provided by contract laboratories), extreme care should be taken when filling them to avoid spills, splatters, or washout of the preservatives.

All equipment and containers that come into contact with the sample must be clean to avoid contamination. Additionally, sample collection equipment and container materials should be totally unreactive to prevent leaching of pollutants. Cleaning procedures are discussed in detail in Section 3.5.

3.3.2 HOW TO COLLECT GRAB SAMPLES BY AUTOMATIC SAMPLER

Grab samples can also be collected using programmed automatic samplers. Automatic samplers come equipped with computers that can be programmed to collect grab samples. Programming for grabs is specific to the type of automatic sampler. Some samplers are portable and have been developed specifically to sample for storm water discharges. These samplers are frequently attached to a rain gauge and/or a flow sensor. Such samplers can be programmed to initiate sample collection by one or more of the following conditions: (1) depth of flow in a channel; (2) rainfall in inches; (3) flow rate; (4) time; (5) external signal; and (6) combinations of the first three conditions. For example, an automatic sampler could be used to collect a sample at 15-minute intervals after its sensors indicate that rainfall has begun.

When using an automatic sampler, planning is very important. First, all equipment must be properly cleaned, particularly the tubing and the sample containers. There are several different types of tubing available, including rubber and Tygon tubing. Tygon tubing is commonly used since it generally does not leach contaminants. Deionized water should be drawn through the sampler to remove any remaining pollutant residuals prior to taking samples. Tubing should also be replaced periodically to avoid algae or bacterial growth.

Sampling personnel should also use adequate and appropriate containers and ensure they are properly cleaned. Section 3.5 contains information on cleaning procedures which should be followed for all equipment. Additionally, the utilization of blanks (a control used to verify the accuracy of analytical results) is recommended to determine if cross-contamination of sampling equipment has occurred. Samplers should also be programmed, set up, and supplied with a source of power. Properly charged batteries should be readily available for portable samplers in advance of a storm event and, as a backup power supply in case of power failure. Finally, although automatic samplers may be useful in some situations, several parameters are not amenable to collection by automatic sampler. These pollutants include fecal streptococcus, fecal coliforms, oil and grease and VOCs which should be collected manually, not automatically, as discussed in Section 3.1.2.

3.4 FLOW-WEIGHTED COMPOSITE SAMPLE COLLECTION

Composite samples are samples simply comprised of a series of individual sample aliquots that have been combined to reflect average pollutant concentrations of the storm water discharge during the

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sampling period. Composite samples can be developed based on time or flow rate. There are four different types of composite samples, as follows:

- Constant Time - Constant Volume - Samples of equal volume are taken at equal increments of time and composited to make an average sample (similar to Exhibit 3-18). This method is not acceptable for samples taken for compliance with the storm water permit application regulations.

- Constant Time - Volume Proportional to Flow Increment - Samples are taken at equal increments of time and are composited proportional to the volume of flow since the last sample was taken (see Exhibit 3-19).

- Constant Time - Volume Proportional to Flow Rate - Samples are taken at equal increments of time and are composited proportional to the flow rate at the time each sample was taken (see Exhibit 3-20).

- Constant Volume - Time Proportional to Flow Volume Increment - Samples of equal volume are taken at equal increments of flow volume and composited (see Exhibit 3-21).

Generally, flow-weighted composite samples must be collected for most parameters. The methods for generating flow-weighted composite samples are discussed in the following sections.

For storm water discharge permit applications, the aliquots for flow-weighted composite samples must be collected during a representative storm for the first 3 hours, or for the duration of the storm event if it is less than 3 hours long. The storm water application regulations allow for flow-weighted composite samples to be collected manually or automatically. For both methods, equal volume aliquots may be collected at the time of sampling and then flow-proportioned and composited in the laboratory, or the aliquot may be collected based on the flow rate at the time of sample collection and composited in the field. When composite samples are collected, the regulations require that each aliquot collection be separated by a minimum of 15 minutes and that a minimum of three sample aliquots be taken within each hour of the discharge. See Exhibit 3-22 for an example of how this requirement may be fulfilled.

The provisions set forth in 40 CFR 122.21(g)(7) for collecting flow-weighted composite samples establish specific requirements for minimum time duration between sample aliquots. Where these conditions cannot be met, the permitting authority may allow alternate protocols with respect to the time duration between sample aliquots (see Chapter 5). However, permission from the permitting

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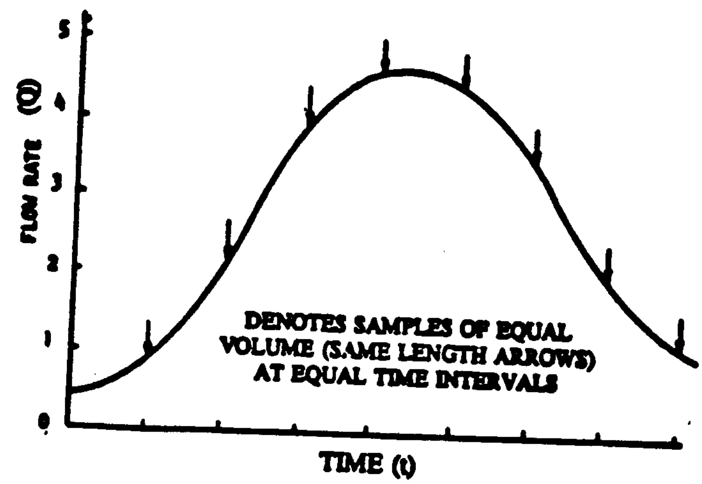
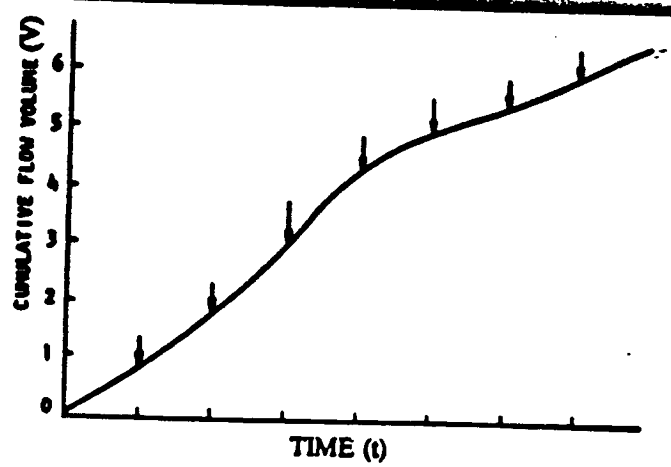
EXHIBIT 3-18. CONSTANT TIME, CONSTANT VOLUME



Method of compositing samples on a fixed volume-fixed time interval basis

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

[illegible] INCREMENT



Method of compositing samples proportional to flow volume at constant time interval

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

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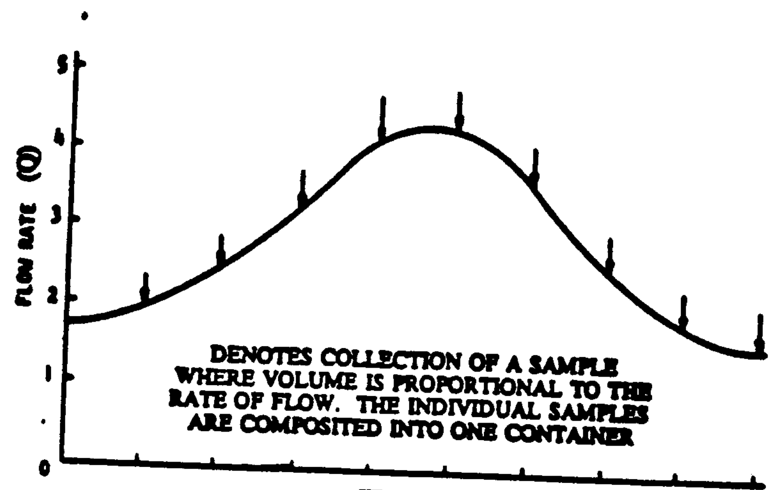
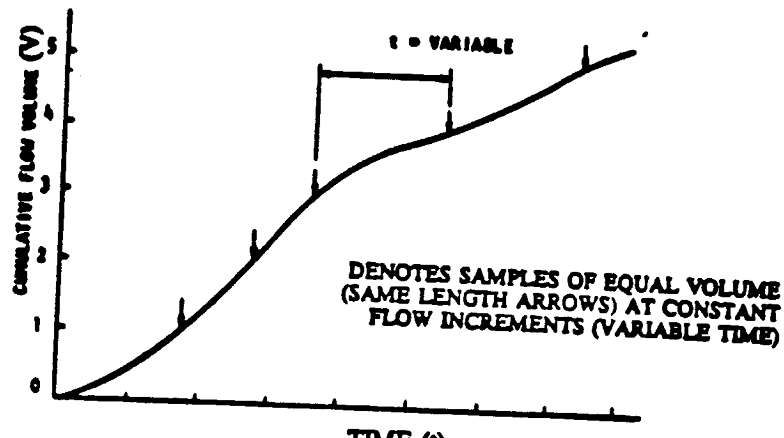
EXHIBIT 3-20. CONSTANT TIME — VOLUME PROPORTIONAL TO FLOW RATE



Method of compositing samples proportional to flow rate

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

[illegible] CONS[illegible] TIME PRO[illegible] FLOW [illegible] INCREMENT

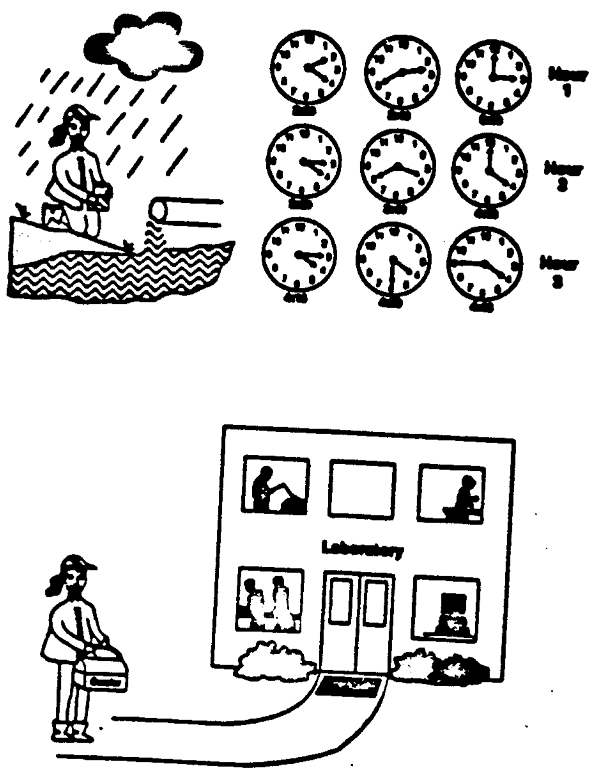


Method of compositing samples of equal volume at equal increments of flow

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

EXHIBIT 3-23 EXAMPLE OF SAMPLING INTERVALS

Suppose that a storm water discharge began at 2:15 p.m. and lasted until 5:15 p.m. on a Friday. The field staff person wants to collect the samples at regular intervals, so s/he plans to collect an aliquot with a volume that is proportional to the flow every 20 minutes. After the third hour of collection, the field staff person must deliver the samples to the laboratory (which is 10 minutes away). The laboratory closes at 5:00 p.m. So, s/he should take the last sample at 4:45 p.m. One way of doing this would be to collect samples (in hour three) at 4:15, 4:30, and 4:45 p.m. This would comply with the three-sample minimum in hour three (4:15-5:15 p.m.) and the required 15-minute minimum interval between collections. It would also allow the field staff person to get the samples to the lab before it closes for the weekend. On the other hand, if s/he missed the sample collection at 4:15 p.m. and instead, collected the sample at 4:20 p.m., then s/he would have to collect the next sample at 4:35 p.m. and the last sample at 4:50 p.m., and the field staff person would not be able to deliver the sample until Monday (by which time the required maximum holding time would be exceeded), and the sampling would need to be repeated.



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authority must be obtained before changes are initiated. Considerations applicable to the collection of flow-weighted composites by automatic and manual techniques are discussed in the following sections.

3.4.1 HOW TO MANUALLY COLLECT FLOW-WEIGHTED COMPOSITE SAMPLES

Manually collected, flow-weighted composite samples may be appropriate for a facility that prefers not to invest in automatic equipment. This technique is cost-effective for short-term monitoring programs and for facilities where few outfalls are being sampled. The fundamental requirement for facilities that use these methodologies is that they should have personnel available to perform the sampling when needed. Those facilities where VOCs analysis of storm water discharges are required should manually collect composite samples since these parameters may not be amenable to sampling by automatic samplers. Compositing of VOC samples should be conducted in the laboratory as discussed in Section 3.5.2.

The manual collection of a flow-weighted sample is performed in the same manner as taking manual grab samples (see Section 3.3.1). The only difference is that a series of samples (or aliquots) will be collected. As discussed in the previous section, there are two ways to manually collect and combine the aliquots for a flow-weighted sample:

- Collect sample aliquot volumes based on the flow at the time of sampling which can immediately be combined to make the composite sample in the field (see Exhibit 3-23)
- Collect equal volume sample aliquots at the time of sampling and then flow-proportion and composite the aliquots in the laboratory (see Exhibit 3-24).

When uniform time intervals are used between the collection of the sample aliquots, the volumes of each aliquot used in the composite sample can be determined based on either volumes of flow or the flow rate, as they will result in similar proportions. However, when there are different time intervals between the sample aliquots, the individual sample aliquot volumes should be based on the runoff volume (calculated from the individual flow rates and durations) associated with each sample aliquot.

Generally, 1,000 ml for each aliquot collected should provide enough sample volume, when composited, for pollutant analyses of the required parameters contained in Section VII.A of Form 2F (see Section 3.6). More aliquot volume may be required if sampling is conducted for additional parameters. The laboratory conducting the analyses should always be contacted prior to a sampling event to determine how much sample volume they will require.

[illegible] SAMPLE ALIQUOT [illegible] FIELD

Step 1: Determine the necessary volume for compositing purposes.

Example: To fulfill analyses for all parameters in Section VII.A of Form 2F for which composite samples are required [Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), nitrate plus nitrite, and phosphorous] a total composite sample volume of 5,000 ml is needed by the contract laboratory.

Step 2: Determine an appropriate interval for collection of samples.

Example: Manually collected flow-weighted composite samples must consist of at least three sample aliquots collected per hour and must be gathered at least 15 minutes apart. For this example, sample aliquots will be collected exactly 20 minutes apart.

Step 3: Estimate or measure the volume of discharge for each sampling event.

Example: A discharge flow volume of 4.8 cubic feet will be used here.

Step 4: Convert the discharge flow volume to liters.

Example: To convert cubic feet to liters, use the conversion factor of 28.32 liters per 1 cubic foot as set forth in the following formula:

$$\textit{Volume (liters)} = \textit{Volume (cubic feet)} \times \frac{28.32\ \textit{liters}}{1\ \textit{cubic foot}}$$

$$\textit{Volume} = 4.8\ \textit{cubic feet} \times \frac{28.32\ \textit{liters}}{1\ \textit{cubic foot}} = 136\ \textit{liters}$$

Step 5: Using Steps 3 and 4, volumes that have been discharged between the collection of each aliquot can be calculated.

(Note that the discharge volumes provided for aliquot numbers 2-9 have already been given for the purposes of this exhibit.)

Example: The procedures set forth in Section 3.2 may be used to calculate discharge volumes. The following table presents aliquot numbers, time of aliquot collection, and discharge volumes.

Aliquot Number	Time of Aliquot Collection	Discharged Volume
1	2:15 p.m.	136 liters
2	2:35 p.m.	200 liters
3	2:55 p.m.	122 liters
4	3:15 p.m.	178 liters
5	3:35 p.m.	156 liters
6	3:55 p.m.	117 liters
7	4:15 p.m.	94 liters
8	4:30 p.m.	21 liters
9	4:45 p.m.	12 liters

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EXHIBIT [illegible] EXAMPLE OF HOW TO COLLECT SAMPLE ALIQUOT VOLUMES BASED ON [illegible] PROPORTIONAL COMPOSITE IN THE FIELD (Continued)

Step 6: Determine the appropriate minimum aliquot volume as the basis for collecting other aliquot samples which together will provide adequate volume to fulfill the analytic requirements.
Example: In Step 1, it was determined that at least 5,000 ml of sample were required for flow-weighted composite sample analytical testing. As discussed in Section 3.4.1, basing the sample collection on a minimum aliquot volume of 1,000 ml gathered every interval (i.e., every 15 minutes) should result in adequate sample volume.

Step 7: Calculate the volume of the sample aliquot which must be collected during each aliquot sample period using the following formula:

$$\textit{Aliquot volume (ml)} = \textit{Minimum aliquot volume (ml)} \times \frac{\textit{Aliquot's discharge volume (liters)}}{\textit{Initial discharge volume (liters)}}$$

Step 6 shows that the minimum aliquot volume is 1,000 ml.

$$\textit{Aliquot \#1 volume (ml)} = 1{,}000 \text{ ml} \times \frac{136 \text{ liters}}{136 \text{ liters}} = 1{,}000 \text{ ml}$$

$$\textit{Aliquot \#2 volume (ml)} = 1{,}000 \text{ ml} \times \frac{200 \text{ liters}}{136 \text{ liters}} = 1471 \text{ ml}$$

$$\textit{Aliquot \#3 volume (ml)} = 1{,}000 \text{ ml} \times \frac{122 \text{ liters}}{136 \text{ liters}} = 897 \text{ ml}$$

$$\textit{Aliquot \#4 volume (ml)} = 1{,}000 \text{ ml} \times \frac{178 \text{ liters}}{136 \text{ liters}} = 1{,}309 \text{ ml}$$

$$\textit{Aliquot \#5 volume (ml)} = 1{,}000 \text{ ml} \times \frac{156 \text{ liters}}{136 \text{ liters}} = 1{,}147 \text{ ml}$$

$$\textit{Aliquot \#6 volume (ml)} = 1{,}000 \text{ ml} \times \frac{117 \text{ liters}}{136 \text{ liters}} = 860 \text{ ml}$$

$$\textit{Aliquot \#7 volume (ml)} = 1{,}000 \text{ ml} \times \frac{94 \text{ liters}}{136 \text{ liters}} = 691 \text{ ml}$$

$$\textit{Aliquot \#8 volume (ml)} = 1{,}000 \text{ ml} \times \frac{21 \text{ liters}}{136 \text{ liters}} = 154 \text{ ml}$$

$$\textit{Aliquot \#9 volume (ml)} = 1{,}000 \text{ ml} \times \frac{12 \text{ liters}}{136 \text{ liters}} = 88 \text{ ml}$$

A table of these calculations follows:

Aliquot Number	Discharged Volume	Aliquot Volume
1	136 liters	1,000 ml
2	200 liters	1,471 ml
3	122 liters	897 ml
4	178 liters	1,309 ml
5	156 liters	1,147 ml
6	117 liters	860 ml
7	94 liters	691 ml
8	21 liters	154 ml
9	12 liters	88 ml

In conclusion, a combination of the above sample aliquots result in a composite of 7,617 ml.

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[illegible] COMPOSITED IN THE LABORATORY

Step 1: Determine the necessary volume for compositing purposes.

Example: To fulfill analyses for all parameters in Section VII.A of Form 2F for which composite samples are required (BOD_5, COD, TSS, TKN, nitrate plus nitrite, and phosphorous) a total composite sample volume of 5,000 ml is needed by the contract laboratory.

Step 2: Determine an appropriate interval for collection of samples.

Example: Manually collected flow-weighted composite samples must consist of at least nine sample aliquots and must be gathered at least 15 minutes apart; only three or four samples per hour may be taken. For convenience, the minimum number of three is chosen. Sample aliquots will be collected every 20 minutes.

Step 3: Determine the aliquot which should be taken during each sampling event.

Example: At least 5,000 ml of sample is required for flow-weighted composite sample analytical testing. As discussed in Section 3.4.1, a minimum aliquot volume of 1,000 ml gathered every interval (i.e., every 15 minutes) should result in adequate sample volume to be used for later flow-weighted compositing.

Step 4: Estimate or measure the volume of discharge for each sampling event while collecting a discrete 1,000-ml aliquot, as discussed in Step 3, for later compositing.

Example: Section 3.2 discusses methods to calculate total discharge volumes. A discharge flow volume of 4.8 cubic feet will be used here.

Step 5: Convert the discharge flow volume to liters.

Example: To convert cubic feet to liters, use the conversion factor of 28.32 liters per 1 cubic foot as set forth in the following formula:

$$Volume\ (liters) = Volume\ (cubic\ feet) \times \frac{28.32\ liters}{1\ cubic\ foot}$$

$$Volume = 4.8\ cubic\ feet \times \frac{28.32\ liters}{1\ cubic\ foot} = 136\ liters$$

EXHIBIT [illegible] EXAMPLE OF HOW TO MANUALLY COLLECT [illegible] SAMPLE ALIQUOTS WHICH [illegible] AND COMPOSITED IN THE LABORATORY (Continued)

Step 6: Using Steps 3 and 4, calculate the volumes that have been discharged between the collection of each aliquot.

Example: The procedures set forth in Section 3.2 may be used to calculate discharge volumes. The following table presents aliquot numbers, time of aliquot collection, and discharge volumes (note that the discharge volumes provided for aliquot numbers 2-9 were chosen for purposes of this exhibit).

Aliquot Number	Time of Aliquot Collection	Discharged Volume
1	2:15 p.m.	136 liters
2	2:35 p.m.	200 liters
3	2:55 p.m.	122 liters
4	3:15 p.m.	178 liters
5	3:35 p.m.	156 liters
6	3:55 p.m.	117 liters
7	4:15 p.m.	94 liters
8	4:30 p.m.	21 liters
9	4:45 p.m.	12 liters

Step 7: Determine the aliquot sample which is associated with the greatest discharge volume.

Example: Aliquot number 2 was taken when the volume was 200 liters. This is the largest discharge volume.

Step 8: Calculate the volume of sample aliquot which must be used subsequent to the sample event to comprise a flow-weighted composite sample. The following formula should be used:

$$\text{Aliquot volume (ml)} = \text{Minimum aliquot volume (ml)} \times \frac{\text{Aliquot's discharge volume (liters)}}{\text{Largest discharge volume (liters)}}$$

Step 3 shows that the minimum aliquot volume is 1,000 ml. Using this value and the data determined as part of Steps 6 and 7, the following can be calculated:

$$\text{Aliquot \#1 volume (ml)} = 1{,}000 \text{ ml} \times \frac{136 \text{ liters}}{200 \text{ liters}} = 680 \text{ ml}$$

$$\text{Aliquot \#2 volume (ml)} = 1{,}000 \text{ ml} \times \frac{200 \text{ liters}}{200 \text{ liters}} = 1{,}000 \text{ ml}$$

$$\text{Aliquot \#3 volume (ml)} = 1{,}000 \text{ ml} \times \frac{122 \text{ liters}}{200 \text{ liters}} = 610 \text{ ml}$$

$$\text{Aliquot \#4 volume (ml)} = 1{,}000 \text{ ml} \times \frac{178 \text{ liters}}{200 \text{ liters}} = 890 \text{ ml}$$

$$\text{Aliquot \#5 volume (ml)} = 1{,}000 \text{ ml} \times \frac{156 \text{ liters}}{200 \text{ liters}} = 780 \text{ ml}$$

$$\text{Aliquot \#6 volume (ml)} = 1{,}000 \text{ ml} \times \frac{117 \text{ liters}}{200 \text{ liters}} = 585 \text{ ml}$$

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[illegible] COMPOSITED IN THE LABORATORY (Continued)

Aliquot #7 volume (ml) = 1,000 ml x 94 liters / 200 liters = 470 ml

Aliquot #8 volume (ml) = 1,000 ml x 21 liters / 200 liters = 105 ml

Aliquot #9 volume (ml) = 1,000 ml x 12 liters / 200 liters = 60 ml

A table of these calculations follows

Aliquot Number	Discharged Volume	Aliquot Volume
1	136 liters	680 ml
2	200 liters	1,000 ml
3	122 liters	610 ml
4	178 liters	890 ml
5	156 liters	780 ml
6	117 liters	585 ml
7	94 liters	470 ml
8	21 liters	105 ml
9	12 liters	60 ml

In conclusion, a combination of the above sample aliquots results in a composite sample of 5,100 ml.

Manually collected flow-weighted composite samples can also be prepared by collecting sample aliquots of equal volume where the collection times are related to the volume of discharge which has passed since the last sample aliquot collection. However, this method is subject to fluctuating flow rates and volumes which may dictate that samples be taken prior to the 15-minute interval required by the regulations. In that case, the alternative sampling protocol would have to be approved by the permitting authority.

3.4.2 HOW TO COLLECT FLOW-WEIGHTED COMPOSITE SAMPLES BY AUTOMATIC SAMPLER

The typical automatic sampler collects sample aliquots after a specific interval. These aliquots can be flow-weight composited by the automatic sampler; or by hand in the laboratory. The automatic sampler may be programmed in one of three ways: (1) to collect a sample at equal time intervals and varying aliquot volumes commensurate with the flow (either rate or volume) that has passed; (2) to collect equal volume aliquots at varying time intervals commensurate with the flow volume that has passed; or (3) to collect equal volume aliquots of sample at equal time intervals.

The first two methods automatically composite the sample but require that the sampler be connected to a flow meter such that the sampler determines either the flow rate or the amount of volume that passes. Since these methods automatically composite samples, one main sample container may be used to receive all aliquots. The third method automatically collects the sample aliquots but does not automatically flow-weight composite the sample. As such, discrete sample containers must be used, and manual flow-weighted compositing must be conducted after the aliquots are collected. Exhibits 3-23 and 3-24 in Section 3.4.1 describe the manual compositing procedures that should be followed.

Manufacturers' instructions for the use of an automatic sampler provide the best explanation of programming options and should be consulted for information on programming samplers for storm water collection. Some of the points regarding automatic samplers discussed in Section 3.3.2 should also be considered.

3.5 SAMPLE HANDLING AND PRESERVATION

Samples must be handled and preserved in accordance with 40 CFR Part 136. This section describes acceptable analytical methods, including requirements regarding sample holding times, containers, sizes, and preservation requirements. For each pollutant or parameter that may have to be analyzed, 40 CFR Part 136 includes information on:

- Container types to be used to store the samples after collection
- Procedures to correctly preserve the samples
- The maximum holding time allowed for each parameter.

The following sections present a detailed discussion of preservation techniques and sample handling procedures. Technical Appendix C presents a matrix of required containers, preservation techniques,

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and holding times for each parameter. Most laboratories can provide clean sample containers, preservatives, sealing, chain-of-custody forms and can advise further on sample handling and preservation.

3.5.1 DECONTAMINATION OF SAMPLE EQUIPMENT CONTAINERS

Storm water sample containers should be cleaned and prepared for field use according to the procedures set forth in 40 CFR Part 136. A summary of the procedures is presented below for plastic containers, any or all of which may be performed by the laboratory or container distributor:

- Nonphosphate detergent and tap water wash
- Tap water rinse
- 10 percent nitric acid rinse (only if the sample is to be analyzed for metals)
- Distilled/deionized water rinse
- Total air dry.

To clean glass containers, the same steps should be taken; but, after the distilled/deionized water rinse, the containers should be rinsed with solvent if appropriate prior to total air drying. After the decontamination procedures have been accomplished, the sample containers should be capped or sealed with foil, and the sampling device should be protected and kept clean. It is a good idea to label sample containers after cleaning. The laboratory should keep a record of the technician performing the cleaning procedure as well as the date and time. This begins the required chain-of-custody procedure for legal custody (see Section 3.10 for more information). A chain-of-custody record accompanies each sample to track all personnel handling the sample. This record is essential to trace the sample integrity in the event that quality control checks reveal problems. For this reason, as well as to avoid problems if contamination issues arise, it is suggested that the laboratory performing the analysis perform the cleaning.

3.5.2 SAMPLE PRESERVATION AND HOLDING TIMES

Preservation techniques ensure that the sample remains representative of the storm water discharge at the time of collection. Since many pollutants in the samples collected are unstable (at least to some extent), the sample should be analyzed immediately or preserved or fixed to minimize changes between the time of collection and analysis. Because immediate analysis is not always possible, most samples are preserved regardless of the time of analysis.

Problems may be encountered when flow-weighted composite samples are collected. Since sample deterioration can take place during the compositing process, it is necessary to preserve or stabilize the samples during compositing in addition to preserving aggregate samples before shipment to the laboratory. Preservation techniques vary depending on the pollutant parameter to be measured; therefore, familiarity with 40 CFR Part 136 (see Technical Appendix C) is essential to ensure effective preservation. It is important to verify that the preservation techniques for one parameter do not affect the analytical results of another in the same sample. If this is the case, two discrete samples should be collected and preserved accordingly.

Sample preservation techniques consist of refrigeration, pH adjustment, and chemical fixation. pH adjustment is necessary to stabilize the target analyte (e.g., addition of NaOH stabilizes cyanide); acidification of total metal samples ensures that metal salts do not precipitate. Refrigeration is the most widely used technique because it has no detrimental effect on the sample composition (i.e., it does not alter the chemistry of the sample), and it does not interfere with most analytical methods. Refrigeration requires the sample to be quickly chilled to a temperature of 4°C. This technique is used at the beginning of sample collection in the field, and is continued during sample shipment, and while the sample is in the laboratory. Even though samples taken for compositing purposes are taken over time each individual sample must be refrigerated. If taken manually, the samples can be placed in an ice box. If taken by a automatic sampler, the sampler unit should have refrigeration capabilities. The analytical laboratory may provide chemicals necessary for fixation, or may tell sampling personnel where they can be purchased.

In addition to preservation techniques, 40 CFR Part 136 indicates maximum holding times. A detailed list of holding times appears in Technical Appendix C. The holding time is the maximum amount of time that samples may be held before analysis and still be considered valid. Samples exceeding these holding times are considered suspect and sample collection may have to be repeated.

Although Technical Appendix C provides required sample containers, preservation techniques, and holding times, some of the more commonly monitored parameters warrant additional discussion. The following provides a more detailed discussion of considerations pertaining to cyanide, VOCs, organics and pesticides, O&G, pH, total residual chlorine, fecal coliform, fecal streptococcus, and 5-day Biochemical Oxygen Demand (BOD_5).

Cyanide

Cyanide is very reactive and unstable. If the sample cannot be analyzed immediately, it must be preserved by pH adjustment after collection. However, prior to pH adjustment, procedures to eliminate residual chlorine and sulfides must be followed immediately.

Where chlorine has the possibility of being present, the sample should be tested for residual chlorine by using potassium iodide-starch test paper previously moistened with acetate buffer. If the sample contains residual chlorine (a blue color indicates the need for treatment), ascorbic acid must be added 0.6 gram (g) at a time until the tests produce a negative result; then, an additional 0.6 g of ascorbic acid should be added to the sample.

Samples containing sulfides may be removed, in which case the holding time is extended to 14 days. Sulfides must be removed as follows:

- Use lead acetate paper moistened with an acetic acid buffer solution to test for the presence of sulfide. Darkening of the lead acetate paper indicates sulfide is present in the sample.
- Add cadmium nitrate to be added to the sample in a manner similar to the ascorbic acid until the test is negative.
- Filter with a 0.45 micrometer (μm) filter and prefilter combination immediately after.

After chlorine and sulfide residuals have been eliminated, the pH must be adjusted to greater than 12.0 standard units (s.u.) and chilled to 4°C.

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If cyanide is suspected to be present, the sampling personnel should bring all materials mentioned above to the sampling location.

VOCs

Sampling for VOCs requires the use of a glass vial. The vial should contain a teflon-coated septum seal. Volatiles will escape from the water to the air if any air is entrapped in the container. Therefore, the sample should be collected so that there are no air bubbles in the container after the screw cap and septum seal are applied. To ensure that air bubbles are not trapped in the vial, the following procedures should be followed:

- Fill the vial until a reverse meniscus forms above the top of the vial
- Screw on the cap (the excess sample will overflow)
- Invert the vial to check for the presence of air bubbles
- If air bubbles are observed, the vial should be opened, emptied, then completely refilled, and the first three actions should be repeated.

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VOC samples should not be composited in the field. To composite a sample, the sampling personnel would have to mix it thoroughly. This mixing action would aerate the sample and cause volatiles to be lost. Therefore, VOC samples should be sent to the laboratory where they can be immediately, and carefully, composited and analyzed with minimal volatilization as per method Nos. 502.1, 502.2, 524.1, and 524.2 as described at 40 CFR 141.24(f)(14)(iv) and (v). There are two ways flow-weighted compositing of VOCs can be accomplished—mathematical compositing or procedural compositing as discussed below.

Mathematical Compositing

In this method, the grab samples are analyzed separately. The sampling personnel collect the requisite number of samples and send them to the laboratory. The laboratory performs the individual analyses on each sample. Five ml (or 25 ml if greater sensitivity is required) of each grab sample are placed into the purge vessel of the GC or GC/MS for analysis. Special precautions must be made to maintain zero headspace in the syringe used to transfer the VOC sample into the purge vessel of the GC or GC/MS. These analytical results are mathematically flow-weight composited using the calculation in Exhibit 3-24. The concentrations (C) should be adjusted by using the following formula:

$$\textit{Adjusted Concentration} = \frac{\textit{Individual Aliquot Volume}}{\textit{Total Composite Sample}} \times C$$

Each sample concentration should be adjusted, and all adjusted concentrations added, to obtain the flow-weighted VOC composite using this method.

Procedural Compositing

For the second method, sampling personnel collect the requisite number of samples and provide the laboratory with flow-weighted values for each sample using the calculation in Exhibit 3-24. The laboratory technician then draws the necessary volume from each aliquot into an adequately sized syringe, physically combining the samples to result in a flow-weighted composite sample for VOC analysis. Necessary volumes are drawn into the syringe with a volume control fitting. The samples are thus composited directly in the syringe and then placed in the purge vessel of the GC or GC/MS. The advantage of this procedure is that only one analysis on the GC or GC/MS has to be performed.

Although the applicant is required to report only flow-weighted composite concentrations, the mathematical compositing method may provide more information, as it will indicate the concentrations of each separate grab sample. For example, if the procedural compositing method is employed and one of the samples has a high concentration and the other three have non-detectable concentrations, the result will be an average which does not represent the concentration in any of the separate grab samples. In certain cases it may be important to know the concentration of each grab as well as the composite concentration. The mathematical compositing method would be the most appropriate compositing method in these cases.

Organics and Pesticides

The procedures affecting organics and pesticides [base/neutral/acids and pesticide polychlorinated biphenyls (PCBs)] are less complex than VOC procedures. Glass containers must be used for sample collection purposes, amber glass should be used to eliminate the potential for reactivity caused by light. These samples should be maintained at 4°C during storage and shipment. A preservative in

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the form of 0.008 percent sodium thiosulfate ($Na_2S_2O_3$) must be added to organic samples if residual chlorine is present. To determine if chlorine is present, a small color indicator test kit can be used. Eighty ml of $Na_2S_2O_3$ per liter of sample must then be added and mixed well until chlorine tests indicate a negative result as per methods 604 and 625 of 40 CFR Part 136 Appendix A. The pH of pesticide samples must be adjusted to between 5 and 9 s.u.

Oil and Grease

O&G tends to adhere to the surfaces that it contacts. Therefore, it should not be transferred from one container to another; rather, a 1-liter container should be used to take the sample. The container used for O&G must be made of glass. A teflon insert should be included in the glass container's lid. However, if teflon is not available, aluminum foil extending out from under the lid may be used. Samples for O&G must be preserved by adding sulfuric acid (H_2SO_4) or hydrochloric acid (HCl) to a pH of less than 2 s.u. and then stored at 4°C.

Additional Considerations

Some pollutants have specific analysis requirements due to short holding times that the applicant must consider. For example:

- Requirements to analyze immediately (pH, total residual chlorine, temperature, sulfite, and dissolved oxygen)
- Requirements to preserve immediately and analyze within 6 hours (fecal coliform and fecal streptococcus)
- Requirements to analyze within 48 hours (BOD_5).

Because of these requirements, field testing equipment may need to be purchased, borrowed, or rented for those parameters that may require field analysis. If the laboratory is located nearby, analysis in the field may not be required.

Laboratories do not always operate in the evenings or on weekends. As a result, holding times for samples taken in the late afternoon or on a Friday may be exceeded. To prevent this from occurring, close coordination with laboratories is necessary. The latest date and time of delivery should be established to avoid taking samples, only to discover they cannot be accepted by the laboratory and analyzed in accordance with 40 CFR Part 136 requirements.

3.6 SAMPLE VOLUMES

Exhibit 3-25 presents minimal suggested sample volumes for specific parameters. This exhibit should be consulted so that the proper volume is collected for analysis of each pollutant of concern. This exhibit may not include all parameters; if a particular parameter is not listed, refer to 40 CFR Part 136.

3.7 SAMPLE DOCUMENTATION

Information should be submitted to the laboratory with the sample to ensure proper handling by the laboratory. Exhibit 3-26 is an example form which can be used to document the following information.

- Unique Sample or Log Number - All samples should be assigned a unique identification number. If there is a serial number on the transportation case, the sampling personnel should add this number to the field records.
- Date and Time of Sample Collection - Date and time of sample collection (including notation of a.m. or p.m.) must be recorded. In the case of composite samples, the sequence of times and aliquot size should be noted.
- Source of Sample, Including Facility Name and Address - Use the outfall identification number from the site map with a narrative description; a diagram referring to the particular site where the sample was taken should be included.
- Name of Sampling Personnel - The names and initials of the persons taking the sample must be indicated. For a composite sample, the names of the persons installing the sampler and the names of the persons retrieving the sample should be included.
- Sample Type - Each sample should indicate whether it is a grab or composite sample. If the sample is a composite, the volume and frequency of individual aliquots should be noted.
- Preservation Used - Any preservatives (and the amount) added to the sample should be recorded. The method of preservation (e.g., refrigeration at 4°C) should be indicated.
- Analysis Required - All parameters for which the sample must be analyzed at the laboratory should be specified.

EXHIBIT [illegible] VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS CONSTITUENTS OF INDUSTRIAL WASTEWATER

Tests	Volume of Sample, ml*
Physical	
Color and odor**	100 to 500
Corrosivity**	flowing sample
Electrical conductivity**	100
pH, electrometric**	100
Radioactivity	100 to 1,000
Specific gravity**	100
Temperature**	flowing sample
Toxicity**	1,000 to 20,000
Turbidity**	100 to 1,000
Chemical	
VOCs	100
Dissolved Gases	
Ammonia,*** NH_3	500
Carbon Dioxide,*** free CO_2	200
Chlorine,*** free Cl_2	200
Hydrogen,*** H_2	1,000
Hydrogen sulfide,*** H_2S	500
Oxygen,*** O_2	500 to 1,000
Sulfur dioxide,*** free SO_2	100
Miscellaneous	
Acidity and alkalinity	100
Bacteria (fecal coliform)	500
Bacteria (fecal streptococcus)	100
Biochemical oxygen demand (BOD)	100 to 500
Carbon dioxide, total CO_2 (including CO_3^{-}, HCO_3^{-}, and free)	200
Chemical oxygen demand (dichromate)	50 to 100
Chlorine requirement	2,000 to 4,000
Chlorine, total residual Cl_2 (including OCl^{-}, HOCl, NH_2Cl, $NHCl_2$, and free)	200
Chloroform-extractable matter	1,000
Detergents	100 to 200
Hardness	50 to 100
Hydrazine	50 to 100

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[illegible] VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS [illegible] WASTEWATER (Continued)

Tests	Volume of Sample, ml*
Miscellaneous (Continued)	
Micro-organisms	100 to 200
Volatile and filming amines	500 to 1,000
Oily matter	3,000 to 5,000
Organic nitrogen	500 to 1,000
Phenolic compounds	800 to 4,000
Polyphosphates	100 to 200
Silica	50 to 100
Solids, dissolved	100 to 20,000
Solids, suspended	50 to 1,000
Tannin and lignin	100 to 200
Cations	
Aluminum, Al+++	100 to 1,000
Ammonium,*** NH_4+	500
Antimony, Sb+++ to Sb+++++	100 to 1,000
Arsenic, As+++ to As+++++	100 to 1,000
Barium, Ba++	100 to 1,000
Cadmium, Cd++	100 to 1,000
Calcium, Ca++	100 to 1,000
Chromium, Cr+++ to Cr++++++	100 to 1,000
Copper, Cu++	200 to 4,000
Iron,*** Fe++ and Fe+++	100 to 1,000
Lead, Pb++	100 to 4,000
Magnesium, Mg++	100 to 1,000
Manganese, Mn++ to Mn+++++++	100 to 1,000
Mercury, Hg+ and Hg++	100 to 1,000
Potassium, Ni++	100 to 1,000
Nickel, Ni++	100 to 1,000
Silver, Ag+	100 to 1,000
Sodium, NA+	100 to 1,000
Strontium, Sr++	100 to 1,000
Tin, Sn++ and Sn++++	100 to 1,000
Zinc, Zn++	100 to 1,000

EXHIBIT [illegible] VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS [illegible] OF INDUSTRIAL WASTEWATER (Continued)

Tests	Volume of Sample, ml*
Anions	
Bicarbonate, HCO_3^-	100 to 200
Bromide, Br^-	100
Carbonate, $CO_3^{=}$	100 to 200
Chloride, Cl^-	25 to 100
Cyanide, Cn^-	25 to 100
Fluoride, Fl^-	200
Hydroxide, OH^-	50 to 100
Iodide, I^-	100
Nitrate, NO_3^-	10 to 100
Nitrite, NO_2^-	50 to 100
Phosphate, Ortho, $PO_4^{=}$, $HPO_4^{=}$, $H_2PO_4^-$	50 to 100
Sulfate, $SO_4^{=}$, HSO_4^-	100 to 1,000
Sulfide, $S^{=}$, HS^-	100 to 500
Sulfite, $SO_3^{=}$, HSO_3^-	50 to 100

*Volumes specified in this table should be considered as guides for the approximate quantity of sample necessary for a particular analysis. The exact quantity used should be consistent with the volume prescribed in the standard method of analysis, whenever a volume is specified.

**Aliquot may be used for other determinations.

***Samples for unstable constituents must be obtained in separate containers, preserved as prescribed, completely filled, and sealed against all exposure.

Source: Associated Water and Air Resource Engineers, Inc., 1973, *Handbook for Monitoring Industrial Wastewater*, EPA Technology Transfer.

- Flow - If flow is measured at the time of sampling, the measurement must be recorded and accompanied by a description of the flow measurement method and calculations.
- Date, Time, and Documentation of Sample Shipment - The shipment method (e.g., air, rail, or bus) as well as the shipping papers or manifest number should be noted.
- Comments - All relevant information pertaining to the sample or the sampling site should be recorded. Such comments could include the condition of the sample site, observed characteristics of the sample, environmental conditions that may affect the sample, and problems encountered during sampling.

EXHIBIT 3-26. FIELD SHEET FOR SAMPLE DOCUMENTATION

Sample Source	Sample ID #	Date: XX/XX/XX
Facility Name		Time: XX:XX a.m./p.m.
Address	Person Performing Sampling	
Outfall ID #	Signature	
Description	Preservation Method	
Diagram of Site	Comments	
Flow Description	Ship Via: Stable Shipping Paper/Manifest	
Flow Calculations	Analysis Required	

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3.8 SAMPLE IDENTIFICATION AND LABELING

Prior to collection of the sample, a waterproof, gummed sample identification label or tag should be attached to the sample container. This label should contain relevant information for sample analysis, such as:

- Facility name
- Name of the sample collector
- Sample identification number
- Date and time of sample collection
- Type of analysis required
- Location of sample collection
- Preservatives used
- Type of sample (grab or composite).

Sample lids should be used to protect the sample's integrity from the time it is collected to the time it is opened in the laboratory. The lid should contain the collector's name, the date and time the sample was collected, and a sample identification number. Information on the seal must be identical to the information on the label. In addition, the lid should be taped shut so that the seal must be broken to open the sample container. Caution should be taken to ensure that glue from tape and label tag wires do not contaminate samples, particularly those containing volatile organics and metals. Also, waterproof ink should be used to avoid smearing on the label from melted ice used for cooling.

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3.9 SAMPLE PACKAGING AND SHIPPING

If the samples are not hand-delivered to the laboratory or analyzed in an onsite laboratory, they should be placed in a transportation case (e.g., a cooler) along with the chain-of-custody record form, pertinent field records, and analysis request forms, and shipped to the laboratory. Glass bottles should be wrapped in foam rubber, plastic bubble wrap, or other material to prevent breakage during shipment. The wrapping can be secured around the bottle with tape. The container lid should also be sealed with tape. Samples should be placed in ice or a synthetic ice substitute that will maintain the sample temperature at 4°C throughout shipment. Ice should be placed in double-wrapped watertight bags so the water will not leak from the shipping case. Metal or heavy plastic ice chests make good sample transportation cases. Filament tape wrapped around each end of the ice chest ensures that it will not open during transport. Sampling records (preferably laminated or waterproof) can be placed in a waterproof envelope and taped to the inside of the transportation case to avoid getting them wet in case a sample container or an ice bag leaks. Shipping containers should also be sealed to prevent tampering. A copy of all sampling records should be kept onsite in case they are requested by the permitting authority.

Most samples will not require any special transportation precautions except careful packaging to prevent breakage and/or spillage. If the sample is shipped by common carrier or sent through the U.S. mail, it must comply with Department of Transportation Hazardous Materials Regulations (49 CFR Parts 171-177). Air shipment of hazardous materials samples may also be covered by requirements of the International Air Transport Association (IATA). Before shipping a sample, the facility should be aware of, and follow, any special shipping requirements. Special packing and shipping rules apply to substances considered hazardous materials as defined by IATA rules. Storm water samples are not generally considered hazardous materials, but in the event of a spill, leakage, etc., at the collection site hazardous materials may be present in the samples. Be aware, before sampling, of what hazardous materials may be in the discharge drainage area. If the presence of hazardous materials is suspected, do not sample unless properly trained.

3.10 CHAIN-OF-CUSTODY PROCEDURES

Once samples have been obtained and collection procedures are properly documented, a written record of the chain of custody of that sample should be made. This is recommended so the applicant can be confident that the samples have not been tampered with and that the sample once analyzed is representative of the storm water discharge. "Chain-of-custody" refers to the documented account of changes in possession that occur for a particular sample or set of samples. The chain-of-custody record allows an accurate step-by-step recreation of the sampling path, from origin through analysis. Information necessary in chain-of-custody is:

- Name of the persons collecting the sample
- Sample ID numbers

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- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory.

To ensure that all necessary information is documented, a chain-of-custody form should be developed. An example of such a form is found in Exhibit 3-27. Chain-of-custody forms should be printed on carbonless, multipart paper so all personnel handling the sample receive a copy. All sample shipments should be accompanied by the chain-of-custody record and a copy of these forms should be retained by the originator. In addition, all receipts associated with the shipment should be retained. Carriers typically will not sign for samples; therefore, seals must be used to verify that tampering has not occurred during shipment.

When transferring possession of samples, the transferee should sign and record the date and time on the chain-of-custody record. In general, custody transfers are made for each sample, although samples may be transferred as a group. Each person who takes custody should fill in the appropriate section of the chain-of-custody record.

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EXHIBIT 3-27. EXAMPLE OF CHAIN-OF-CUSTODY FORM

CHAIN OF CUSTODY RECORD

8-15076

Source: U.S. EPA, Region 8

4-7-8

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4. ANALYTICAL CONSIDERATIONS

All storm water discharges must be sampled and analyzed in accordance with the test procedures provided in 40 CFR Part 136. This section discusses pollutant parameters which must be analyzed by storm water permit applicants. If the applicant wants to use an alternative test method, the facility must apply for approval (by submitting a description of the method to the permitting authority for approval) prior to application submission [see 40 CFR 136.4(d)(3)]. Section 5.4 elaborates on how to obtain approval for an analytical method for a parameter that is not included in 40 CFR Part 136. EPA-approved analytical methods at 40 CFR 136.3, Tables IB and IC are shown in Appendix C of this document.

When choosing the appropriate 40 CFR Part 136 analytical method, the applicant should consider sample interferences and potential field sampling error. Most method detection levels are established under ideal sample conditions (e.g., with little or no sample matrix interferences or sampling error). Thus, for storm water samples, the method chosen should account for sampling error and interferences.

4.1 INDUSTRIAL REQUIREMENTS

Industrial dischargers must provide information on the following parameters, as required in 40 CFR 122.26(c)(1)(I)(E):

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- Any pollutant limited in an effluent guideline to which the facility is subject
- Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility has an existing NPDES permit)
- O&G, pH, BOD_5, COD, TSS, total phosphorus, TKN, and nitrate plus nitrite nitrogen
- Any pollutant known or believed to be present [as required in 40 CFR 122.21(g)(7)]
- Flow measurements or estimates of the flow rate, the total amount of discharge for the storm events sampled, and the method of flow measurement or estimation
- The date and duration (in hours) of the storm events sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff, and the time between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event (in hours).

4.1.1 INDIVIDUAL APPLICANTS

Industrial facilities submitting an individual permit application must provide sampling data in three parts of the Form 2F application form as discussed below. (Form 2F restates requirements listed in 40 CFR 122.21 and 122.26).

Section VII.A Parameters

Section VII.A of Form 2F requires the facility to sample (grab and flow-weighted samples) for O&G, BOD_5, COD, TSS, TKN, nitrate plus nitrite nitrogen, total phosphorus, and pH. These parameters are to be monitored by every facility applying for a storm water discharge permit, regardless of the type of operations that exist at the site. Sampling for additional parameters may be required, depending on the type of facility applying for the permit or the pollutants expected to be present in the discharge. These additional requirements are discussed in detail below.

Section VII.B Parameters

Section VII-B of Form 2F requires the applicant to identify all pollutants that are limited in an effluent guideline to which the facility is subject, as well as other toxic and nonconventional pollutants listed in the facility's NPDES permit for its process wastewater. EPA interprets that for pollutants listed in NPDES process wastewater permits, at a minimum, facilities must sample their storm water discharge for those pollutants specifically limited in their process wastewater permit. States can be more stringent, however, and may interpret this requirement to mean all pollutants listed in the permit. Once these parameters are identified, the applicant will be required to sample for these parameters by both grab and flow-weighted composite samples, except for the specified pollutants which must be grab sampled only. Form 2F requires the applicant to submit maximum values. The average values column is not compulsory, but should be completed if data are available. Applicable effluent guidelines appear in 40 CFR Parts 405-471. A listing of the Subchapter N—Effluent Guidelines and Standards by which the applicant may be regulated appears in Exhibit 4-1. The applicant must refer to the effluent guidelines and standards for the particular industry, and should determine which guidelines apply and which parameters should be listed in Section VII.B of Form 2F.

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EXHIBIT [illegible] SUBCHAPTER N EFFLUENT GUIDELINES AND STANDARDS

Part	Effluent Guidelines and Standards	Part	Effluent Guidelines and Standards
405	Dairy Products Processing Point Source Category,	431	Builder's Paper and Board Mills Point Source Category
406	Grain Mils Point Source Category	432	Meat Products Point Source Category
407	Canned and Preserved Fruits and Vegetables Point Source Category	433	Metal Finishing Point Source Category
408	Canned and Preserved Seafood Point Source Category	434	Coal Mining Point Source Category
409	Sugar Processing Point Source Category	435	Oil and Gas Extraction Point Source Category
410	Textile Mills Point Source Category	436	Mineral Mining and Processing Point Source Category
411	Cement Manufacturing Point Source Category	439	Pharmaceutical Manufacturing Point Source Category
412	Feedlots Point Source Category	440	Ore Mining and Dressing Point Source Category
413	Electroplating Point Source Category	443	Paving and Roofing Point Source Category
414	Organic Chemicals, Plastics, and Synthetic Fibers Point Source Category	446	Paint Formulating Point Source Category
415	Inorganic Chemicals Manufacturing Point Source Category	447	Ink Formulating Point Source Category
416	(Reserved)	454	Gum and Wood Chemicals Manufacturing Point Source Category
417	Soap and Detergent Manufacturing Point Source Category	455	Pesticide Chemicals Manufacturing Point Source Category
418	Fertilizer Manufacturing Point Source Category	457	Explosives Manufacturing Point Source Category
419	Petroleum Refining Manufacturing Point Source Category	458	Carbon Black Manufacturing Point Source Category
420	Iron and Steel Manufacturing Point Source Category	459	Photographic Point Source Category
421	Nonferrous Metals Manufacturing Point Source Category	460	Hospital Point Source Category
422	Phosphate Manufacturing Point Source Category	461	Battery Manufacturing Point Source Category
423	Steam Electric Power Generating Point Source Category	463	Plastics Molding and Forming Point Source Category
424	Ferroalloy Manufacturing Point Source Category	464	Metal Molding and Casting Point Source Category
425	Leather Tanning and Finishing Point Source Category	465	Coil Coating Point Source Category
426	Glass Manufacturing Point Source Category	466	Porcelain Enameling Point Source Category
427	Asbestos Manufacturing Point Source Category	467	Aluminum Forming Point Source Category
428	Rubber Manufacturing Point Source Category	468	Copper Forming Point Source Category
429	Timber Products Processing Point Source Category	469	Electrical and Electronic Components Point Source Category
430	Pulp, Paper and Paperboard Point Source Category	471	Nonferrous Metals Forming and Metal Powders Point Source Category

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Section VII.C Parameters

Section VII.C requires the applicant to list, for each outfall, each pollutant described in 40 CFR Part 122, Appendix D, Tables II, III, IV, and V (Tables 2F-2, 2F-3, and 2F-4 of application Form 2F) that it knows, or has reason to believe, may be present in the storm water discharge. These pollutants consist of conventional and nonconventional pollutants, toxic pollutants and total phenol, Gas Chromatography/Mass Spectrometry (GC/MS) fraction volatile compounds, acid compounds, base/neutral compounds, pesticides, and hazardous substances. These tables are also provided on the back of Form 2F. Tables II and III of 40 CFR Part 122 Appendix D have been combined in Table 2F-3 of application Form 2F. Table IV of 40 CFR Part 122 Appendix D is listed as Table 2F-2 of application Form 2F and Table V of 40 CFR Part 122 Appendix D is listed as Table 2F-4 of application Form 2F. There are specific requirements associated with each table. If pollutants in Table IV of 40 CFR Part 122 Appendix D (Table 2F-2 of application Form 2F), are directly or indirectly limited by an effluent guideline limitation, the applicant must analyze for it and report the data. For other pollutants listed in Table IV of 40 CFR Part 122 Appendix D (Table 2F-2 of the application form), the applicant must either report quantitative data, if available, or briefly describe the reasons the pollutant is expected to be in the discharge.

For every pollutant in Tables II and III of 40 CFR Part 122 Appendix D (Table 2F-3 of application Form 2F) expected to be discharged in concentrations of 10 parts per billion (ppb) or greater, the applicant must submit quantitative data. For acrolein, acrylonitrile, 2,4-dinitrophenol, and 2-methyl-4,6-dinitrophenol, the applicant must submit quantitative data if any of these four pollutants is expected to be discharged in concentrations of 100 ppb or greater. For every pollutant expected to be discharged with a concentration less than 10 ppb (or 100 ppb for the four parameters mentioned above), the applicant must either submit quantitative data or briefly explain why the pollutant is expected to be discharged.

For the parameters identified in Table V of 40 CFR Part 122 Appendix D (Table 2F-4 of application Form 2F) that the applicant believes to be present in the discharge, no sampling is required. If previous analyses of these parameters were conducted, the results must be reported. Otherwise, the applicant is required to explain why these pollutants are believed to be present.

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Small Business Exemption

Small businesses are exempted from the reporting requirements for the organic toxic pollutants presented in 40 CFR Part 122, Table II of Appendix D. Applicants can claim a small business exemption if:

- The facility is a coal mine and the probable annual production is less than 100,000 tons per year. The applicant may submit past production data or estimate future production data instead of conducting analyses for the organic toxic pollutants listed in Table 2F-3 of application Form 2F.
- The facility is not a coal mine, and the gross total annual sales for the most recent 3 years is, on average, less than $100,000 per year (reflected in second quarter 1980 dollars). The applicant may submit sales data for those years instead of conducting analyses for the organic toxic pollutants listed in Table 2F-3 of application Form 2F.

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Section VIII

Section VIII of Form 2F requires the applicant to provide biological toxicity testing data for storm water discharges associated with industrial activity. Applicants are required to perform biological toxicity testing for the storm water application if the facility's NPDES permit for its process wastewater lists biological toxicity (EPA interprets "listed" as limited). For example, if a facility's NPDES process wastewater permit has an acute toxicity limit of a lethal concentration (LC_{50}), equal to 75 percent effluent using ceriodaphnia, then that facility must also test its storm water discharges associated with industrial activity and report the results of the tests in Section VIII of Form 2F.

Until whole effluent toxicity methods are promulgated by EPA in 40 CFR Part 136, toxicity testing should be conducted using the most appropriate methods and species as determined by the permitting authority. In the absence of State acute toxicity testing protocols, EPA recommends using the methods described in Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Fresh Water and Marine Organisms. EPA/600/4-90-027 (Rev. September 1991)

4.1.2 GROUP APPLICANTS

Industrial facilities submitting a group application must also provide sampling data (from the sampling subgroup) which is required to be submitted in Sections VII, VIII, and IX along with the certification in Section X of Form 2F. At a minimum, these parameters include O&G, BOD_5, COD, TSS, TKN, nitrate plus nitrite nitrogen, total phosphorous, and pH. Furthermore, all pollutants listed in an effluent guideline or limited in an NPDES permit applicable to the sampling facilities within the group must be sampled, as well as pollutants suspected of being present based on significant materials and industrial activities present onsite.

4.2 MUNICIPAL REQUIREMENTS

For Part 1 of the municipal permit application, municipalities must submit samples from the field screening effort for pH, total chlorine, total copper, phenol, and detergents (or surfactants). A narrative description of the color, odor, turbidity, and presence of oil sheen and surface scum must be included. For Part 2 of the permit application, municipalities must provide quantitative data for the organic pollutants listed in Table II of 40 CFR Part 122 Appendix D, and the pollutants listed in 40 CFR Part 122, Appendix D, Table III, as well as some additional pollutants. These pollutants are listed in Exhibit 4-2.

Furthermore, 40 CFR 122.26(d)(2)(iii)(A)(5) requires that estimates be provided of the annual pollutant load of the cumulative discharges to waters of the U.S. from all identified municipal outfalls, and the event mean concentration of the cumulative discharges to waters of the U.S. from all identified municipal outfalls during storm events for the parameters listed in Exhibit 4-2. Estimates of the parameters must be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods.

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EXHIBIT [illegible] PARAMETERS WHICH MUST BE ANALYZED BY MUNICIPAL APPLICANTS

Pollutants Contained in Table III of 40 CFR Part 122, Appendix D

Total antimony	Total cadmium	Total lead	Total selenium	Total zinc
Total arsenic	Total chromium	Total mercury	Total silver	Total cyanide
Total beryllium	Total copper	Total nickel	Total thallium	Total phenols

Pollutants Contained in Table II of 40 CFR Part 122, Appendix D

Acrolein	Toluene	Benzo(a)pyrene	2,6-dinitrotoluene	Gamma-BHC
Acrylonitrile	1,2-trans-dichloroethylene	3,4-benzofluoranthene	Di-n-octyl phthalate	Delta-BHC
Benzene	1,1,1-trichloroethane	Benzo(ghi)perylene	1,2-diphenylhydrazine	Chlordane
Bromoform	1,1,2-trichloroethane	Benzo(k)fluoranthene	Fluoranthene	4,4'-DDT
Carbon Tetrachloride	Trichloroethylene	Bis(2-chloroethoxy)methane	Fluorene	4,4'-DDE
Chlorobenzene	Vinyl chloride	Bis(2-chloroethyl)ether	Hexachlorobenzene	4,4'-DDD
Chlorodibromomethane	2-chlorophenol	Bis(2-chloroisopropyl)ether	Hexachlorobutadiene	Dieldrin
Chloroethane	2,4-dichlorophenol	Bis(2-ethylhexyl)phthalate	Hexachlorocyclopentadiene	Alpha-endosulfan
2-Chloroethylvinyl ether	2,4-dimethylphenol	4-bromophenyl phenyl ether	Hexachloroethane	Beta-endosulfan
Chloroform	4,6-dinitro-o-cresol	Butylbenzyl phthalate	Indeno(1,2,3-cd)pyrene	Endosulfan sulfate
Dichlorobromomethane	2,4-dinitrophenol	2-chloronaphthalene	Isophorone	Endrin
1,1-dichloroethane	2-nitrophenol	4-chlorophenyl phenyl ether	Naphthalene	Endrin aldehyde
1,2-dichloroethane	4-nitrophenol	Chrysene	Nitrobenzene	Heptachlor
1,1-dichloroethylene	p-chloro-m-cresol	Dibenzo(a,h)anthracene	N-nitrosodimethylamine	Heptachlor epoxide
1,2-dichloropropane	Pentachlorophenol	1,2-dichlorobenzene	N-nitrosodi-n-propylamine	PCB-1242
1,3-dichloropropylene	Phenol	1,3-dichlorobenzene	N-nitrosodiphenylamine	PCB-1254
Ethylbenzene	2,4,6-trichlorophenol	1,4-dichlorobenzene	Phenanthrene	PCB-1221
Methyl bromide	Acenaphthene	3,3-dichlorobenzidine	Pyrene	PCB-1232
Methyl chloride	Acenaphthylene	Diethyl phthalate	1,2,4-trichlorobenzene	PCB-1248
Methylene chloride	Anthracene	Dimethyl phthalate	Aldrin	PCB-1260
1,1,2,2-tetrachloroethane	Benzidine	Di-n-butyl phthalate	Alpha-BHC	PCB-1016
Tetrachloroethylene	Benzo(a)anthracene	2,4-dinitrotoluene	Beta-BHC	Toxaphene

Additional Pollutants Which Must be Analyzed

TSS	O&G	TKN
TDS	Fecal coliform	Nitrate plus nitrite nitrogen
COD	Fecal streptococcus	Total and dissolved phosphorus
BOD_5	pH	
	Total residual chlorine	

Source: 40 CFR Part 122, Appendix D

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5. FLEXIBILITY IN SAMPLING

The requirements for storm water sampling for permit applications offer some flexibility by the permitting authority. The areas of flexibility are discussed below.

5.1 PROTOCOL MODIFICATIONS

The permitting authority may allow sampling protocol modifications for specific requirements on a case-by-case basis. For example, the permitting authority may accept application forms with incomplete sampling data if there was no rainfall at the applicant's facility prior to the submission deadline. However, the permitting authority will require that sampling data be submitted as soon as possible. The reason for not submitting data must be certified by a corporate official (for industrial facilities) or the principal executive officer or ranking official (for municipalities).

Another area where permitting authorities may allow flexibility in storm water sampling is acceptance of quantitative data from a storm event that does not meet the representative rainfall criteria of within 50 percent of the volume and duration for the average storm event for the area. The permitting authority may decide that the discharge data provided is better than no data at all.

In addition, the permitting authority may establish appropriate site-specific sampling procedures or requirements, including sampling locations; the season in which the sampling takes place; the minimum duration between the previous measurable storm event and the storm event sampled; the minimum or maximum level of precipitation required for an appropriate storm event; the form of precipitation sampled (snow melt or rainfall); protocols for collecting samples under 40 CFR Part 136; and additional time for submitting data on a case-by-case basis. The permitting authority should be contacted for preapproval of any necessary protocol modifications. In the case of group applications, EPA Headquarters should be contacted.

5.2 PETITION FOR SUBSTITUTING SUBSTANTIALLY IDENTICAL EFFLUENTS

As described at 40 CFR 122.21(g)(7), when an industrial applicant has two or more outfalls with substantially identical effluents, the permitting authority may allow the applicant to test only one outfall and to report that the quantitative data also apply to the substantially identical outfalls. In the case of group applications, the petition must be submitted to EPA Headquarters.

For facilities seeking to demonstrate that storm water outfalls are substantially identical, a variety of methods can be used as determined by the permitting authority. Three possible petition options are discussed here: (1) submission of a narrative description and a site map; (2) submission of matrices; or (3) submission of model matrices. Detailed guidance on each of the three options for demonstrating substantially identical outfalls is provided below. An owner/operator certification should be submitted with each option. See Section 5.2.3 for an example of this certification.

5.2.1 OPTION ONE: NARRATIVE DESCRIPTION/SITE MAP

Facilities demonstrating that storm water outfalls are substantially identical may submit a narrative description of the facility and a site map to the permitting authority . The narrative portion must include a description of why the outfalls are substantially identical. Petitioners may demonstrate that these outfalls contain storm water discharges associated with:

- Substantially identical industrial activities and processes;
- Substantially identical significant materials that may be exposed to storm water [including, but not limited to, raw materials, fuels, materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to Section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA); fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have the potential to be released with storm water discharges as per 40 CFR 122.26(b)(12)];
- Substantially identical storm water management practices (such as retention ponds, enclosed areas, diversion dikes, gutters, and swales) and material management practices (such as protective coverings and secondary containment); and
- Substantially identical flows, as determined by the estimated runoff coefficient and approximate drainage area at each outfall.

The site map should include an indication of the facility's topography; each of the drainage and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area for each storm water outfall; all past or present areas used for outdoor storage or disposal of significant materials; identification of the significant materials in each drainage area; and identification of each existing structural control measures used to reduce pollutants in storm water

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runoff, materials loading and access areas, and areas where pesticides, herbicides, soil conditioners, and fertilizers are applied.

Exhibit 5-1 offers an example of a narrative description/site map petition that sufficiently demonstrates identical outfalls. A demonstration of how to determine runoff coefficient estimates was presented in Section 3.2.2. Exhibit 5-2 presents an example of a site map to be included with the narrative description.

5.2.2 OPTION TWO: USE OF MATRICES TO INDICATE IDENTICAL OUTFALLS

Facilities attempting to demonstrate that storm water outfalls are substantially identical may submit matrices and an owner/operator certification describing specific information associated with each outfall to the permitting authority. Matrix information is required only for those outfalls that the permit applicant is attempting to demonstrate are identical, not for all outfalls. Petitioners must demonstrate, using the matrices, that the outfalls have storm water discharges that meet the criteria listed in Section 5.2.1. Refer to Exhibit 5-3 for examples of matrices that demonstrate substantially identical outfalls and Section 3.2.2 for guidance on determining runoff coefficient estimates.

5.2.3 OPTION THREE: MODEL MATRICES

Facilities attempting to demonstrate that storm water outfalls are substantially identical may submit model matrices and an owner/operator certification to the permitting authority. This option is particularly appropriate for facilities with a large number of storm water outfalls and the potential for numerous groupings of identical outfalls. In addition, this option may be useful in group applications that have a large sampling subgroup.

Model matrices should contain information for <u>one grouping of substantially identical outfalls</u>. For example, if a facility has 150 outfalls and several groupings of identical outfalls, the facility would <u>choose one</u> of the groupings of identical outfalls to provide information in the model matrices. The petitioner must demonstrate, using these matrices, that all outfalls within this grouping have storm water discharges that meet the criteria listed in Section 5.2.1.

The facility should provide an owner certification that all other groupings of outfalls have been examined and certified as substantially identical outfalls according to the criteria established in the

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EXHIBIT [illegible] PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP)

Examples

I. The Pepper Company of Philadelphia, Pennsylvania, is primarily engaged in manufacturing paperboard, including paperboard coated on the paperboard machine (from wood pulp and other fiber pulp). This establishment is classified under SIC code 2631. Pursuant to the November 16, 1990, NPDES storm water permit application regulations, this facility is considered to be "engaging in industrial activity" for the purposes of storm water permit application requirements in 40 CFR 122.26(b)(14)(i) and (ii).

II. "When an applicant has two or more outfalls with substantially identical effluents, the Director may allow the applicant to test only one outfall and report that the quantitative data also apply to the substantially identical outfalls." [40 CFR 122.21(g)(7)]

In accordance with 40 CFR 122.21(g)(7) of the NPDES regulations, The Pepper Company hereby petitions the State of Pennsylvania (the permitting authority) for approval to sample certain representative storm water outfalls in groupings of storm water outfalls that are substantially identical. The Pepper Company will demonstrate that of the ten (10) outfalls discharging storm water from our paperboard manufacturing plant, there are two pairs of substantially identical outfalls. Outfalls 3 and 4 are substantially identical and should be grouped together. Outfalls 8 and 9 are substantially identical and should be grouped together. Outfalls 1, 2, 5, 6, 7, and 10 have distinct characteristics and, therefore, will not be grouped together with other outfalls for the purposes of storm water discharge sampling.

III. The Pepper Company will demonstrate that the substantially identical outfalls that have been grouped together contain storm water discharges associated with: (1) substantially identical industrial activities and processes that are occurring outdoors; (2) substantially identical significant materials (including raw materials, fuels, finished materials, waste products, and material handling equipment) that may be exposed to storm water; (3) substantially identical material management practices (such as runoff diversions, gutters and swales, protective coverings, and structural enclosures); and (4) substantially identical flows, as determined by the estimated runoff coefficient and approximate drainage area at each outfall.

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EXHIBIT ... PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

1. **Industrial Activities**

A. Description of Industrial Activities at the Pepper Company

The Pepper Company receives wastepaper in bales. This baled wastepaper is sent through a hydropulper and converted to pulp. The fiber material is concentrated, stored, and then drawn through refiners to the paper machines. Wires, plastics, and miscellaneous material are removed during the pulping.

Three systems are used to produce top liner, back paper, and filler. The highest quality fiber is used for the top liner, the medium quality is used for the back paper, and the poorest quality is used for the filler paper. Wireforming or conventional boxboard processes are employed to produce clay-coated boxboard, using a water-based clay-coating material. Additional materials may be used as binders. These are stored indoors and are not exposed to precipitation. Ammonia is used in the clay-coating process. Off-grade fiber and trim material are ground up and returned to the liquid process stream. Slime control agents, consisting of bactericides, are used in association with this process. These agents are organic materials used to prevent souring of mill operations. They are received in drums and stored indoors. Empty drums are returned to the supplier to reuse. In addition, the Pepper Company operates an onsite landfill for the disposal of miscellaneous waste materials removed during pulping and paper cuttings operations.

B. Demonstration of Why Outfalls Are Substantially Identical in Terms of Industrial Activities Conducted Outdoors.

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of industrial activities conducted outdoors. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper. The wastepaper, which consists of old corrugated containers, mixed paper, and other types of wastepaper, is received weekly and stored for up to 3 weeks in Storage Areas #1 and #2. These uncovered storage areas are enclosed by chain-link fencing.

Outfalls 8 and 9

Outfalls 8 and 9 drain storm water runoff from areas where all industrial activities occur indoors. The industrial activities occurring under roof cover at these two outfalls include hydropulping, storage of concentrated fiber material, refining, and paperboard production. These industrial processes have no potential for contact with precipitation.

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EXHIBIT ... PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

2. Significant Materials

A. Description of Significant Materials at the Pepper Company

The significant materials listed below are used by the Pepper Company to manufacture paperboard. These materials are stored indoors, unless otherwise indicated.

(i) Raw materials, including baled wastepaper (off-spec damaged paper stock or recycled paper) [wastepaper is stored outdoors at Storage Areas #1 and #2]; clays, ammonias, sizings, and slime control agents (chlorine dioxide); caustic; ammonia, which is stored in two tanks. [See Storage Area #3].

(ii) Waste Materials, including miscellaneous materials removed during pulping and paper cuttings (such as staples, rubber bands, styrofoam, etc.). These waste materials are stored indoors in open dumpsters. However, prior to disposing of the waste in the onsite landfill, these dumpsters are moved outdoors where they are potentially exposed to precipitation for 12 hours or less. [See Storage Area #3].

(iii) Finished Products, including paperboard and molded fiber products. These are always stored indoors.

(iv) Others, including wood pallets (which are used to transport and haul raw materials, waste materials, and finished products) are stored both indoors and outdoors. [See Storage Area #3]. The Pepper Company has an above-ground fuel tank with a pump. [See Storage Area #3].

B. Demonstration of Why Outfalls are Substantially Identical in Terms of Significant Materials that Potentially May be Exposed to Storm Water

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of significant materials that may be exposed to storm water. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper. The wastepaper, which consists of old corrugated containers, mixed paper, and other types of wastepaper, is received weekly and stored for up to 3 weeks in Storage Areas #1 and #2. These uncovered storage areas are enclosed by chain-link fencing.

Outfalls 8 and 9

Outfalls 8 and 9 are substantially identical in terms of significant materials. Both outfalls contain storm water runoff from areas that have no significant materials potentially exposed to storm water. All industrial activities occurring in the areas drained by Outfalls 8 and 9 occur completely indoors.

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EXHIBIT [illegible] PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

3. Material Management Practices

A. Description of Material Management Practices at the Pepper Company

The Pepper Company uses a wide range of storm water management practices and material management practices to limit the contact of significant materials with precipitation. Non-structural storm water management practices include employee training, spill reporting and clean-up, and spill prevention techniques. Structural storm water management practices include:

(I) Diversion Devices (both above-ground trenches and subterranean drains) are used to divert surface water from entering a potentially contaminated area.

(II) Gutters/Swales (constructed of concrete or grass) channel storm water runoff to drainage systems leading to separate storm sewers.

(iv) Overland Flow (which is the flow of storm water over vegetative areas prior to entrance into a storm water conveyance) allows much of the storm water to infiltrate into the ground. The remainder is naturally filtered prior to reaching the storm water conveyance. This is not considered sheet flow since natural drainage channels may be carved out during a heavy storm event.

B. Demonstration of Why Outfalls Are Substantially Identical in Terms of Storm Water Management Practices Used

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of storm water management practices used. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper, located in Storage Areas #1 and #2. Concrete gutters at both sites channel storm water away from the storage areas down to the respective outfalls.

Outfalls 8 and 9

Outfalls 8 and 9 are substantially identical in terms of storm water management practices used. Both outfalls contain storm water runoff from areas that have no significant materials potentially exposed to storm water. All industrial activities occurring in the areas drained by Outfalls 8 and 9 occur completely indoors. Both outfalls receive overland flow storm water. From roof drains, the storm water in both drainage areas is then conveyed over similarly graded vegetative areas prior to entrance into the respective outfalls.

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[illegible] SUBSTANTIALLY IDENTICAL [illegible] (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

4. **Flow Characteristics**

   A. **Demonstration of Why Outfalls Are Substantially Identical in Terms of Flow, as Determined by The Estimated Runoff Coefficient and Approximate Drainage Area at Each Outfall**

<u>Outfalls 3 and 4</u>

Outfalls 3 and 4 are substantially identical in terms of flow. Both drainage areas have a 2 to 7 percent grade and contain fine textured soil (greater than 40 percent clay) with a vegetative cover. The estimated runoff coefficient for both outfalls is .2. The approximate drainage area for each outfall is similar. Outfall 3 has an approximate drainage area of 3,500 square feet. Outfall 4 has an approximate drainage area of 2,900 square feet.

<u>Outfalls 8 and 9</u>

Outfalls 8 and 9 are substantially identical in terms of flow. Both drainage areas have a 2 to 7 percent grade and contain fine textured soil (greater than 40 percent clay) with a vegetative cover. The estimated runoff coefficient for both outfalls is .2. The approximate drainage area for each outfall is similar. Outfall 8 has an approximate drainage area of 7,600 square feet. Outfall 9 has an approximate drainage area of 8,700 square feet.

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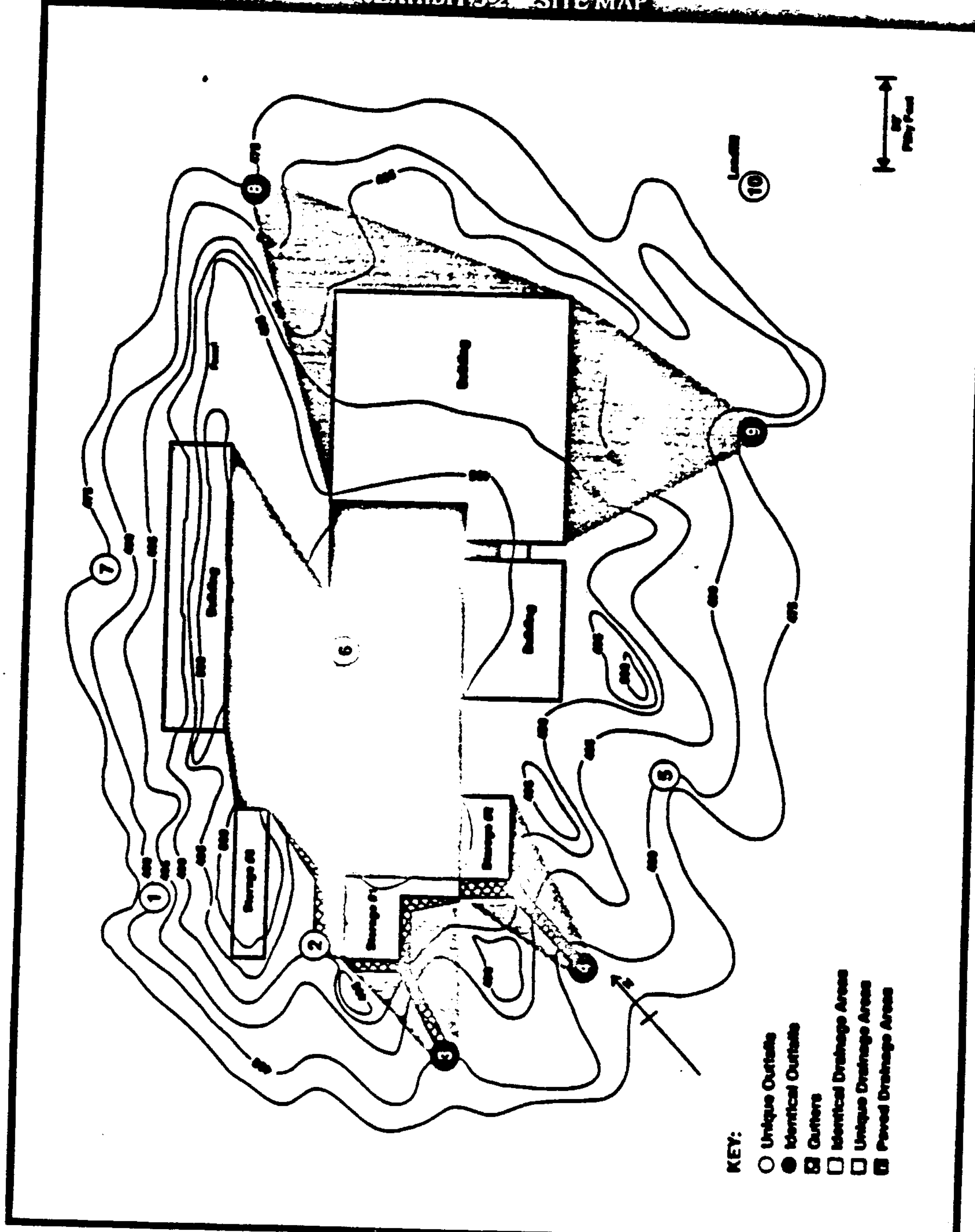
EXHIBIT 5-2. SITE MAP



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[illegible] MATRIC[illegible] OUTFALLS

Industrial Activities

OUTFALL	A	B	C	D	E
3	X	–	–	X	–
4	X	–	–	X	–
8	–	–	–	–	–
9	–	–	–	–	–

Key:

A = Outdoor storage of raw materials and material-handling equipment
B = Fueling
C = Waste materials storage (dumpster)
D = Loading/unloading of raw materials, intermediate products, and final products
E = Landfill activity

Significant Materials That May Be Exposed to Storm Water

OUTFALL	A	B	C	D	E	F
3	-	–	–	–	X	–
4	–	–	–	–	X	–
8	–	–	–	–	–	–
9	–	–	–	–	–	–

Key:

A = Outdoor ammonia tank
B = Wood pallets
C = Above ground gas tank
D = Waste materials
E = Baled wastepaper
F = Finished products

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EXHIBIT [illegible] MATRICES DEMO[illegible] SUBSTANTIALLY IDENTICAL [illegible] OUTFALLS (Continued)

Storm Water Management Practices

OUTFALL	A	B	C
3	–	X	–
4	–	X	–
8	–	–	X
9	–	–	X

Key:

A = Runoff diversions
B = Gutters/swales
C = Overland flow (not sheet flow; flow through vegetative areas)

Flow Characteristics

OUTFALL	A	B
3	0.2	3,500
4	0.2	2,900
8	0.2	7,600
9	0.2	8,700

Key:

A = Estimated runoff coefficient
B = Approximate drainage area of outfall (square feet)

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model matrices described in Exhibit 5-3. The owner/operator who signs documents in this section should include the following certification:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations" [as per 40 CFR 122.22(d)].

5.3 ALTERNATE 40 CFR PART 136 METHOD

As required in 40 CFR 136.4, the applicant must request the approval of an alternate test procedure in writing (in triplicate) prior to testing. The request must be submitted to the Regional Administrator through the Director of the State agency responsible for issuing NPDES permits. The applicant must:

- Provide the name and address of the responsible person or firm making the discharge (if not the applicant), the applicable identification number of the existing or pending permit, the issuing agency, the type of permit for which the alternate test procedure is requested, and the discharge serial number;
- Identify the pollutant or parameter for which approval of an alternate testing procedure is being requested;
- Provide justification for using testing procedures other than those specified in 40 CFR Part 136;
- Provide a detailed description of the proposed alternate test procedure, together with references to published studies of the applicability of the alternate test procedure to the effluents in question;
- Provide comparability data (for applicants applying for nation wide approval of an alternative test procedures).

The permitting authority will notify the applicant within 90 days regarding the approval of the alternate method.

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5.4 LACK OF METHOD IN 40 CFR PART 136

If a specific pollutant that must be tested does not have a corresponding analytical method listed in 40 CFR Part 136, the applicant must submit information on an appropriate method to be used. The permitting authority must approve its use prior to collection and analysis of sampling data. The laboratory should be consulted for suggestions and information about analytical methods that can be used. All information justifying the alternative method should be sent to the permitting authority prior to use.

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6. HEALTH AND SAFETY

Storm water sampling activities may occur when the sampling environment and/or storm water discharges create hazardous conditions. Hazardous conditions associated with sampling include:

- Hazardous weather conditions (e.g., wind, lightning, flooding, etc.)
- Sampling in confined spaces (e.g., manholes)
- Hazards associated with chemicals
- Biological hazards (e.g., rodents and snakes)
- Physical hazards (e.g., traffic, falling objects, sharp edges, slippery footing, and the potential for lifting injuries from opening or removing access panels and manhole covers, etc.)

It is essential that sampling personnel be aware of these hazards. Sampling personnel should be trained to evaluate potentially hazardous situations and develop ways for handling them. Since sampling hazards can be life threatening, safety must be the highest priority for all personnel. This chapter outlines general health and safety issues and concerns. Additional references discussed below should be consulted for more specific guidance to avoid adverse health and safety situations.

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6.1 GENERAL TRAINING REQUIREMENTS

Preparation and training of all sampling personnel should be completed before beginning any sampling task. Extreme care should be taken to allow for safety precautions including proper equipment and appropriate operational techniques, sufficient time to accomplish the task, training on potential hazards, and emergency procedures. EPA's Order 1440.2 sets out the policy, responsibilities, and mandatory requirements for the safety of personnel who are involved in sampling activities. This order, which is found within the EPA NPDES Compliance Monitoring Inspector Training: Sampling manual, provides further guidance to applicants' storm water sampling personnel. Basic emergency precautions include having access to both local emergency phone numbers and communication equipment (i.e., phones or radios), and ensuring that personnel are trained in first aid and carry first aid equipment.

6.2 NECESSARY SAFETY EQUIPMENT

Exhibit 6-1 contains a list of safety equipment that may be appropriate depending on the characteristics of the sampling site.

EXHIBIT 6-1 LIST OF SAFETY EQUIPMENT	
Flashlight	18-inch traffic cones
Meters (for oxygen, explosivity, toxic gases)	Insect/rodent repellant
Ladder	Ventilation equipment
Safety harness	50 feet of 1/2-inch nylon rope
Hard hat	Safety shoes
Safety goggles	Rain wear
Coveralls	Gloves (rubber)
Respirator	First aid kit
Reflective vests	Self-contained breathing apparatus
Source: Adapted from NPDES Compliance Monitoring Inspector Training: Sampling, U.S. EPA, August 1990.	

6.3 HAZARDOUS WEATHER CONDITIONS

Common sense should dictate whether sampling be conducted during adverse weather conditions. No sampling personnel should place themselves in danger during high winds, lightning storms, or flooding conditions which might be unsafe. Under extreme conditions, a less hazardous storm event should be sampled.

6.4 SAMPLING IN CONFINED SPACES

Confined spaces encountered by storm water sampling personnel typically include manholes and deep, unventilated ditches. A confined space is generally defined as a space that is somewhat enclosed with limited access and inadequate ventilation.

The National Institute of Occupational Safety and Health (NIOSH) has developed a manual entitled "Working in Confined Spaces" which should be consulted prior to confined space entry. Also, several States have developed specific procedures which should also be consulted. Unless they have been trained fot confined space entry, sampling personnel should avoid entry under all circumstances.

6.4.1 HAZARDOUS CONDITIONS IN CONFINED SPACES

Confined spaces pose a safety threat to sampling personnel because of low oxygen, explosivity, and toxic gases. When entering a confined space, a qualified person should ensure that the atmosphere is safe by sampling to test for oxygen levels, potential flammable hazards, and toxic materials known or suspected to be present. If atmospheric conditions are detected, the confined space should be ventilated or sampling personnel should use a self-contained air supply and wear a life line. At least one person should remain outside of the confined space in the event that problems arise. If atmospheric testing has not been properly conducted, the confined space should not be entered. Manholes can also pose a threat to safety because of the small confined area, slippery surfaces, sharp objects, unsafe ladders, etc.

6.4.2 SPECIAL TRAINING REQUIREMENTS

Personnel should not enter into a confined space unless trained in confined space entry techniques. Such training covers hazard recognition, the use of respiratory equipment and atmospheric testing devices, use of special equipment and tools, and emergency and rescue procedures. In addition, at least one member of the sampling crew should be certified in basic first aid and Cardiopulmonary Resuscitation (CPR). Sampling personnel should, on an annual basis, practice confined space rescues.

6.4.3 PERMIT SYSTEM

If entry into a confined space is necessary, an entry permit system should be developed which includes a written procedure. This permit should include, at a minimum:

- Description of type of work to be done
- Hazards that may be encountered

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- Location and description of the confined space
- Information on atmospheric conditions at confined space
- Personnel training and emergency procedures
- Names of sampling personnel.

The manual developed by NIOSH discusses this permit system in more detail. Furthermore, the Occupational Safety and Health Administration (OSHA) proposed a rule on June 5, 1989 (54 FR 24080) that would implement a permit system. The rule is expected to be finalized and published late in 1992.

6.5 CHEMICAL HAZARDS

Sampling personnel can also be at risk of exposure to hazardous chemicals—either chemicals in the actual storm water discharge or the chemicals that have been placed in the sample collection containers for sample preservation. Therefore, direct contact with the preservatives and the storm water (if hazardous chemicals are suspected to be present) should be avoided. Sampling personnel should wear gloves and safety glasses to avoid skin and eye exposure to harmful chemicals. Sampling personnel should be trained to avoid exposure and instructed as to what to do if exposure occurs (e.g., flush the eyes, rinse the skin, ventilate the area, etc.).

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6.6 BIOLOGICAL HAZARDS

Storm water sampling personnel may also encounter biological hazards such as rodents, snakes, and insects. The sampling crew should remain alert to these hazards. As mentioned in Section 6.2, necessary sampling equipment, for certain locations, should include insect/rodent repellant and a first aid kit.

6.7 PHYSICAL HAZARDS

The sampling crew should be aware of a number of physical hazards that could cause accidents at the sampling site. These hazards include traffic hazards, sharp edges, falling objects, slippery footing, and lifting injuries from removing manhole covers. Sampling personnel should pay close attention in order to prevent these safety hazards at all times.

If the sample point is in a manhole, a street gutter, or ditch near the street, particular attention must be given to marking off the work area to warn oncoming traffic of the presence of the sampling crew. Traffic cones, warning signs, and barricades should be placed in appropriate places around the sampling point.

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TECHNICAL APPENDIX A

FORMS 2F AND 1

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Please print or type in the unshaded areas only

EPA ID Number (copy from Item I of Form 1)

Form Approved. OMB No. 2040-0086
Approval expires 5-31-92

Form 2F NPDES

EPA

United States Environmental Protection Agency
Washington, DC 20460

Application for Permit to Discharge Storm Water Discharges Associated with Industrial Activity

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 28.6 hours per application, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of this collection of information, or suggestions for improving this form, including suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M St., SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20[illegible]

I. Outfall Location

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. Outfall Number (list)	B. Latitude			C. Longitude			D. Receiving Water (name)

II. Improvements

A. Are you now required by any Federal, State, or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

1. Identification of Conditions, Agreements, Etc.	2. Affected Outfalls		3. Brief Description of Project	4. Final Compliance Date	
	number	source of discharge		a. req.	b. proj.

B. You may attach additional sheets describing any additional water pollution (or other environmental projects which may affect your discharges) you now have under way or which you plan. Indicate whether each program is now under way or planned, and indicate your actual or planned schedules for construction.

III. Site Drainage Map

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including: each of its intake and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied; each of its hazardous waste treatment, storage or disposal units (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the f[illegible]

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Continue on Page 2

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Continued from the Front

IV. Narrative Description of Pollutant Sources

A. For each outfall, provide an estimate of the area (include units) of impervious surfaces (including paved areas and building roofs) drained to the outfall, and an estimate of the total surface area drained by the outfall.

Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)	Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)

B. Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage, or disposal; past and present materials management practices employed to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied.

C. For each outfall, provide the location and a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the schedule and type of maintenance for control and treatment measures and the ultimate disposal of any solid or fluid wastes other than by discharge.

Outfall Number	Treatment	List Codes from Table 2F-1

V. Nonstormwater Discharges

A. I certify under penalty of law that the outfall(s) covered by this application have been tested or evaluated for the presence of nonstormwater discharges, and that all nonstormwater discharges from these outfall(s) are identified in either an accompanying Form 2C or Form 2E application for the outfall.

Name and Official Title (type or print)	Signature	Date Signed

B. Provide a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test.

VI. Significant Leaks or Spills

Provide existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years, including the approximate date and location of the spill or leak, and the type and amount of material released.

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EPA ID Number (copy from Item I of Form 1)

VII. Discharge Information

A,B,C, & D: See instructions before proceeding. Complete one set of tables for each outfall. Annotate the outfall number in the space provided. Tables VII-A, VII-B, and VII-C are included on separate sheets numbered VII-1 and VII-2.

E. Potential discharges not covered by analysis - is any toxic pollutant listed in table 2F-2, 2F-3 or 2F-4, a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ Yes (list all such pollutants below) ☐ No (go to Section IX)

VIII. Biological Toxicity Testing Data

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☐ Yes (list all such pollutants below) ☐ No (go to Section IX)

IX. Contract Analysis Information

Were any of the analyses reported in Item VII performed by a contract laboratory or consulting firm?

☐ Yes (list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below) ☐ No (go to Section X)

A. Name	B. Address	C. Area Code & Phone No.	D. Pollutants Analyzed

X. Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title (type or print)	B. Area Code and Phone No.
C. Signature	D. Date Signed

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EPA ID Number (copy from Item 1 of Form 1)

Form Approved OMB No. 2040-0086
Approval expires 5-31-92

VII. Discharge Information (Continued from page 3 of Form 2F)

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		
Oil and Grease						
Biological Oxygen Demand (BOD5)						
Chemical Oxygen Demand (COD)						
Total Suspended Solids (TSS)						
Total Kjeldahl Nitrogen						
Nitrate plus Nitrite Nitrogen						
Total Phosphorus						
pH	Minimum	Maximum	Minimum	Maximum		

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		

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Part C - List each pollutant shown in Tables 2F-2, 2F-3, and 2F-4 that you know or have reason to believe is present. See the instructions for additional details and requirements. Complete one table for each outfall.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1. Date of Storm Event	2. Duration of Storm Event (in minutes)	3. Total rainfall during storm event (in inches)	4. Number of hours between beginning of storm measured and end of previous measurable rain event	5. Maximum flow rate during rain event (gallons/minute or specify units)	6. Total flow from rain event (gallons or specify units)

7. Provide a description of the method of flow measurement or estimate.

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Instructions - Form 2F
Application for Permit to Discharge Storm Water Associated with Industrial Activity

Who Must File Form 2F

Form 2F must be completed by operators of facilities which discharge storm water associated with industrial activity or by operators of storm water discharges that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard.

Operators of discharges which are composed entirely of storm water must complete Form 2F (EPA Form 3510-2F) in conjunction with Form 1 (EPA Form 3510-1).

Operators of discharges of storm water which are combined with process wastewater (process wastewater is water that comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, waste product, or wastewater) must complete and submit Form 2F, Form 1, and Form 2C (EPA Form 3510-2C).

Operators of discharges of storm water which are combined with nonprocess wastewater (nonprocess wastewater includes noncontact cooling water and sanitary wastes which are not regulated by effluent guidelines or a new source performance standard, except discharges by educational, medical, or commercial chemical laboratories) must complete Form 1, Form 2F, and Form 2E (EPA Form 3510-2E).

Operators of new sources or new discharges of storm water associated with industrial activity which will be combined with other nonstormwater new sources or new discharges must submit Form 1, Form 2F, and Form 2D (EPA Form 3510-2D).

Where to File Applications

The application forms should be sent to the EPA Regional Office which covers the State in which the facility is located. Form 2F must be used only when applying for permits in States where the NPDES permits program is administered by EPA. For facilities located in States which are approved to administer the NPDES permits program, the State environmental agency should be contacted for proper permit application forms and instructions.

Information on whether a particular program is administered by EPA or by a State agency can be obtained from your EPA Regional Office. Form 1, Table 1 of the "General Instructions" lists the addresses of EPA Regional Offices and the States within the jurisdiction of each Office.

Completeness

Your application will not be considered complete unless you answer every question on this form and on Form 1. If an item does not apply to you, enter "NA" (for not applicable) to show that you considered the question.

Public Availability of Submitted Information

You may not claim as confidential any information required by this form or Form 1, whether the information is reported on the forms or in an attachment. Section 402(j) of the Clean Water Act requires that all permit applications will be available to the public. This information will be made available to the public upon request.

Any information you submit to EPA which goes beyond that required by this form, Form 1, or Form 2C you may claim as confidential, but claims for information which are effluent data will be denied.

If you do not assert a claim of confidentiality at the time of submitting the information, EPA may make the information public without further notice to you. Claims of confidentiality will be handled in accordance with EPA's business confidentiality regulations at 40 CFR Part 2.

Definitions

All significant terms used in these instructions and in the form are defined in the glossary found in the General Instructions which accompany Form 1.

EPA ID Number

Fill in your EPA Identification Number at the top of each odd-numbered page of Form 2F. You may copy this number directly from item I of Form 1.

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Item I

You may use the map you provided for Item XI of Form 1 to determine the latitude and longitude of each of your outfalls and the name of the receiving water.

Item II-A

If you check "yes" to this question, complete all parts of the chart, or attach a copy of any previous submission you have made to EPA containing the same information.

Item II-B

You are not required to submit a description of future pollution control projects if you do not wish to or if none is planned.

Item III

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including:

each of its drainage and discharge structures;

the drainage area of each storm water outfall;

paved areas and building within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied;

each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste for less than 90 days under 40 CFR 262.34);

each well where fluids from the facility are injected underground; and

springs, and other surface water bodies which receive storm water discharges from the facility;

Item IV-A

For each outfall, provide an estimate of the area drained by the outfall which is covered by impervious surfaces. For the purpose of this application, impervious surfaces are surfaces where storm water runs off at rates that are significantly higher than background rates (e.g., predevelopment levels) and include paved areas, building roofs, parking lots, and roadways. Include an estimate of the total area (including all impervious and pervious areas) drained by each outfall. The site map required under item III can be used to estimate the total area drained by each outfall.

Item IV-B

Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored, or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of these materials; past and present materials management practices employed, in the last three years, to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied. Significant materials should be identified by chemical name, form (e.g., powder, liquid, etc.), and type of container or treatment unit. Indicate any materials treated, stored, or disposed of together. "Significant materials" includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of CERCLA; any chemical the facility is required to report pursuant to Section 313 of Title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

Item IV-C

For each outfall, structural controls include structures which enclose material handling or storage areas, covering materials, berms, dikes, or diversion ditches around manufacturing, production, storage or treatment units, retention ponds, etc. Nonstructural controls include practices such as spill prevention plans, employee training, visual inspections, preventive maintenance, and housekeeping measures that are used to prevent or minimize the potential for releases of pollutants.

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Item V

Provide a certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by an NPDES permit. Tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics,' as well as other appropriate tests. Part B must include a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test. All non-storm water discharges must be identified in a Form 2C or Form 2E which must accompany this application (see beginning of instructions under section titled "Who Must File Form 2F" for a description of when Form 2C and Form 2E must be submitted).

Item VI

Provide a description of existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years.

Item VII-A, B, and C

These items require you to collect and report data on the pollutants discharged for each of your outfalls. Each part of this item addresses a different set of pollutants and must be completed in accordance with the specific instructions for that part. The following general instructions apply to the entire item.

General Instructions

Part A requires you to report at least one analysis for each pollutant listed. Parts B and C require you to report analytical data in two ways. For some pollutants addressed in Parts B and C, if you know or have reason to know that the pollutant is present in your discharge, you may be required to list the pollutant and test (sample and analyze) and report the levels of the pollutants in your discharge. For all other pollutants addressed in Parts B and C, you must list the pollutant if you know or have reason to know that the pollutant is present in the discharge, and either report quantitative data for the pollutant or briefly describe the reasons the pollutant is expected to be discharged. (See specific instructions on the form and below for Parts A through C.) Base your determination that a pollutant is present in or absent from your discharge on your knowledge of your raw materials, material management practices, maintenance chemicals, history of spills and releases, intermediate and final products and byproducts, and any previous analyses known to you of your effluent or similar effluent.

A. **Sampling:** The collection of the samples for the reported analyses should be supervised by a person experienced in performing sampling of industrial wastewater or storm water discharges. You may contact EPA or your State permitting authority for detailed guidance on sampling techniques and for answers to specific questions. Any specific requirements contained in the applicable analytical methods should be followed for sample containers, sample preservation, holding times, the collection of duplicate samples, etc. The time when you sample should be representative, to the extent feasible, of your treatment system operating properly with no system upsets. Samples should be collected from the center of the flow channel, where turbulence is at a maximum, at a site specified in your present permit, or at any site adequate for the collection of a representative sample.

For pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, and fecal coliform, grab samples taken during the first 30 minutes (or as soon thereafter as practicable) of the discharge must be used (you are not required to analyze a flow-weighted composite for these parameters). For all other pollutants both a grab sample collected during the first 30 minutes (or as soon thereafter as practicable) of the discharge and a flow-weighted composite sample must be analyzed. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period of greater than 24 hours.

All samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area.

A grab sample shall be taken during the first thirty minutes of the discharge (or as soon thereafter as practicable), and a flow-weighted composite shall be taken for the entire event or for the first three hours of the event.

Grab and composite samples are defined as follows:

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Grab sample: An individual sample of at least 100 milliliters collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge. This sample is to be analyzed separately from the composite sample.

Flow-Weighted Composite sample: A flow-weighted composite sample may be taken with a continuous sampler that proportions the amount of sample collected with the flow rate or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire event or for the first three hours of the event, with each aliquot being at least 100 milliliters and collected with a minimum period of fifteen minutes between aliquot collections. The composite must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically. Where GC/MS Volatile Organic Analysis (VOA) is required, aliquots must be combined in the laboratory immediately before analysis. Only one analysis for the composite sample is required.

Data from samples taken in the past may be used, provided that:

All data requirements are met;

Sampling was done no more than three years before submission; and

All data are representative of the present discharge.

Among the factors which would cause the data to be unrepresentative are significant changes in production level, changes in raw materials, processes, or final products, and changes in storm water treatment. When the Agency promulgates new analytical methods in 40 CFR Part 136, EPA will provide information as to when you should use the new methods to generate data on your discharges. Of course, the Director may request additional information, including current quantitative data, if they determine it to be necessary to assess your discharges. The Director may allow or establish appropriate site-specific sampling procedures or requirements, including sampling locations, the season in which the sampling takes place, the minimum duration between the previous measurable storm event and the storm event sampled, the minimum or maximum level of precipitation required for an appropriate storm event, the form of precipitation sampled (snow melt or rainfall), protocols for collecting samples under 40 CFR Part 136, and additional time for submitting data on a case-by-case basis.

B. **Reporting:** All levels must be reported as concentration and mass (note: grab samples are reported in terms of concentration). You may report some or all of the required data by attaching separate sheets of paper instead of filling out pages VII-1 and VII-2 if the separate sheets contain all the required information in a format which is constant with pages VII-1 and VII-2 in spacing and identification of pollutants and columns. Use the following abbreviations in the columns headed "Units."

Concentration		Mass	
ppm	parts per million	lbs	pounds
mg/1	milligrams per liter	ton	tons (English tons)
ppb	parts per billion	mg	milligrams
ug/1	micrograms per liter	g	grams
kg	kilograms	T	tonnes (metric tons)

All reporting of values for metals must be in terms of "total recoverable metal," unless:

(1) An applicable, promulgated effluent limitation or standard specifies the limitation for the metal in dissolved, valent, or total form; or

(2) All approved analytical methods for the metal inherently measure only its dissolved form (e.g., hexavalent chromium); or

(3) The permitting authority has determined that in establishing case-by-case limitations it is necessary to express the limitations on the metal in dissolved, valent, or total form to carry out the provisions of the CWA. If you measure only one grab sample and one flow-weighted composite sample for a given outfall, complete only the "Maximum Values" columns and insert "1" into the "Number of Storm Events Sampled" column. The permitting authority may require you to conduct additional analyses to further characterize your discharges.

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If you measure more than one value for a grab sample or a flow-weighted composite sample for a given outfall and those values are representative of your discharge, you must report them. You must describe your method of testing and data analysis. You also must determine the average of all values within the last year and report the concentration and mass under the "Average Values" columns, and the total number of storm events sampled under the "Number of Storm Events Sampled" columns.

C. Analysis: You must use test methods promulgated in 40 CFR Part 136; however, if none has been promulgated for a particular pollutant, you may use any suitable method for measuring the level of the pollutant in your discharge provided that you submit a description of the method or a reference to a published method. Your description should include the sample holding time, preservation techniques, and the quality control measures which you used. If you have two or more substantially identical outfalls, you may request permission from your permitting authority to sample and analyze only one outfall and submit the results of the analysis for other substantially identical outfalls. If your request is granted by the permitting authority, on a separate sheet attached to the application form, identify which outfall you did test, and describe why the outfalls which you did not test are substantially identical to the outfall which you did test.

Part VII-A

Part VII-A must be completed by all applicants for all outfalls who must complete Form 2F.

Analyze a grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results except use only grab samples for pH and oil and grease. See discussion in General Instructions to Item VII for definitions of grab sample collected during the first thirty minutes of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Part VII-B

List all pollutants that are limited in an effluent guideline which the facility is subject to (see 40 CFR Subchapter N to determine which pollutants are limited in effluent guidelines) or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See discussion in General Instructions to Item VII for definitions of grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Analyze a grab sample collected during the first thirty minutes of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results, except as provided in the General Instructions.

Part VII-C

Part VII-C must be completed by all applicants for all outfalls which discharge storm water associated with industrial activity, or that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard. Use both a grab sample and a composite sample for all pollutants you analyze for in this part except use grab samples for residual chlorine and fecal coliform. The "Average Values" column is not compulsory but should be filled out if data are available. Part C requires you to address the pollutants in Table 2F-2, 2F-3, and 2F-4 for each outfall. Pollutants in each of these Tables are addressed differently.

Table 2F-2: For each outfall, list all pollutants in Table 2F-2 that you know or have reason to believe are discharged (except pollutants previously listed in Part VII-B). If a pollutant is limited in an effluent guideline limitation which the facility is subject to, the pollutant must be analyzed and reported in Part VII-B. If a pollutant in Table 2F-2 is indirectly limited by an effluent guideline limitation through an indicator (e.g., use of TSS as an indicator to control the discharge of iron and aluminum), you must analyze for it and report the data in Part VII-B. For other pollutants listed in Table 2F-2 (those not limited directly or indirectly by an effluent limitation guideline), that you know or have reason to believe are discharged, you must either report quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Table 2F-3: For each outfall, list all pollutants in Table 2F-3 that you know or have reason to believe are discharged. For every pollutant in Table 2F-3 expected to be discharged in concentrations of 10 ppb or greater, you must submit quantitative data. For acrolein, acrylonitrile, 2,4 dinitrophenol, and 2-methyl-4,6 dinitrophenol, you must submit quantitative data if any of these four pollutants is expected to be discharged

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in concentrations of 100 ppb or greater. For every pollutant expected to be discharged in concentrations less than 10 ppb (or 100 ppb for the four pollutants listed above), then you must either submit quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Small Business Exemption - If you are a "small business," you are exempt from the reporting requirements for the organic toxic pollutants listed in Table 2F-3. There are two ways in which you can qualify as a "small business". If your facility is a coal mine, and if your probable total annual production is less than 100,000 tons per year, you may submit past production data or estimated future production (such as a schedule of estimated total production under 30 CFR 795.14(c)) instead of conducting analyses for the organic toxic pollutants. If your facility is not a coal mine, and if your gross total annual sales for the most recent three years average less than $100,000 per year (in second quarter 1980 dollars), you may submit sales data for those years instead of conducting analyses for the organic toxic pollutants. The production or sales data must be for the facility which is the source of the discharge. The data should not be limited to production or sales for the process or processes which contribute to the discharge, unless those are the only processes at your facility. For sales data, in situations involving intracorporate transfer of goods and services, the transfer price per unit should approximate market prices for those goods and services as closely as possible. Sales figures for years after 1980 should be indexed to the second quarter of 1980 by using the gross national product price deflator (second quarter of 1980=100). This index is available in National Income and Product Accounts of the United States (Department of Commerce, Bureau of Economic Analysis).

Table 2F-4: For each outfall, list any pollutant in Table 2F-4 that you know or believe to be present in the discharge and explain why you believe it to be present. No analysis is required, but if you have analytical data, you must report them. Note: Under 40 CFR 117.12(a)(2), certain discharges of hazardous substances (listed at 40 CFR 177.21 or 40 CFR 302.4) may be exempted from the requirements of section 311 of CWA, which establishes reporting requirements, civil penalties, and liability for cleanup costs for spills of oil and hazardous substances. A discharge of a particular substance may be exempted if the origin, source, and amount of the discharged substances are identified in the NPDES permit application or in the permit, if the permit contains a requirement for treatment of the discharge, and if the treatment is in place. To apply for an exclusion of the discharge of any hazardous substance from the requirements of section 311, attach additional sheets of paper to your form, setting forth the following information:

1. The substance and the amount of each substance which may be discharged.
2. The origin and source of the discharge of the substance.
3. The treatment which is to be provided for the discharge by:
   a. An onsite treatment system separate from any treatment system treating your normal discharge;
   b. A treatment system designed to treat your normal discharge and which is additionally capable of treating the amount of the substance identified under paragraph 1 above; or
   c. Any combination of the above.

See 40 CFR 117.12(a)(2) and (c), published on August 29, 1979, in 44 FR 50766, or contact your Regional Office (Table 1 on Form 1, Instructions), for further information on exclusions from section 311.

Part VII-D

If sampling is conducted during more than one storm event, you only need to report the information requested in Part VII-D for the storm event(s) which resulted in any maximum pollutant concentration reported in Part VII-A, VII-B, or VII-C.

Provide flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, the method of flow measurement, or estimation. Provide the data and duration of the storm event(s) sampled, rainfall measurements, or estimates of the storm event which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event.

Part VII-E

List any toxic pollutant listed in Tables 2F-2, 2F-3, or 2F-4 which you currently use or manufacture as an intermediate or final product or byproduct. In addition, if you know or have reason to believe that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is discharged or if you use or manufacture 2,4,5-trichlorophenoxy acetic acid (2,4,5,-T); 2-(2,4,5-trichlorophenoxy) propanoic acid (Silvex, 2,4,5,-TP); 2-(2,4,5-trichlorophenoxy) ethyl, 2,2-dichloropropionate (Erbon); O,O-dimethyl O-(2,4,5-trichlorphenyl) phosphorothioate (Ronnel); 2,4,5-trichlorophenol (TCP); or hexachlorophene (HCP); then list TCDD. The Director may waive or modify the requirement if you demonstrate that it would be unduly burdensome to identify each toxic pollutant and the Director has adequate information to issue your permit. You may not claim this information as confidential; however, you do not have to distinguish between use or production of the pollutants or list the amounts.

Item VIII

Self explanatory. The permitting authority may ask you to provide additional details after your application is received.

Item X

The Clean Water Act provides for severe penalties for submitting false information on this application form.

Section 309(c)(4) of the Clean Water Act provides that "Any person who knowingly makes any false material statement, representation, or certification in any application, . . . shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction of such person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both." 40 CFR Part 122.22 requires the certification to be signed as follows:

(A) For a corporation: by a responsible corporate official. For purposes of this section, a responsible corporate official means (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25,000,000 (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

Note: EPA does not require specific assignments or delegation of authority to responsible corporate officers identified in 122.22(a)(1)(i). The Agency will presume that these responsible corporate officers have the requisite authority to sign permit applications unless the corporation has notified the Director to the contrary. Corporate procedures governing authority to sign permit applications may provide for assignment or delegation to applicable corporate position under 122.22(a)(1)(ii) rather than to specific individuals.

(B) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively; or

(C) For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of EPA).

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Table 2F-1
Codes for Treatment Units

Physical Treatment Processes

1-A	Ammonia Stripping
1-B	Dialysis
1-C	Diatomaceous Earth Filtration
1-D	Distillation
1-E	Electrodialysis
1-F	Evaporation
1-G	Flocculation
1-H	Flotation
1-I	Foam Fractionation
1-J	Freezing
1-K	Gas-Phase Separation
1-L	Grinding (Comminutors)
1-M	Grit Removal
1-N	Microstraining
1-O	Mixing
1-P	Moving Bed Filters
1-Q	Multimedia Filtration
1-R	Rapid Sand Filtration
1-S	Reverse Osmosis (Hyperfiltration)
1-T	Screening
1-U	Sedimentation (Settling)
1-V	Slow Sand Filtration
1-W	Solvent Extraction
1-X	Sorption

Chemical Treatment Processes

2-A	Carbon Adsorption
2-B	Chemical Oxidation
2-C	Chemical Precipitation
2-D	Coagulation
2-E	Dechlorination
2-F	Disinfection (Chlorine)
2-G	Disinfection (Ozone)
2-H	Disinfection (Other)
2-I	Electrochemical Treatment
2-J	Ion Exchange
2-K	Neutralization
2-L	Reduction

Biological Treatment Processes

3-A	Activated Sludge
3-B	Aerated Lagoons
3-C	Anaerobic Treatment
3-D	Nitrification-Denitrification
3-E	Pre-Aeration
3-F	Spray Irrigation/Land Application
3-G	Stabilization Ponds
3-H	Trickling Filtration

Other Processes

4-A	Discharge to Surface Water
4-B	Ocean Discharge Through Outfall
4-C	Reuse/Recycle of Treated Effluent
4-D	Underground Injection

Sludge Treatment and Disposal Processes

5-A	Aerobic Digestion
5-B	Anaerobic Digestion
5-C	Belt Filtration
5-D	Centrifugation
5-E	Chemical Conditioning
5-F	Chlorine Treatment
5-G	Composting
5-H	Drying Beds
5-I	Elutriation
5-J	Flotation Thickening
5-K	Freezing
5-L	Gravity Thickening
5-M	Heat Drying
5-N	Heat Treatment
5-O	Incineration
5-P	Land Application
5-Q	Landfill
5-R	Pressure Filtration
5-S	Pyrolysis
5-T	Sludge Lagoons
5-U	Vacuum Filtration
5-V	Vibration
5-W	Wet Oxidation

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Table 2F-2

Conventional and Nonconventional Pollutants

Bromide
Chlorine, Total Residual
Color
Fecal Coliform
Fluoride
Nitrate-Nitrite
Nitrogen, Total Organic
Oil and Grease
Phosphorus, Total
Radioactivity
Sulfate
Sulfide
Surfactants
Aluminum, Total
Barium, Total
Boron, Total
Cobalt, Total
Iron, Total
Magnesium, Total
Molybdenum, Total
Manganese, Total
Tin, Total
Titanium, Total

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Table 2F-3

Toxic Pollutants

Toxic Pollutants and Total Phenols

Antimony, Total
Arsenic, Total
Beryllium, Total
Cadmium, Total
Chromium, Total
Copper, Total
Lead, Total
Mercury, Total
Nickel, Total
Selenium, Total
Silver, Total
Thallium, Total
Zinc, Total
Cyanide, Total
Phenols, Total

GC/MS Fraction Volatiles Compounds

Acrolein
Acrylonitrile
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-Chloroethylvinyl Ether
Chloroform
Dichlorobromomethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropylene
Ethylbenzene
Methyl Bromide
Methyl Chloride
Methylene Chloride
1,1,2,2,-Tetrachloroethane
Tetrachloroethylene
Toluene
1,2-Trans-Dichloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl Chloride

Acid Compounds

2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
4,6-Dinitro-O-Cresol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
p-Chloro-M-Cresol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol
2-methyl-4,6 dinitrophenol

Base/Neutral

Acenaphthene
Acenaphthylene
Anthracene
Benzidine
Benzo(a)anthracene
Benzo(a)pyrene
3,4-Benzofluoranthene
Benzo(ghi)perylene
Benzo(k)fluoranthene
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl)phthalate
4-Bromophenyl Phenyl Ether
Butylbenzyl Phthalate
2-Chloronaphthalene
4-Chlorophenyl Phenyl Ether
Chrysene
Dibenzo(a,h)anthracene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
Diethyl Phthalate
Dimethyl Phthalate
Di-N-Butyl Phthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-N-Octylphthalate
1,2-Diphenylhydrazine (as Azobenzene)
Fluroranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Isophorone
Napthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodi-N-Propylamine
N-Nitrosodiphenylamine
Phenanthrene
Pyrene
1,2,4-Trichlorobenzene

Pesticides

Aldrin
Alpha-BHC
Beta-BHC
Gamma-BHC
Delta-BHC
Chlordane
4,4'-DDT
4,4'-DDE
4,4'-DDD
Dieldrin
Alpha-Endosulfan
Beta-Endosulfan
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
PCB-1242
PCB-1254
PCB-1221
PCB-1232
PCB-1248
PCB-1260
PCB-1016
Toxaphene

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Table 2F-4
Hazardous Substances

Toxic Pollutant

Asbestos

Hazardous Substances

Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos

Cresol
Crotonaldehyde

Cyclohexane
2,4-D (2,4-Dichlorophenoxyacetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid
Dichlorvos
Diethyl amine
Dimethyl amine

Dinitrobenzene
Diquat
Disulfoton
Diuron
Epichlorohydrin
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion
Isoprene
Isopropanolamine
Kelthane

Kepone
Malathion

Mercaptodimethur
Methoxychlor

Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mevinphos
Mexacarbate
Monoethyl amine
Monomethyl amine
Naled

Napthenic acid
Nitrotoluene
Parathion
Phenolsulfonate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Strontium
Strychnine
Styrene
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)
TDE (Tetrachlorodiphenyl ethane)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofan
Triethylamine

Trimethylamine
Uranium
Vanadium
Vinyl acetate
Xylene
Xylenol
Zirconium

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Form Approved OMB No. 2040-0086 Approval expires 5-31-92

FORM 1 GENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

[illegible]

I. EPA I.D. NUMBER

F | | D

I. EPA I.D. NUMBER

III. FACILITY NAME

V. FACILITY MAILING ADDRESS

VI. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

GENERAL INSTRUCTIONS

[illegible] items I, III, V, and VI [illegible]

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS. Complete A through J [illegible] to the EPA. [illegible]

SPECIFIC QUESTIONS	YES	NO	[illegible]	SPECIFIC QUESTIONS	YES	NO	[illegible]
A. Is this facility a [illegible] (FORM 2A)				B. [illegible] to waters of the U.S.? (FORM 2B)			
C. Is this a facility which currently results in [illegible] to waters of the U.S. other than those described in A or B above? (FORM 2C)				D. Is this a proposed facility (other than those described in A or B above) which will result in a discharge to waters of the U.S.? (FORM 2D)			
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)				F. Do you or will you inject at this facility [illegible] (FORM 4)			
G. Do you or will you inject at this facility any [illegible] hydrocarbons? (FORM 4)				H. Do you or will you inject at this facility fluids for [illegible] (FORM 4)			
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)				J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)			

III. NAME OF FACILITY

1 SKIP

IV. FACILITY CONTACT

A. NAME & TITLE (last, first, & title)

B. PHONE (area code & no.)

2

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX

3

B. CITY OR TOWN | C. STATE | D. ZIP CODE

4

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER

5

B. COUNTY NAME

C. CITY OR TOWN | D. STATE | E. ZIP CODE | F. COUNTY CODE

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CONTINUE ON REVERSE

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CONTINUED FROM THE FRONT

VII. SIC CODES (4-digit, in order of priority)

A. FIRST		B. SECOND	
7	(specify)	7	(specify)

C. THIRD		D. FOURTH	
7	(specify)	7	(specify)

VIII. OPERATOR INFORMATION

A. NAME

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B. Is the name listed in Item VIII-A also the owner? ☐ YES ☐ NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)

F = FEDERAL
S = STATE
P = PRIVATE
M = PUBLIC (other than federal or state)
O = OTHER (specify)

(specify)

D. PHONE (area code & no.)

A

E. STREET OR P.O. BOX

F. CITY OR TOWN | G. STATE | H. ZIP CODE

8

IX. INDIAN LAND

Is the facility located on Indian lands? ☐ YES ☐ NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water)	D. PSD (Air Emissions from Proposed Sources)	
9 N	9 P	
B. UIC (Underground Injection of Fluids)	**E. OTHER (specify)**	
9 U	9	(specify)
C. RCRA (Hazardous Wastes)	**E. OTHER (specify)**	
9 R		(specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED

COMMENTS FOR OFFICIAL USE ONLY

C

EPA Form 3510-1 (6-80)

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APPENDIX B

NOAA WEATHER RADIO INFORMATION

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NOAA WEATHER RADIO MANUFACTURERS LIST	
RADIO SHACK Weather Radio 2617 West Seventh St. Fort Worth, TX 76107 (817) 390-3011	✓ ●
GENERAL ELECTRIC Model 7-2934 (800) 626-2000	✓ ●
UNIDEN BEARCAT Bearcat Weather Alert 6345 Castleway Court Indianapolis, IN 46250 (800) 722-6637	■
ELECTROLERT Weatheralert Forecaster 4949 South 25A Tipp City, OH 45371 (513) 667-2461	✓ ● ■
SPRINGFIELD INSTRUMENTS Talking Weather Center/Station 76 Passaic St. Wood-Ridge, NJ 07075 (201) 777-2900	■
WOODSON ELECTRONICS Plectron 505 Lincoln St. Overton, NE 68863 (308) 987-2404	X
GORMAN - REDLICH MANUFACTURING James T. Gorman 257 West Union St. Athens, OH 45701 (617) 593-3150	X

PRICE RANGE:

- ✓ Under $50
- ■ $50 to $100
- X Over $100
- ● Features AM/FM model radios with weather band

PLEASE NOTE, THIS LIST IS NOT ALL-INCLUSIVE, AND INCLUSION ON THIS LIST DOES NOT CONSTITUTE ENDORSEMENT OF ANY COMPANY BY EPA OR THE U.S. GOVERNMENT.

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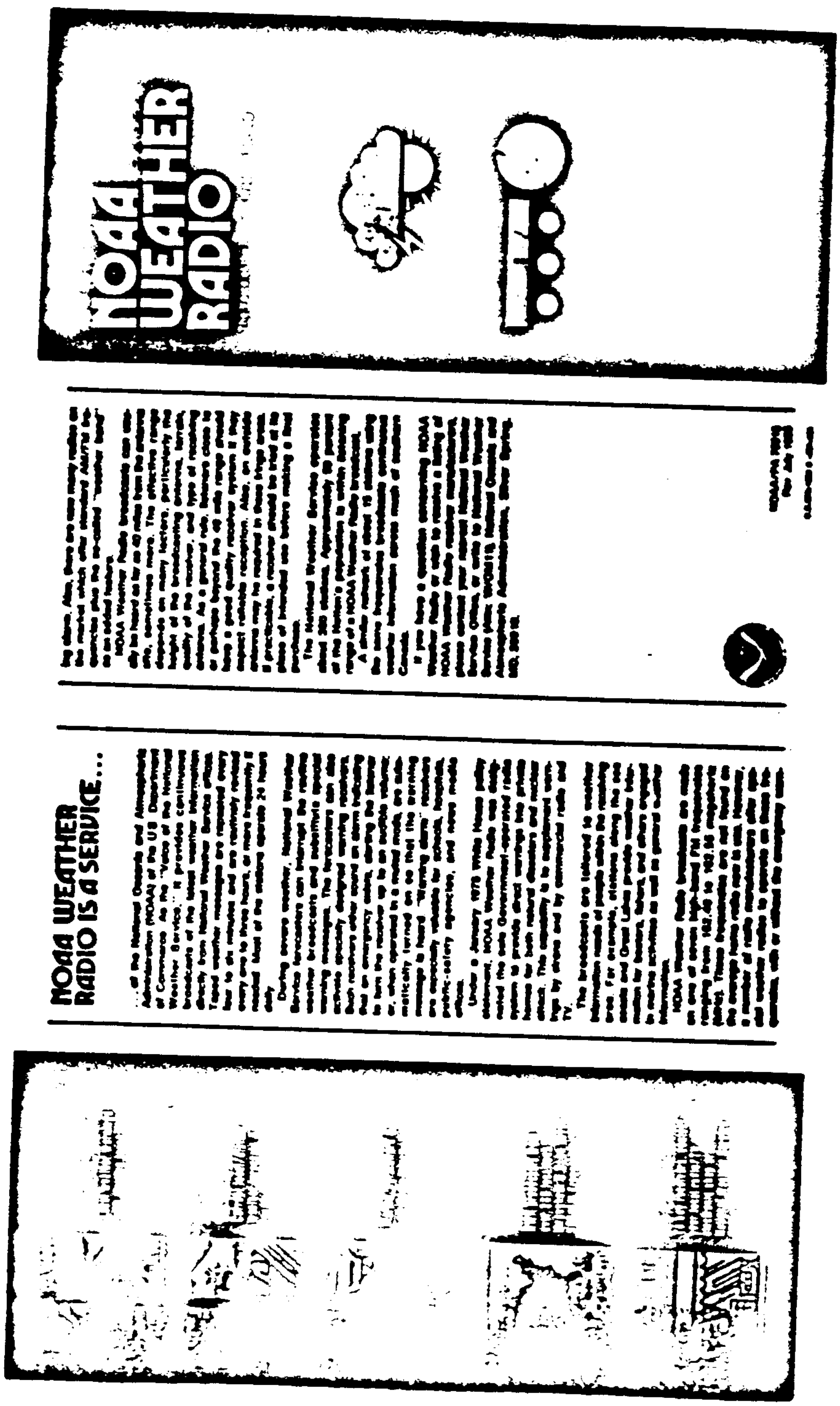
NOAA WEATHER RADIO
NOAA WEATHER RADIO IS a SERVICE...

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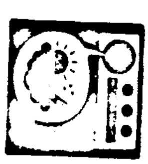

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TECHNICAL APPENDIX C

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, HOLDING TIMES AND 40 CODE OF FEDERAL REGULATIONS (CFR) PART 136

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REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	Container(1)	Preservative (2), (3)	Maximum Holding Time (4)
Bacterial Tests			
Coliform, fecal and total	P, G	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	6 hours
Fecal streptococci	P, G	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	6 hours
Inorganic Tests			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical oxygen demand	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C NaOH to pH>12 0.6g ascorbic acid (5)	14 days (6)
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH<2 H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic Nitrogen	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Metals (7)			
Chromium VI	P, G	Cool, 4°C	28 hours
Mercury	P, G	HNO_3 to pH<2	28 hours
Metals, except above	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	Container(1)	Preservative (2), (3)	Maximum Holding Time (4)
Nitrate-nitrite	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
O&G	G	Cool, 4°C H_2SO_4 or HCl to pH<2	28 days
Organic carbon	P, G	Cool, 4°C HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately Cool, 4°C	48 hours
Oxygen, Dissolved Probe	G bottle and top	None required	Analyze immediately
Dissolved oxygen, Winkler method	G bottle and top	Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours

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REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	Container(1)	Preservative (2), (3)	Maximum Holding Time (4)
Organic Tests (8)			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	14 days
Purgeable aromatics	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5) HCl to pH<2 (9)	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5) Adjust pH to 4-5 (10)	14 days
Phenols (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Benzidines (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction (13)
Phthalate esters (11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines (11), (14)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
PCBs (11) acrylonitrite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and isophorone (11)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $NA_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Polynuclear aromatic hydrocarbons (11)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Haloethers (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Chlorinated hydrocarbons (11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Pesticides Tests			
Pesticides (11)	G, Teflon-lined cap	Cool, 4°C pH 5-9 (15)	7 days until extraction, 40 days after extraction
Radiological Tests			
Alpha, beta, and radium	P, G	HNO_3 to pH<2	6 months

40 CFR 136.3 TABLE II NOTES	
(1)	Polyethylene (P) or Glass (G).
(2)	Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3)	When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weights or less (pH about 12.30 or less).
(4)	Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.
(5)	Should only be used in the presence of residual chlorine.
(6)	Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7)	Samples should be filtered immediately on-site before adding preservative for dissolved metals.
(8)	Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9)	Sample receiving no pH adjustment must be analyzed within seven days of sampling.
(10)	The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

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40 CFR 136.3 TABLE II NOTES

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark,and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12, 13 (re the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O^3$.

Source: 40 CFR 136.3 Table II

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TABLE IA—LIST OF APPROVED BIOLOGICAL TEST PROCEDURES

Parameter and units	Method [1]	EPA [2]	Reference (Method Number or Page): Standard Methods 15th Ed.	ASTM	USGS
Bacteria:					
1. Coliform (fecal) number per 100 mL	MPN, 5 tube, 3 dilution; or, membrane filter (MF) [4], single step.	Page 132.	908C		
2. Coliform (fecal) in presence of chlorine number per 100 mL	MPN, 5 tube, 3 dilution; or, MF [4]; single step. [5]	p. 124	909		B-0050-77.
3. Coliform (total), number per 100 mL	MPN, 5 tube, 3 dilution; or, MF [4] single step or two step.	p. 114	908A		
		p. 108	909A		B-0025-77.
4. Coliform (total) in presence of chlorine, number per 100 mL	MPN, 5 tube, dilution; or MF [4] with enrichment.	p. 114	908A		
		p. 111	909 (A+A.5a)		
5. Fecal streptococci, number per 100 mL	MPN, 5 tube, 3 dilution; MF [4]; or, plate count.	p. 139	910A		
	p. 136		910B		B0055-77.[6]
	p. 143		910C		

Table IA Notes

[1] The method used must be specified when results are reported.

[2] "Microbiological Methods for Monitoring the Environment, Water and Waste, 1978", EPA-600/8-78-017, U.S. Environmental Protection Agency.

[3] Greeson, P.E., et al. "Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples, "U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A4, Laboratory Analysis, 1977.

[4] 0.45 μm membrane filter or other pore size certified by the manufacturer to fully retain organisms to be cultivated, and free of extractables which could interfere with their growth and development.

[5] Since the membrane filter technique usually yields low and variable recovery from chlorinated wastewaters, the MPN method will be required to resolve any controversies.

[6] Approved only if dissolution of the KF Streptococcus Agar (Section 5.1, USGS Method B-0055-77) is made in a boiling water bath to avoid scorching of the medium.

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES

Parameter, units and method	Reference (method No. or page): EPA 1979 [3,4]	Std. methods 16th ED	ASTM	USGS [1]	Other
1. Acidity, as $CaCO_3$, mg/L: Electrometric end point or phenolphthalein end point.	305.1	402(4.a)	1067-88(E)		
2. Alkalinity, as $CaCO_3$, mg/L:					
Electrometric or colorimetric titration to pH 4.5, manual, or.	310.1	403	D1067-88(B)	I-1030-84	33.014[2].
Automated	310.2			I-2030-84	
3. Aluminum—Total,[5] mg/L: Digestion [6] followed by:					
AA direct aspiration	202.1	303C		I-3051-85	
AA furnace	202.2	304			
Inductively coupled plasma (ICP)					200.7.[4]
Direct current plasma (DCP) or					Note 32.
Colorimetric (Eriochrome cyanine R)		306B			
4. Ammonia (as N), mg/L: Manual distillation (at pH 9.5) [6] followed by:	350.2	417A			33.057.[2]
Nesslerization	350.2	417B	D1426-79(A)	I-3520-84	33.057.[2]
Titration	350.2	417D			
Electrode	350.3	417 E or F	D1426-79(D)		
Automated phenate or	350.1	417G	D1426-79(C)	I-4523-84	
Automated electrode					Note 6.
5. Antimony—Total [5], mg/L: Digestion [6] followed by:					
AA direct aspiration	204.1	303A			
AA furnace, or	204.2	304			
Inductively coupled plasma					200.7.[4]
6. Arsenic—Total [5], mg/L: Digestion [6] followed by	206.5				
AA gaseous hydride	206.3	303E	D2972-84(B)	I-3062-84	
AA furnace	206.2	304			
Inductively coupled plasma, or					200.7.[4]
Colorimetric (SDDC)	206.4	307B	D2972-84(A)	I-3060-84	
7. Barium—Total,[5] mg/L: Digestion [6] followed by:					
AA direct aspiration	208.1	303C		I-3084-85	
AA furnace	208.2	304			
ICP, or					200.7.[4]
DCP					Note 32.
8. Beryllium—Total,[5] mg/L: Digestion [6] followed by:					
AA direct aspiration	210.1	303C	D3645-84(A)	I-3095-85	
AA furnace	210.2	304			

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page): EPA 1979[1-3]	Std. methods 16th ED	ASTM	USGS[1]	Other
ICP					
DCP, or					200.7.[4]
Colorimetric (aluminon)		309B			Note 33.
9. Biochemical oxygen demand (BOD$_5$), mg/L:					
Dissolved Oxygen Depletion	405.1	507		I-1578-78[8]	973.44[3], p. 17.[9]
10. Boron—Total, mg/L:					
Colorimetric (curcumin)	212.3	404A		I-3112-85	
ICP, or					
DCP					200.7.[4]
11. Bromide, mg/L: Titrimetric	320.1		D1246-82(C)	I-1125-85	Note 33.
12. Cadmium—Total,[5] mg/L; Digestion[6] followed by:					p. S44.[10]
AA direct aspiration	213.1	303 A or B	D3557-84 (A or B)	I-3135-85 or I-3136-85	974.27[3]
AA furnace	213.2	304			p. 37.[9]
ICP					
DCP					200.7.[4]
Voltametry,[11] or					Note 33.
Colorimetric (Dithizone)		310B	D3557-84(C)		
13. Calcium—Total,[5] mg/L; Digestion[6] followed by:					
AA direct aspiration	215.1	303A	D511-84(B)	I-3152-85	
ICP					
DCP, or					200.7.[4]
Titrimetric (EDTA)	215.2	311C	D511-84(A)		Note 33.
14. Carbonaceous biochemical oxygen demand (CBOD$_5$), mg/L[12]: Dissolved Oxygen Depletion with nitrification inhibitor.		507(5.e.6)			
15. Chemical oxygen demand (COD), mg/L:					
Titrimetric, or	410.1, 410.2, or 410.3	508A	D1252-83	I-3560-85 or I-3562-85	973.46[3], p. 17.[9]
Spectrophotometric, manual or automated	410.4			I-3561-85	Notes 18 or 19.
16. Chloride, mg/L:					
Titrimetric (silver nitrate)		407A	D512-81(B)	I-1183-85	
or (Mercuric nitrate), or	325.3	407B	D512-81(A)	I-1184-85	973.51.[3]
Colorimetric, manual or			D512-81(C)	I-1187-85	
Automated (Ferricyanide)	325.1, or 325.2	407D		I-2187-85	
17. Chlorine—Total residual, mg/L: Titrimetric:					
Amperometric direct	330.1	408C	D1253-76(A)		
Starch end point direct	330.3	408A	D1253-76(B)		
Back titration either end point[14], or	330.2	408B	Part 16.2		
DPD-FAS	330.4	408D			
Spectrophotometric, DPD	330.5	408E			
Or Electrode					Note 15.
18. Chromium VI dissolved, mg/L; 0.45 micron filtration followed by:					
AA chelation-extraction, or	218.4	303B		I-1232-85	
Colorimetric (Diphenylcarbazide)				I-1230-85	307B.[10]
19. Chromium—Total,[5] mg/L; Digestion[6] followed by:					
AA direct aspiration	218.1	303A	D1687-84(D)	I-3236-85	974.27.[3]
AA chelation-extraction	218.3	303B			
AA furnace	218.2	304			
ICP					
DCP, or					200.7.[4]
Colorimetric (Diphenylcarbazide)		312B	D1687-84(A)		Note 33.
20. Cobalt—Total,[5] mg/L; Digestion[6] followed by:					
AA direct aspiration	219.1	303 A or B	D3558-84 (A or B)	I-3239-85 or I-3240-85	p. 37.[9]
AA furnace	219.2	304			
ICP, or					
DCP					200.7.[4]
21. Color platinum cobalt units or dominant wavelength, hue, luminance purity:					Note 33.
Colorimetric (ADMI), or	110.1	204C			
(Platinum cobalt), or	110.2	204A			Note 17.
Spectrophotometric	110.3	204B		I-1250-85	

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page): EPA 1979 [34]	Std. methods 16th ED	ASTM	USGS [1]	Other
22. Copper—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	220.1	303 A or B	D1688-84 (D or E)	I-3270-85 or I-3271-85	33.089,[3] p. 37.[9]
AA furnace	220.2	304			
ICP					
DCP, or					200.7.[4]
Colorimetric (Neocuproine), or (Bicinchoninate).		313B	D1688-84(A)		Note 20. Note 19.
23. Cyanide—Total, mg/L: Manual distillation with $MgCl_2$ followed by		412B			
Titrimetric, or		412C			
Spectrophotometric, manual or	335.2	412D	D2036-82(A)	I-3300-85	p. 22.[9]
Automated [11]	335.3		D2036-82(A)		
24. Cyanide amenable to chlorination, mg/L: Manual distillation with $MgCl_2$ followed by titrimetric or spectrophotometric.	335.1	412F	D2036-82(B)		
25. Fluoride—Total, mg/L: Manual distillation[6] followed by:		413A			
Electrode, manual or	340.2	413B	D1179-72(B)		
Automated.				I-4327-84	
Colorimetric (SPADNS)	340.1	413C	D1179-72(A)		
Or Automated complexone	340.3	413E			
26. Gold—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	231.1	303A			
AA furnace, or	231.2	304			
DCP					Note 20.
27. Hardness—Total, as $CaCO_3$, mg/L:					
Automated colorimetric	130.1				
Titrimetric (EDTA), or Ca plus Mg as their carbonates, by inductively coupled plasma or AA direct aspiration. (See Parameters 13 and 33.).	130.2	314B	D1126-86	I-1338-85	33.082.[3]
28. Hydrogen ion (pH), pH units:					
Electrometric, measurement, or	150.1	423	D1293-84 (A or B)	I-1586-85	33.083.[3]
Automated electrode					
29. Iridium—Total[5], mg/L; Digestion[6] followed by:					Note 20.
AA direct aspiration, or	235.1	303A			
AA furnace	235.2	304			
30. Iron—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	236.1	303 A or B	D1068-84 (C or D)	I-3381-85	33.089.[3]
AA furnace	236.2	304			
ICP					
DCP, or					200.7.[4]
Colorimetric (Phenanthroline)		315B	D1068-84(A)		Note 20.
31. Kjeldahl nitrogen—Total, (as N), mg/L: Digestion and distillation followed by:	351.3	420 A or B	D3590-84(A)		Note 21.
Titration	351.3	417D	D3590-84(A)		
Nesslerization	351.3	417B	D3590-84(A)		33.051.[3]
Electrode	351.3	417 E or F			
Automated phenate	351.1				
Semi-automated block digestor, or	351.2			I-4551-78 [8]	
Potentiometric	351.4		D3590-84(A)		
			D3590-84(A)		
32. Lead—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	239.1	303 A or B	D3559-84 (A or B)	I-3399-85	33.089.[3]
AA furnace	239.2	304			
ICP					
DCP					200.7.[4]
Voltametry,[14] or					Note 20.
Colorimetric (Dithizone)		316B	D3559-85(C)		
33. Magnesium—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	242.1	303A	D511-84(B)	I-3447-85	33.089.[3]
ICP					200.7.[4]
DCP, or					Note 20.
Gravimetric		318B	D511-77(A)		
34. Manganese—Total,[5] mg/L; Digestion [6] followed by:					
AA direct aspiration	243.1	303 A or B	D858-84 (B or C)	I-3454-85	33.089.[3]
AA furnace	243.2	304			
ICP					
DCP, or					200.7.[4]
Colorimetric (Persulfate) or					Note 20.
(Periodate)		319B	D858-84(A)		33.126.[3] Note 20.

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page): EPA 1979 [35]	Std methods 16th ED	ASTM	USGS [1]	Other
35. Mercury—Total [5], mg/L:					
Cold vapor, manual or	245.1	303F	D3223-80	I-3462-84	30.005 [8]
Automated	245.2				
36. Molybdenum—Total [5] mg/L: Digestion [6] followed by:					
AA direct aspiration	246.1	303C		I-3490-85	
AA furnace	246.2	304			
ICP, or					200.7 [4]
DCP					Note 28.
37. Nickel—Total [5] mg/L: Digestion [6] followed by:					
AA direct aspiration	249.1	303 A or B	D1886-84 (C or D).	I-3499-85	
AA furnace	249.2	304			
ICP					200.7 [4]
DCP, or					Note 28.
Colorimetric (Heptoxime)		321B			
38. Nitrate (as N), mg/L: Colorimetric (Brucine sulfate), or Nitrate-nitrite N minus Nitrite N (See parameters 39 and 40).	352.1		D992-71		33.300 [8], 419D [10], p. 28 [9]
39. Nitrate-nitrite (as N), mg/L: Cadmium reduction, Manual or	353.3	418C	D3867-85(B)		
Automated, or	353.2	418F	D3867-85(A)	I-4545-84	
Automated hydrazine	353.1				
40. Nitrite (as N), mg/L: Spectrophotometric:					
Manual or	354.1	419	D1254-67		Note 24.
Automated (Diazotization)				I-4540-84	
41. Oil and grease—Total recoverable, mg/L: Gravimetric (extraction).	413.1	503A			
42. Organic carbon—Total (TOC), mg/L: Combustion or oxidation.	415.1	505	D2579-85 (A or B).		33.044 [8], p. 4 [20]
43. Organic nitrogen (as N) mg/L: Total Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4).					
44. Orthophosphate (as P), mg/L: Ascorbic acid method:					
Automated or	365.1	424G		I-4601-84	33.116 [8]
Manual single reagent	365.2	424F	D515-88(A)		33.111 [8]
or Manual two reagent	365.3				
45. Osmium—Total [5], mg/L: Digestion [6] followed by:					
AA direct aspiration, or	252.1	303C			
AA furnace	252.2	304			
46. Oxygen, dissolved, mg/L: Winkler (Azide modification), or	360.2	421B	D888-81(C)	I-1575-78 [8]	33.008 [8]
Electrode	360.1	421F		I-1576-78 [8]	
47. Palladium—Total [5] mg/L: Digestion [6] followed by:					
AA direct aspiration	253.1				p. S27. [9]
AA furnace	253.2				p. S28. [9]
DCP					Note 28.
48. Phenols, mg/L:					
Manual distillation [26]	420.1		D1783-80 (A or B).		Note 29.
Followed by:					
Colorimetric (4AAP) manual, or	420.1				Note 29.
Automated [19]	420.2				
49. Phosphorus (elemental) mg/L: Gas-liquid chromatography.					Note 27.
50. Phosphorus—Total, mg/L: Persulfate digestion followed by	365.2	424C(III)			33.111 [8]
Manual or	365.2 or 365.3	424F	D515-88(A)		
Automated ascorbic acid reduction, or	365.1	424G		I-4600-84	33.116 [8]
Semi-automated block digestor	365.4				
51. Platinum—Total [5] mg/L: Digestion [6] followed by:					
AA direct aspiration	255.1	303A			
AA furnace	255.2	304			
DCP					Note 28.
52. Potassium—total [5], mg/L: Digestion followed by:					
AA direct aspiration	258.1	303A		I-3630-84	33.103 [8]
Inductively coupled plasma					200.7 [4]
Flame photometric, or		322B	D1428-82(A)		
Colorimetric (Cobaltinitrite)					317B [10]
53. Residue—Total, mg/L: Gravimetric, 103–105°C.	160.3	209A		I-3750-84	
54. Residue—filterable, mg/L: Gravimetric 180°C	160.1	209B		I-1750-84	
55. Residue—nonfilterable (TSS), mg/L: Gravimetric, 103–105°C post washing of residue.	160.2	209C		I-3765-84	

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	EPA 1979	Std. methods 16th ED	ASTM	USGS	Other
56. Residue—settleable, mg/L: Volumetric, (Imhoff cone) or gravimetric.	160.5	209E		1	
57. Residue—Volatile, mg/L: Gravimetric, 550°C.	160.4	209D		I-3753-84	
58. Rhodium—Total, mg/L: Digestion followed by:					
AA direct aspiration, or	265.1	303A			
AA furnace	265.2	304			
59. Ruthenium—Total, mg/L: Digestion followed by:					
AA direct aspiration, or	267.1	303A			
AA furnace	267.2	304			
60. Selenium—Total, mg/L: Digestion followed by:					
AA furnace	270.2	304			
Inductively coupled plasma, or					200.7
AA gaseous hydride	270.3	303E	D3859-84(A)	I-3667-84	
61. Silica—Dissolved, mg/L: 0.45 micron filtration followed by:					
Colorimetric, Manual or	370.1	425C	D859-80(B)	I-1700-84	
Automated (Molybdosilicate), or				I-2700-84	
Inductively coupled plasma					200.7
62. Silver—Total, mg/L: Digestion followed by:					
AA direct aspiration	272.1	303 A or B		I-3720-85	33.050, p. 37
AA furnace	272.2	304			
Colorimetric (Dithizone)					310B
ICP, or					200.7
DCP					Note 35
63. Sodium—Total, mg/L: Digestion followed by:					
AA direct aspiration	273.1	303A		I-3735-85	33.107
ICP					200.7
DCP, or					Note 35
Flame photometric		325B	D1428-82(A)		
64. Specific conductance, micromhos/cm at 25°C: Wheatstone bridge	120.1	205	D1125-82(A)	I-1780-84	33.082
65. Sulfate (as SO_4), mg/L:					
Automated colorimetric (barium chloranilate).	375.1				
Gravimetric, or	375.3	426 A or B	D516-82(A)		33.124
Turbidimetric	375.4		D516-82(B)		426C
66. Sulfide (as S), mg/L:					
Titrimetric (iodine) or	376.1	427D			
Colorimetric (methylene blue)	376.2	427C		I-3840-84	228A
67. Sulfite (as SO_3), mg/L: Titrimetric (iodine-iodate).	377.1	428A	D1339-84(C)		
68. Surfactants, mg/L: Colorimetric (methylene blue).	425.1	512B	D2330-82(A)		
69. Temperature, °C: Thermometric	170.1	212			Note 31
70. Thallium—Total, mg/L: Digestion followed by:					
AA direct aspiration	279.1	303A			
AA furnace, or	279.2	304			
Inductively coupled plasma					200.7
71. Tin—Total, mg/L: Digestion followed by:					
AA direct aspiration, or	282.1	303A		I-3850-78	
AA furnace.	282.2	304			
72. Titanium—Total, mg/L: Digestion followed by:					
AA direct aspiration	283.1	303C			
AA furnace	283.2	304			
DCP					
73. Turbidity, NTU: Nephelometric	180.1	214A	D1889-81	I-3860-84	Note 35
74. Vanadium—Total, mg/L: Digestion followed by:					
AA direct aspiration	286.1	303C			
AA furnace	286.2	304			
ICP					
DCP, or					200.7
Colorimetric (Gallic acid)		327B	D3373-84(A)		Note 35
75. Zinc—Total, mg/L: Digestion followed by:					
AA direct aspiration	289.1	303 A or B	D1691-84 (C or D)	I-3900-85	33.050, p. 37
AA furnace	289.2	304			
ICP					
DCP, or					200.7
Colorimetric (Dithizone) or		328C			Note 35
(Zincon)					Note 35

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

[1] "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments," U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 85–495, 1986, unless otherwise stated.

[2] "Official Methods of Analysis of the Association of Official Analytical Chemists," methods manual, 14th ed. (1985).

[3] For the determination of total metals the sample is not filtered before processing. A digestion procedure is required to solubilize suspended material and to destroy possible organic-metal complexes. Two digestion procedures are given in "Methods for Chemical Analysis of Water and Wastes, 1979." One (section 4.1.3), is a vigorous digestion using nitric acid. A less vigorous digestion using nitric and hydrochloric acids (section 4.1.4) is preferred; however, the analyst should be cautioned that this mild digestion may not suffice for all sample types. Particularly, if a colorimetric procedure is to be employed, it is necessary to ensure that all organo-metallic bonds be broken so that the metal is in a reactive state. In those situations, the vigorous digestion is to be preferred making certain that at no time does the sample go to dryness. Samples containing large amounts of organic materials would also benefit by this vigorous digestion. Use of the graphite furnace technique, inductively coupled plasma, as well as determinations for certain elements such as arsenic, the noble metals, mercury, selenium, and titanium require a modified digestion and in all cases the method write-up should be consulted for specific instruction and/or cautions.

NOTE: If the digestion included in one of the other approved references is different than the above, the EPA procedure must be used.

Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter. Following filtration of the sample, the referenced procedure for total metals must be followed. Sample digestion for dissolved metals may be omitted for AA (direct aspiration or graphite furnace) and ICP analyses provided the sample solution to be analyzed meets the following criteria:

a. has a low COD (<20)
b. is visibly transparent with a turbidity measurement of 1 NTU or less,
c. is colorless with no perceptible odor, and
d. is of one liquid phase and free of particulate or suspended matter following acidification.

[4] The full text of Method 200.7, "Inductively Coupled Plasma Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes," is given at Appendix C of this Part 136.

[5] Manual distillation is not required if comparability data on representative effluent samples are on company file to show that this preliminary distillation step is not necessary; however, manual distillation will be required to resolve any controversies.

[6] Ammonia, Automated Electrode Method, Industrial Method Number 379-75 WE, dated February 19, 1976, Technicon AutoAnalyzer II, Technicon Industrial Systems, Tarrytown, NY, 10591.

[7] The approved method is that cited in "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", USGS TWRI, Book 5, Chapter A1 (19[illegible]).

[8] American National Standard on Photographic Processing Effluents, Apr. 2, 1975. Available from ANSI, 1430 Broadway, New York, NY 1[illegible].

[9] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[10] The use of normal and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.

[11] Carbonaceous biochemical oxygen demand ($CBOD_5$) must not be confused with the traditional BOD_5 test which measures "total BOD." The addition of the nitrification inhibitor is not a procedural option, but must be included to report the $CBOD_5$ parameter. A discharger whose permit requires reporting the traditional BOD_5 may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states $CBOD_5$ is required, can the permittee report data using the nitrification inhi[illegible].

[12] OIC Chemical Oxygen Demand Method, Oceanography International Corporation, 512 West Loop, P.O. Box 2980, College Station, TX 7[illegible].

[13] Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[14] The back titration method will be used to resolve controversy.

[15] Orion Research Instruction Manual, Residual Chlorine Electrode Model 97–70, 1977, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 021[illegible].

[16] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition, 197[illegible].

[17] National Council of the Paper Industry for Air and Stream Improvement, (Inc.) Technical Bulletin 253, December 1971.

[18] Copper, Biscinchoninate Method, Method 8506, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO [illegible].

[19] After the manual distillation is completed, the autoanalyzer manifolds in EPA Methods 335.3 (cyanide) or 420.2 (phenols) are simplified by connecting the re-sample line directly to the sampler. When using the manifold setup shown in Method 335.3, the buffer 6.2 should be replaced with the buffer 7.6 found in Method 335.2.

[20] Hydrogen Ion (pH) Automated Electrode Method, Industrial Method Number 378-75WA, October 1976, Technicon AutoAnalyzer II, Technicon Industrial Systems, Tarrytown, NY 1[illegible].

[21] Iron, 1,10-Phenanthroline Method, Method 8008, 1980, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[22] Manganese, Periodate Oxidation Method, Method 8034, Hach Handbook of Wastewater Analysis, 1979, pages 2-113 and 2-117, Hach Chemical Company, Loveland, CO [illegible]7.

[23] Goerlitz, D., Brown, E., "Methods for Analysis of Organic Substances in Water," U.S. Geological Survey Techniques of Water-Resources Inv., book 5, ch. A3, page 4 ([illegible]).

[24] Nitrogen, Nitrite, Method 8507, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.

[25] Just prior to distillation, adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.

[26] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp. 576–81 of the 14th Edition: Method 510A for distillation, Method 510B for the manual colorimetric procedure, or Method 510C for the manual spectrophotometric proc[illegible].

[27] R. F. Addison and R. G. Ackman, "Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography," *Journal of Chromatography*, vol. 47, No. 3, pp. 421–426, 197[illegible].

[28] Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to a pH of 12. Therefore, for levels of silver above 1 mg/L, 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M $Na_2S_2O_3$ and 2M NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satis[illegible].

[29] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 15th Edition.

[30] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 13th Edition.

[31] Stevens, H. H., Ficke, J. F., and Smoot, G. F., "Water Temperature—Influential Factors, Field Measurement and Data Presentation," U.S. Geological Survey, Techniques of Water Resources Investigations, Book 1, Chapter D1, 1975.

[32] Zinc, Zincon Method, Method 8009, Hach Handbook of Water Analysis, 1979, pages 2-231 and 2-333, Hach Chemical Company, Loveland, CO [illegible].

[33] "Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029," 1986, Applied Research Laboratories, Inc., 24911 Avenue Stanford, Valencia, CA 91355.

[34] Precision and recovery statements for the atomic absorption direct aspiration and graphite furnace methods, and for the spectrophotometric SDDC method for arsenic are provided in appendix D of this part titled, "Precision and Recovery Statements for Methods for Measuring Metals".

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS

Parameter [1]	EPA Method Number [2,7]			Other
	GC	GC/MS	HPLC	
1. Acenaphthene	610	625, 1625	610	
2. Acenaphthylene	610	625, 1625	610	
3. Acrolein	603	[4]624, 1624		

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TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter [1]	EPA Method Number [2, 7]			Other
	GC	GC/MS	HPLC	
4. Acrylonitrile	603	[4]624, 1624		
5. Anthracene	610	625, 1625	610	
6. Benzene	602	624, 1624		
7. Benzidine		[5]625, 1625	605	Note 3, p. 1;
8. Benzo(a)anthracene	610	625, 1625	610	
9. Benzo(a)pyrene	610	625, 1625	610	
10. Benzo(b)fluoranthene	610	625, 1625	610	
11. Benzo(g,h,i)perylene	610	625, 1625	610	
12. Benzo(k)fluoranthene	610	625, 1625	610	
13. Benzyl chloride				Note 3, p. 130; Note 6, p. S102.
14. Benzyl butyl phthalate	606	625, 1625		
15. Bis(2-chloroethoxy) methane	611	625, 1625		
16. Bis(2-chloroethyl) ether	611	625, 1625		
17. Bis(2-ethylhexyl) phthalate	606	625, 1625		
18. Bromodichloromethane	601	624, 1624		
19. Bromoform	601	624, 1624		
20. Bromomethane	601	624, 1624		
21. 4-Bromophenylphenyl ether	611	625, 1625		
22. Carbon tetrachloride	601	624, 1624		Note 3, p. 130;
23. 4-Chloro-3-methylphenol	604	625, 1625		
24. Chlorobenzene	601, 602	624, 1624		Note 3, p. 130;
25. Chloroethane	601	624, 1624		
26. 2-Chloroethylvinyl ether	601	624, 1624		
27. Chloroform	601	624, 1624		Note 3, p. 130;
28. Chloromethane	601	624, 1624		
29. 2-Chloronaphthalene	612	625, 1625		
30. 2-Chlorophenol	604	625, 1625		
31. 4-Chlorophenylphenyl ether	611	625, 1625		
32. Chrysene	610	625, 1625	610	
33. Dibenzo(a,h)anthracene	610	625, 1625	610	
34. Dibromochloromethane	601	624, 1624		
35. 1,2-Dichlorobenzene	601, 602, 612	624, 625, 1625		
36. 1,3-Dichlorobenzene	601, 602, 612	624, 625, 1625		
37. 1,4-Dichlorobenzene	601, 602, 612	625, 1624, 1625		
38. 3,3'-Dichlorobenzidine		625, 1625	605	
39. Dichlorodifluoromethane	601			
40. 1,1-Dichloroethane	601	624, 1624		
41. 1,2-Dichloroethane	601	624, 1624		
42. 1,1-Dichloroethene	601	624, 1624		
43. trans-1,2-Dichloroethene	601	624, 1624		
44. 2,4-Dichlorophenol	604	625, 1625		
45. 1,2-Dichloropropane	601	624, 1624		
46. cis-1,3-Dichloropropene	601	624, 1624		
47. trans-1,3-Dichloropropene	601	624, 1624		
48. Diethyl phthalate	606	625, 1625		
49. 2,4-Dimethylphenol	604	625, 1625		
50. Dimethyl phthalate	606	625, 1625		
51. Di-n-butyl phthalate	606	625, 1625		
52. Di-n-octyl phthalate	606	625, 1625		
53. 2,4-Dinitrophenol	604	625, 1625		
54. 2,4-Dinitrotoluene	609	625, 1625		
55. 2,6-Dinitrotoluene	609	625, 1625		
56. Epichlorohydrin				Note 3, p. 130; Note 6, p. S102.
57. Ethylbenzene	602	624, 1624		
58. Fluoranthene	610	625, 1625	610	
59. Fluorene	610	625, 1625	610	
60. Hexachlorobenzene	612	625, 1625		
61. Hexachlorobutadiene	612	625, 1625		
62. Hexachlorocyclopentadiene	612	[5]625, 1625		
63. Hexachloroethane	612	625, 1625		
64. Ideno(1,2,3-cd)pyrene	610	625, 1625	610	
65. Isophorone	609	625, 1625		
66. Methylene chloride	601	624, 1624		Note 3, p. 130;
67. 2-Methyl-4,6-dinitrophenol	604	625, 1625		
68. Naphthalene	610	625, 1625	610	
69. Nitrobenzene	609	625, 1625		
70. 2-Nitrophenol	604	625, 1625		
71. 4-Nitrophenol	604	625, 1625		
72. N-Nitrosodimethylamine	607	625, 1625		
73. N-Nitrosodi-n-propylamine	607	[5]625, 1625		
74. N-Nitrosodiphenylamine	607	[5]625, 1625		
75. 2,2'-Oxybis(1-chloropropane)	611	625, 1625		
76. PCB-1016	608	625		Note 3, p. 43;
77. PCB-1221	608	625		Note 3, p. 43;
78. PCB-1232	608	625		Note 3, p. 43;
79. PCB-1242	608	625		Note 3, p. 43;
80. PCB-1248	608	625		Note 3, p. 43;
81. PCB-1254	608	625		Note 3, p. 43;
82. PCB-1260	608	625		Note 3, p. 43;
83. Pentachlorophenol	604	625, 1625		Note 3, p. 140;
84. Phenanthrene	610	625, 1625	610	
85. Phenol	604	625, 1625		
86. Pyrene	610	625, 1625	610	

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TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter[1]	EPA Method Number[2,7] GC	GC/MS	HPLC	Other
87. 2,3,7,8-Tetrachlorodibenzo-p-dioxin		[6]613		
88. 1,1,2,2-Tetrachloroethane	601	624, 1624		Note 3, p. 130.
89. Tetrachloroethene	601	624, 1624		Note 3, p. 130.
90. Toluene	602	624, 1624		
91. 1,2,4-Trichlorobenzene	612	625, 1625		Note 3, p. 130.
92. 1,1,1-Trichloroethane	601	624, 1624		
93. 1,1,2-Trichloroethane	601	624, 1624		Note 3, p. 130.
94. Trichloroethene	601	624, 1624		
95. Trichlorofluoromethane	601	624		
96. 2,4,6-Trichlorophenol	604	625, 1625		
97. Vinyl chloride	601	624, 1624		

Table IC Notes

[1] All parameters are expressed in micrograms per liter (µg/L).

[2] The full text of Methods 601–613, 624, 625, 1624, and 1625, are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit," of this Part 136.

[3] "Methods for Benzidine: Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September, 1978.

[4] Method 624 may be extended to screen samples for Acrolein and Acrylonitrile. However, when they are known to be present, the preferred method for these two compounds is Method 603 or Method 1624.

[5] Method 625 may be extended to include benzidine, hexachlorocyclopentadiene, N-nitrosodimethylamine, and N-nitrosodiphenylamine. However, when they are known to be present, Methods 605, 607, and 612, or Method 1625, are preferred methods for these compounds.

[6] 625, Screening only.

[7] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[8] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 601–613, 624, 625, 1624, and 1625 (See Appendix A of this Part 136) in accordance with procedures each in section 8.2 of each of these Methods. Additionally, each laboratory, on an on-going basis must spike and analyze 10% (5% for Methods 624 and 625 and 100% for methods 1624, and 1625) of all samples to monitor and evaluate laboratory data quality in accordance with sections 8.3 and 8.4 of these Methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and cannot be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES[1]

Parameter µg/L	Method	EPA[2,7]	Standard Methods 15th Ed	ASTM	Other
1. Aldrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
2. Ametryn	GC				Note 3, p. 83; Note 6, p. S68.
3. Aminocarb	TLC				Note 3, p. 94; Note 6, p. S16.
4. Atraton	GC				Note 3, p. 83; Note 6, p. S68.
5. Atrazine	GC				Note 3, p. 83; Note 6, p. S68.
6. Azinphos methyl	GC				Note 3, p. 25; Note 6, p. S51.
7. Barban	TLC				Note 3, p. 104; Note 6, p. S64.
8. α-BHC	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[8]625			
9. β-BHC	GC	608		D3086	
	GC/MS	625			
10. δ-BHC	GC	608		D3086	
	GC/MS	[8]625			
11. γ-BHC (Lindane)	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
12. Captan	GC		509A		Note 3, p. 7.
13. Carbaryl	TLC				Note 3, p. 94; Note 6, p. S60.
14. Carbophenothion	GC				Note 4, p. 30; Note 6, p. S73.
15. Chlordane	GC	608	509A	D3086	Note 3, p. 7.
	GC-MS	625			
16. Chlorpropham	TLC				Note 3, p. 104; Note 6, p. S64.
17. 2,4-D	GC		509B		Note 3, p. 115; Note 4, p. 35.
18. 4,4'-DDD	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC-MS	625			
19. 4,4'-DDE	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
20. 4,4'-DDT	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
21. Demeton-O	GC				Note 3, p. 25; Note 6, p. S51.
22. Demeton-S	GC				Note 3, p. 25; Note 6, p. S51.
23. Diazinon	GC				Note 3, p. 25; Note 4, p. 30; Note 6, p. S51.
24. Dicamba	GC				Note 3, p. 115.
25. Dichlofenthion	GC				Note 4, p. 30; Note 6, p. S73.
26. Dichloran	GC		509A		Note 3, p. 7.
27. Dicofol	GC			D3086	
28. Dieldrin	GC	608	509A		Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
29. Dioxathion	GC				Note 4, p. 30; Note 6, p. S73.
30. Disulfoton	GC				Note 3, p. ; Note 6, p. S51.
31. Diuron	TLC				Note 3, p. 104; Note 6, p. S64.
32. Endosulfan I	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[8]625			

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TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES [1]—Continued

Parameter μg/L	Method	EPA [2,7]	Standard Methods 15th Ed	ASTM	Other
33. Endosulfan II	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[5] 625			
34. Endosulfan sulfate	GC	608			
	GC/MS	625			
35. Endrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	[5] 625			
36. Endrin aldehyde	GC	608			
	GC/MS	625			
37. Ethion	GC				Note 4, p. 30; Note 6, p. S73.
38. Fenuron	TLC				Note 3, p. 104; Note 6, p. S64.
39. Fenuron-TCA	TLC				Note 3, p. 104; Note 6, p. S64.
40. Heptachlor	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
41. Heptachlor epoxide	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30; Note 6, p. S73.
	GC/MS	625			
42. Isodrin	GC				Note 4, p. 30; Note 6, p. S73.
43. Linuron	TLC				Note 3, p. 104; Note 6, p. S64.
44. Malathion	GC		509A		Note 3, p. 25; Note 4, p. 30; Note 6, p. S51.
45. Methiocarb	TLC				Note 3, p. 94; Note 6, p. S60.
46. Methoxychlor	GC		509A	D3086	Note 3, p. 7; Note 4, p. 30.
47. Mexacarbate	TLC				Note 3, p. 94; Note 6, p. S60.
48. Mirex	GC		509A		Note 3, p. 7.
49. Monuron	TLC				Note 3, p. 104; Note 6, p. S64.
50. Monuron-TCA	TLC				Note 3, p. 104; Note 6, p. S64.
51. Neburon	TLC				Note 3, p. 104; Note 6, p. S64.
52. Parathion methyl	GC		509A		Note 3, p. 25; Note 4, p. 30.
53. Parathion ethyl	GC		509A		Note 3, p. 25.
54. PCNB	GC		509A		Note 3, p. 7.
55. Perthane	GC			D3086	
56. Prometron	GC				Note 3, p. 83; Note 6, p. S68.
57. Prometryn	GC				Note 3, p. 83; Note 6, p. S68.
58. Propazine	GC				Note 3, p. 83; Note 6, p. S68.
59. Propham	TLC				Note 3, p. 104; Note 6, p. S64.
60. Propoxur	TLC				Note 3, p. 94; Note 6, p. S60.
61. Secbumeton	TLC				Note 3, p. 83; Note 6, p. S68.
62. Siduron	TLC				Note 3, p. 104; Note 6, p. S64.
63. Simazine	GC				Note 3, p. 83; Note 6, p. S68.
64. Strobane	GC		509A		Note 3, p. 7.
65. Swep	TLC				Note 3, p. 104; Note 6, p. S64.
66. 2,4,5-T	GC		509B		Note 3, p. 115; Note 4, p. 35.
67. 2,4,5-TP (Silvex)	GC		509B		Note 3, p. 115.
68. Terbuthylazine	GC				Note 3, p. 83; Note 6, p. S68.
69. Toxaphene	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
70. Trifluralin	GC		509A		Note 3, p. 7

Table ID Notes

[1] Pesticides are listed in this table by common name for the convenience of the reader. Additional pesticides may be found under Table IC, where entries are listed by chemical name.

[2] The full text of methods 608 and 625 are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit", of this Part 136.

[3] "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September, 1978. This EPA publication includes thin-layer chromatography (TLC) methods.

[4] "Methods for Analysis of Organic Substances in Water," U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A3 [illegible]

[5] The method may be extended to include α-BHC, δ-BHC, endosulfan I, endosulfan II, and endrin. However, when they are known to exist, Method 608 is the preferred method.

[6] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of Standard Methods for the Examination of Water and Wastewater (1981).

[7] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 608 and 625 (See Appendix A of this Part 136) in accordance with procedures given in section 8.2 of each of these methods. Additionally, each laboratory, on an on-going basis, must spike and analyze 10% of all samples analyzed with Method 608 or 5% of all samples analyzed with Method 625 to monitor and evaluate laboratory data quality in accordance with Sections 8.3 and 8.4 of these methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and cannot be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

TABLE IE—LIST OF APPROVED RADIOLOGICAL TEST PROCEDURES

Parameter and units	Methods	EPA [1]	Reference (method No. or page)		
			Standard methods 15th ed.	ASTM	USGS [2]
1. Alpha-Total, pCi per liter	Proportional or scintillation counter.	900.0	703	D1943-81	pp. 75 and 78.[3]
2. Alpha-Counting error, pCi per liter	Proportional or scintillation counter.	Appendix B	703	D1943-81	p. 79.
3. Beta-Total, pCi per liter	Proportional counter	900.0	703	D1890-81	pp. 75 and 78.[3]
4. Beta-Counting error, pCi	Proportional counter	Appendix B	703	D1890-81	p. 79.
5. (a) Radium-Total, pCi per liter	Proportional counter	903.0	705	D2460-70	
(b) ^{226}Ra, pCi per liter	Scintillation counter	903.1	706	D3454-79	p. 81.

TABLE IE NOTES:

[1] "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032 (1980 update), U.S. Environmental Protection Agency, August 1980.

[2] Fishman, M.J. and Brown, Eugene, "Selected Methods of the U.S. Geological Survey of Analysis of Wastewaters," U.S. Geological Survey, Open-File Report 76-177 (1976).

[3] The method found on p. 75 measures only the dissolved portion while the method on p. 78 measures only the suspended portion. Therefore, the two results must be added to obtain the "total."

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TECHNICAL APPENDIX D

REFERENCES

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REFERENCES

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TECHNICAL APPENDIX E

GLOSSARY

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GLOSSARY

Aliquot: A discrete sample used for analysis.

Biochemical Oxygen Demand (BOD): The quantity of oxygen consumed during the biochemical oxidation of matter over a specified period of time, usually 5 days (BOD_5).

Chain-of-Custody: Procedures used to minimize the possiblility of tampering with samples.

Chemical Oxygen Demand (COD): Measurement of all the oxidizable matter found in a runoff sample, a portion of which could deplete dissolved oxygen in receiving waters.

Composite Sample: Used to determine "average" loadings or concentrations of pollutants, such samples are collected at regular time intervals, and pooled into one large sample, can be developed on time or flow rate.

Confined Space: Enclosed space that an employee can bodily enter and perform assigned work, that has limited means of exit and entry, that is not designed for continuous employee occupancy, and has one of the following characteristics:

- Contains or has a known potential to contain a hazardous atmosphere
- Contains a material with the potential for engulfment of an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or a floor that slopes downward and tapers to a smaller cross section
- Contains any other recognized serious safety or health hazard.

Conveyance: A channel or passage which conducts or carries water including any pipe, ditch, channel, tunnel, conduit, well, or container.

Detention Ponds: A surface water impoundment constructed to hold and manage storm water runoff.

Discharge: Any addition of any pollutant to waters of the U.S. from any conveyance.

Effluent: Any discharge flowing from a conveyance.

Flumes: A specially shaped open channel flow section providing a change in the channel area and/or slope which results in an increased velocity and change in the level of the liquid flowing through the flume. A flume normally consists of three sections: (1) a converging section; (2) a throat section; and (3) a diverging section. The flow rate through the flume is a function of the liquid level at some point in the flume.

Flow-Weighted Composite Sample: Means a composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

Flow-Proportional Composite Sample: Combines discrete aliquots of a sample collected over time, based on the flow of the wastestream being sampled. There are two methods used to collect this type of sample. One collects a constant sample volume at time intervals which vary based on stream flow. The other collects aliquots at varying volumes based on stream flow, at constant time intervals.

First Flush: Individual sample taken during the first 30 minutes of a storm event. The pollutants in this sample can often be used as a screen for non-storm water discharges since such pollutants are flushed out of the system during the initial portion of the discharge.

Grab Sample: A discrete sample which is taken from a wastestream on a one-time basis with no regard to flow or time; instantaneous sample that is analyzed separately.

Head of Liquid: Depth of flow.

Illicit Discharge: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to an NPDES permit and discharges from fire fighting activities.

Materials Management Practices: Practices used to limit the contact between significant materials and precipitation. These may include structural or nonstructural controls such as dikes, berms, sedimentation ponds, vegetation strips, spill response plans, etc.

Municipal Separate Storm Sewer Systems: A conveyance or system of conveyances including roads with drainage systems, storm drains, gutters, ditches under the jurisdiction of a city, town, borough, county, parish, or other public body.

Outfall: Point source where an effluent is discharged into receiving waters.

Point Source: Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff (see 40 CFR 122.3).

Reverse Meniscus: The curved upper surface of a liquid in a container.

Runoff Coefficient: Means the fraction of total rainfall that will appear at the conveyance as runoff.

Significant Materials: Include, but are not limited to, raw materials, fuels, solvents, detergents, metallic products, CERCLA hazardous substances, fertilizers, pesticides, and wastes such as ashes, slag, and sludge that have potential for release with storm water discharges [see 40 CFR 122.26(b)(12)].

Storm Water: Storm water runoff, snow melt runoff, and surface runoff, and drainage.

Storm Water Discharge Associated with Industrial Activity: Discharge from any conveyance which is used for collecting and conveying storm water which is directly related to manufacturing processing or raw materials storage areas at an industrial plant [see 40 CFR 122.26(b)(14)].

Time Composite Sample: Prepared by collecting fixed volume aliquots at specified time intervals and combining into a single sample for analysis.

Turbidity: Describes the capability of light to pass through water.

Weir: A device used to gauge the flow rate of liquid through a channel; is essentially a dam built across an open channel over which the liquid flows, usually through some type of notch.

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TECHNICAL A

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TECHNICAL APPENDIX F

ACRONYMS

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ACRONYMS

BOD_5	Biochemical Oxygen Demand (5-day)
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
COD	Chemical Oxygen Demand
COV	Coefficient of Variation
CPR	Cardiopulmonary Resuscitation
CWA	Clean Water Act
DOT	Department of Transportation
ECD	Electron Capture Detector
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
ESE	Environmental Science & Engineering, Inc.
FWPCA	Federal Water Pollution Control Act
FID	Flame Ionization Detector
FR	Federal Register
GC/MS	Gas Chromatography/Mass Spectometry
gpm	gallons per minute
H	Head
HCl	Hydrochloric Acid
HNO_3	Nitric Acid
HPLC	High Pressure Liquid Chromatography
H_2SO_4	Sulfuric Acid
IATA	International Air Transport Association
LC_{50}	Lethal Concentration
NaOH	Sodium Hydroxide
$Na_2S_2O_3$	Sodium Thiosulfate
NCDC	National Climate Data Center
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Agency
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
O&G	Oil and Grease
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PE	Professional Engineer
ppb	parts per billion
Q	Flow Rate
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SIC	Standard Industrial Classification
s.u.	standard units
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
VOC	Volatile Organic Compound

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January 1994

Office of Water (4503F)

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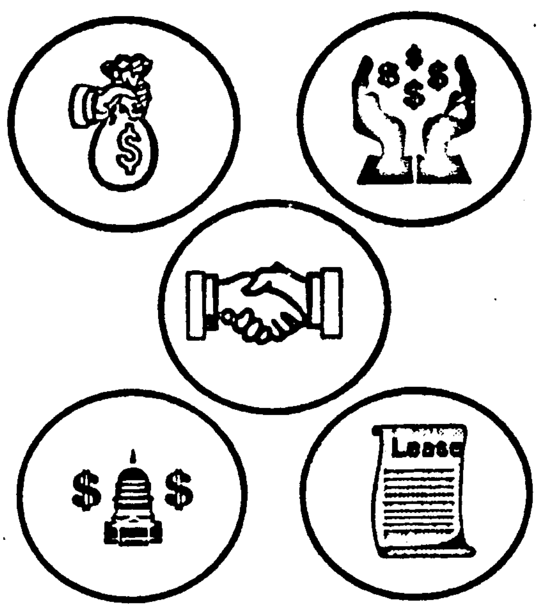
A State and Local Government Guide to Environmental Program Funding Alternatives



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Environmental Program Funding Alternatives

Implementation of environmental protection programs at the state and local levels often requires nonfederal government funding. Traditionally, funding for environmental programs has come from general revenue funds. Now that federal, state, and local governments are facing fiscal constraints, alternative sources of funding are becoming important options for implementing nonpoint source pollution controls and other environmental protection measures. Traditional sources of funding, such as taxes and bonds, are being supplemented by innovative funding sources like special license plates and income tax checkoffs.

There are four basic ways to fund public programs and facilities: current revenues (pay as you go), borrowing (bonding), intergovernmental transfers/assistance (fees or taxes collected by one level of government and passed on to another in the form of loans or grants), and public-private partnerships (private sector involvement in historically public sector activities). Since not every financing source or mechanism is appropriate for every state or local program, legal, administrative, and political aspects of financing must be taken into consideration when selecting funding alternatives.

This booklet provides an overview of traditional funding mechanisms and introduces state and local governments to innovative alternatives to traditional funding. The focus is on nonpoint source pollution, but funding sources and mechanisms can be applied to environmental programs in general. A list of contacts and references is included at the back of the booklet to answer questions and provide additional information.

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Contents

What Are State Revolving Funds?

State Revolving Funds (SRFs) provide long-term, low-interest loans to local governments or individuals for capital investments. The repayment of these loans over time allows the fund to revolve its lending ability continuously. In other words, through repayments the number of available loans is increased. Established by the Clean Water Act Amendments of 1987, SRFs are intended to be administered and operated by the states to provide a permanent source of financing for state and local government water quality projects. SRF assistance can be used for the construction of wastewater treatment plants, the implementation of approved state nonpoint source management programs and ground-water protection strategies under section 319 of the

> ***California Uses State Revolving Fund to Control NPS Pollution***
>
> California uses part of its State Revolving Fund (SRF) for nonpoint source pollution control. The fund is administered by the State Water Board. The State Water Board has separated the administration of the fund from the wastewater treatment facilities program and has developed a flexible program that will evaluate and select for funding a wide variety of nonpoint source pollution control projects. Eligible projects include construction of demonstration projects, retention/detention basins, wetlands for stormwater treatment, and a variety of best management practices to reduce or remove nonpoint source pollutants. The nonpoint source program for the SRF also permits the establishment of substate revolving funds that can provide funding to private individuals to finance new onsite septic systems, mound systems, leach fields, etc.

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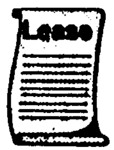
Clean Water Act, and the development and implementation of estuary conservation and management plans under section 320 of the Clean Water Act.

What Are Leases?



A lease is a contract that allows another party to use land or a building for a specified time, usually in return for repayment. Leasing obligations aren't considered debt in most states, and voter approval for financing is not required.

A lease-purchase agreement (municipal lease) grants the party holding the property lease (the lessee) the option of applying lease payments to the purchase of the facility. The lessee is responsible for paying taxes. These agreements can be used to finance the purchase of environmentally sensitive areas, land for wetlands restoration, or other projects.

Georgia Leases Shellfish Beds to Commercial Fishermen

Georgia promotes oyster management through its innovative Shellfish Program. Georgia does not allow open shellfishing. Recreational harvesting by the general public takes place in designated public grounds, and commercial harvesters must obtain a lease for harvesting shellfish from the Georgia Department of Natural Resources, Coastal Resources Division. Leases are awarded on the basis of bids for a specific shellfish harvesting area. The bid is awarded to the most preferable combination of lease payments and the strongest management plan. The shellfish resource management plans are judged on the basis of certain criteria, such as shell deposition methods. Funds gained from the lease program are used to manage the shellfish program.

4-7-99

A sale-lease back arrangement allows the owner of a facility to sell it to another entity and subsequently lease it back from the new owner. Under a tax-exempt lease, for example, Town X sells a sewage treatment plant to Y Corporation in order to finance upgrades and repays Y Corporation's investment with lease payments. These arrangements can provide alternative financing for a facility and may limit a government's liability.

What Are Grants?

Grants are sums of money awarded to state or local governments or nonprofit organizations that do not need to be repaid. Grants are awarded for the purpose of financing a particular activity or facility.

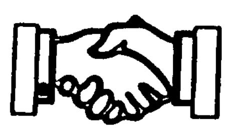
EPA grants provide funding for state and local governments to meet national environmental quality goals. EPA establishes criteria to receive grant funds, which applicants must meet before using the funds for a specific activity or program. Section 319 of the Clean Water Act allocates federal funds to states for implementing approved nonpoint source management programs. Grant money can also be used for post-implementation monitoring and groundwater assessment as part of an approved NPS pollution control program.

Sea Grant Funded through NOAA

The Sea Grant College Chesapeake Bay Studies Program is funded through an environmental research grant financed and administered by NOAA. The program provides a focal point for all of NOAA's Chesapeake Bay efforts. It funds research on fish populations, toxic substance transport, fate and effects, and remote sensing, and it coordinates directly with the state/federal Chesapeake Bay Program on issues related to living resources, habitat restoration, and coastal zone management.

Section 604(b) of the Clean Water Act requires an allotment of funds to provide grants to states to carry out water quality management planning. Section 314 of the Clean Water Act provides funding for project grants to states for assessing the water quality of publicly owned lakes, developing lake restoration and protection plans, implementing the plans to restore and preserve a lake, and performing post-restoration monitoring to determine the longevity and effectiveness of the restoration. Section 106 of the Clean Water Act provides state and interstate agencies and Indian tribes with funding to administer programs for the prevention, reduction, and elimination of water pollution, for example the prevention and abatement of surface water pollution. Other grant programs under the Clean Water Act include section 604(b) (Water Quality Management Planning), section 320 (National Estuary Program), section 104(b)(3) (Water Quality Cooperative Agreements), and section 104(g) (Small Community Outreach). Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) requires states to establish Coastal Nonpoint Source Programs, which must be approved by both NOAA and EPA. Approved programs will be implemented through changes to the state nonpoint source management program approved and funded by EPA under section 319 of the Clean Water Act and through changes to the state coastal zone management program approved by NOAA under section 306 of the Coastal Zone Management Act.

What Are Public-Private Partnerships?



Public-private partnerships can be defined as private sector involvement in what historically have been public sector activities. Private sector investment in capital facilities reduces the burden on public budgets. For example, a developer could build a stormwater facility large enough to also treat the runoff from nearby public roads. Partnerships can be used to pay for capital and/or operating costs, when neither the public nor the private entity can afford to fund the project alone. Capital arrangements involve private ownership and operation of a public facility. Private construction and operating costs are often lower than public costs.

> ***Wetlands Mitigation Partnership***
>
> The U.S. Army Corps of Engineers issued a permit to some Florida developers to restore a degraded 345-acre wetland on land owned by the city of Pembroke Pines. These entrepreneurs, who call themselves the Florida Wetlandsbank, sell credits to other developers who have impacted degraded wetlands elsewhere and have gained approval to satisfy the state's wetlands mitigation requirements through offsite mitigation. The Florida Wetlandsbank will transform the land into a public park.

Private sector wastewater treatment programs have been 15 to 20 percent more cost-efficient than public programs (USEPA, *The Clean Air Act of 1990: A Guide to Public Financing Options*). Public-private partnerships often result in higher-quality service and shorter implementation time, according to a 1991 survey of state officials. However, statutory or regulatory changes needed to arrange public-private partnerships may delay implementation of a program. Other issues that may need to be considered include government concern over loss of control in a partnership, political opposition from government workers, and negative public opinion.

What Are Taxes?

A tax is a charge against income, property, or the sale of goods and services. Most jurisdictions do not require that a tax be used for a specific purpose but instead use the funds to provide a variety of public services, such as solid waste management, public safety, education, and environmental programs. However, taxes can be targeted to raise funds for a specific activity.

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Property and sales taxes are charged as a percentage of property value or gross sales and are imposed at the state and local levels. Revenue from a property or sales tax can be used to fund projects. Dare County, North Carolina, for example, has an economy dominated by seasonal tourism. The county uses sales taxes on lodging, meals, and entertainment to obtain funds to finance public facilities that must accommodate the infra-structure needs of sudden, but temporary, population in-creases. Similar local sales taxes could be used by a state or local gov-ernment to fund nonpoint pollution control programs at the local level.

> **Annual NPS Control Tax**
>
> A proposal has been developed to charge Puget Sound, Washington, landowners an annual nonpoint source pollution control tax based on property size and land use. Owners with onsite sewage systems, live-stock, and parcels in areas required to develop comprehensive storm-water management plans would be assessed a surcharge if land uses are not managed to reduce nonpoint source pollution.

Real estate transfer taxes are assessed as a percentage of property values when property is sold. These taxes are imposed on property buyers, sellers, or both. Funds raised by such taxes could be dedicated to help pur-chase environmentally sensitive lands or to support resource conser-vation programs.

Commodity taxes are charged on specific items (commodities) such as gasoline, cigarettes, and hunting or fishing equip-ment. The money raised could be targeted for environmental programs or services. The federal gasoline tax, for example,

> **Tobacco Tax Used to Protect Water Quality**
>
> A tobacco tax helps finance Wash-ington State's water quality protec-tion plan. In 1986, the Washington legislature passed the Centennial Clean Water Act, which established a sales tax on tobacco products. The law dedicates half of the funds raised to the control of wastewater discharged directly into marine wa-ters and the other half to water qual-ity initiatives such as ground water protection.

> **Duck Stamps Used to Propagate Waterfowl**
>
> In 1974, the Maryland General Assembly enacted a bill requiring all who hunt waterfowl in the state to purchase a $1.10 stamp annually that must be signed by the hunter, affixed to his/her statewide license, and carried while hunting. Funds from the sale of the stamps are used for the propagation of waterfowl in the state. The cost of the stamp has since increased to $6.00, generating nearly $400,000 a year. Similar programs can be used to generate funds for a variety of environmental programs such as the purchase of environmentally sensitive habitat.

finances highway improvements. Since 1981, a tax on the diesel fuel consumed by tugboats has helped to finance maintenance of the Nation's system of inland waterways.

Tax surcharges are fees added to established tax rates. They are often used for sudden unforeseen events. A tax surcharge on residential sewer bills, for instance, might be used to finance the replacement of stormwater retention basins destroyed during a hurricane.

Tax incentives and disincentives. A tax system can be set up to encourage or discourage certain behaviors by offering tax reductions or

> **Tax Incentives**
>
> Road capacity can be allocated more efficiently by taxing its users during peak travel times. This tax takes the form of a "congestion toll." It can be used as an incentive to travel before or after rush hour, take the bus, or carpool. The resultant decrease in traffic could reduce capital outlays for highways by making many expansion projects unnecessary. In regions facing severe transportation and air pollution problems, such as southern California, road-use tolls are being implemented. A system of congestion tolls for drivers crossing the San Francisco-Oakland Bay Bridge began in September 1993.
>
> Water can be allocated more efficiently by imposing higher prices during peak hours of use or an increased fee for water use above an allocated amount. This economic incentive fosters conservation.

increases. Incentives often take the form of state tax credits, deductions, or rebates. A tax credit for the use of low-flow plumbing fixtures, for example, can encourage water efficiency. Because of the desire to save money, disincentives often take the form of fees, taxes, or price increases. A tax or fee can discourage the inefficient use of a product because of the increased cost of using more of a product than needed.

Tax differentiation is a tax incentive used to promote the consumption of environmentally safe products. This financing mechanism involves a surcharge added to the cost of a polluting product to encourage the consumer to purchase a cleaner alternative.

A selective sales tax can be levied either as a retail tax or as an inspection fee. Kansas, for example, charges a per-ton fertilizer inspection fee, with proceeds going to support the State Water Plan. A selective sales tax could fund remediation of agricultural nonpoint source pollution or could fund research on farming techniques to reduce environmental impacts. This tax could apply to pesticides, herbicides, automotive lubricants, etc.

Tax increment financing is the dedication of incremental increases in real estate taxes to repay an original investment in improved public facilities, such as stormwater facilities, that resulted in increased real estate values. Tax increment financing is appropriate for areas

Tax Increment Financing Used to Redevelop Depressed Areas

Tax increment financing is appropriate for areas where substantial new development is probable. The City of Orlando, Florida, for example, created a Community Redevelopment Trust in 1982 to establish a fund to redevelop depressed areas of the city. The city created a series of revenue bonds to finance public housing, transportation, and other capital investment. These bonds are not a general obligation of the trust or the City of Orlando; they are secured by an irrevocable lien on the increment in property tax revenues paid into the Trust Fund and interest earned by the Trust Fund.

where substantial new development is anticipated as a result of public investment in roads, sewers, or other infrastructure. A cleaner watershed, for instance, could boost neighboring property values. The tax increment created could be used to support continued environmental protection programs.

What Are Fees?

Fees are charges for services rendered and are one way for governments to recover the costs of providing certain services to the public. Although laws vary widely, many states require that fees be set at rates that cover only the actual costs of the services provided, including administrative services.

Stormwater Utility Fees

There are more than 100 stormwater utilities in the United States. Methods of determining stormwater utility charges vary considerably around the country, depending on local stormwater management goals and conditions. In general, utilities are either publicly owned and operated enterprises or privately owned enterprises whose ability to profit from providing public services is regulated by a public agency. Utility fees provide a more reliable source of funds for local stormwater management than do property taxes.

Plan review fees are assessed by a local government for conducting a review of development plans to ensure that they meet certain requirements. This technical review is used to determine the adequacy of stormwater management facilities or erosion and sediment controls and to ensure proper siting of structures or onsite sewage disposal systems. These fees help cover the cost of conducting plan reviews and inspections.

Stormwater utility fees are imposed on property owners to pay for stormwater management. The charge can be based on the amount of runoff generated from the property, the amount of impervious area (hard surfaces) on the property, or the assessed value of the property.

Impact fees transfer the costs of infrastructure services (roads, sewers, stormwater treatment, etc.) needed for private development directly to developers or property owners. Unlike user fees, which recover costs over the life of a project, impact fees are usually collected in one lump sum at the beginning of a project. These fees are particularly attractive to local governments because they relieve up-front financing pressures on local budgets. In California, for example, several wastewater treatment plants have been financed with fees paid by developers based on the projects' anticipated treatment requirements. Impact fees can be used to fund the installation and maintenance of stormwater management facilities on newly developed sites.

> ***Impact Fees for New Development***
>
> Carroll County, Maryland, charges an impact fee on new land development. The amount of the fee depends on the type of development (i.e., a single-family home, commercial development, etc.). These fees fund a variety of programs ranging from water supply protection to elementary school education.

Inspection fees are charged to cover the costs of making sure that development plans are properly implemented. These fees may defray the program costs of erosion and sediment control, septic system siting and installation inspections, and stormwater treatment facility operation and maintenance.

> ***Homeowners Pay Inspection and Operation and Maintenance Fees***
>
> Otter Tail County, Minnesota, has developed an onsite utility to protect its lakes from contamination due to onsite sewage disposal system failures. All onsite system owners pay a basic fee for inspections and administration costs and have the option to pay an additional amount for additional services. Operation and maintenance costs are financed by fees paid by homeowners.

User fees are the most common way to recover the costs of providing a service. These fees can be tied directly to the use of a resource or facility (sports fishing and hunting license fees, park entrance fees, etc.). User fees are particularly useful at the local level where user groups are easily identified.

Product charges, similar to commodity taxes, are fees that can be added to the price of products that could potentially cause degradation of water quality, such as nonreturnable containers, batteries, lubricating oil, fertilizers, and pesticides. These revenues can be earmarked for environmental programs.

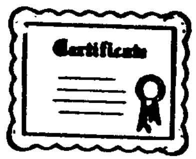
Capacity credits are a form of financing in which private interests (usually developers) purchase future capacity in a public facility such as a stormwater treatment facility. Applicants are guaranteed future access to the excess capacity of that particular facility. Where project construction hinges on adequate funding, capacity credits can contribute to project completion.

Effluent discharge fees are levied on an industrial facility by a government authority, based on the volume of pollutants discharged into water. Under an effluent discharge fee system, a discharger is required to pay a certain amount for every unit of pollution discharged into surface water. The system can be based on water quality objectives, the costs for financing a pollution abatement scheme, or effluent standards. The system has several advantages: it allows firms to reduce pollution at lower costs than those incurred under a

> ***Effluent Discharge Fees for Industrial and Municipal Sources***
>
> Wisconsin has established an unusually comprehensive fee system for its water program to recover total direct and indirect program costs. The state issues general permits and levies permit fees for discharges based on volume and type of pollutant. Such pollutants are associated with various industrial sources or users, such as concrete products operations; sand, gravel, or crushed stone operations; swimming pools; petroleum storage terminals; water treatment plants; and dredging projects involving uncontaminated sediments. This effluent discharge fee program generated more than $7 million in 1993.

command-and-control approach; it provides incentives to firms to invest in pollution control technology; and it can generate revenue that can be used to fund activities that promote environmental quality. The disadvantages of the charge system are the complex planning, analysis, monitoring, enforcement, litigation, and interjurisdictional negotiation required by local authorities. In addition, assigning monetary values to pollution damage may be difficult.

What Are Bonds?



Bonds are a mechanism to borrow capital for a project and distribute the burden of repayment over the life span of the project among those who benefit from it. Just as individuals borrow to finance their homes through bank-issued mortgages, governments borrow funds from investors by issuing debt in the form of bonds. Bonds usually finance capital facilities, such as erosion control structures and stormwater treatment facilities. Typically, bonds are used only to finance projects that have both known and proven life expectancies.

$75 Million Bond Passed to Protect Environmentally Sensitive Lands

Broward County, Florida, residents voted to pass a $75 million bond to purchase environmentally sensitive lands. The money has been used to purchase more than 560 acres of wetlands, pristine uplands, endangered species habitat, and lands necessary for maintaining the integrity of the Everglades ecosystem. Initial site maintenance (exotic plant removal, fencing, etc.) will be paid for with bond money. Long-term maintenance will be funded as part of the county parks department's operating budget.

Short-term bonds are usually payable within 1 year. Establishing short-term debt provides interim funding of projects waiting to receive long-term financing. There are two categories of short-term bonds: notes and

tax-exempt commercial paper. Notes are loans issued in anticipation of grants, bonds, or taxes. Tax-exempt commercial paper is a form of unsecured debt backed by a letter or line of credit.

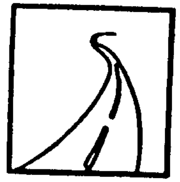
Long-term bonds traditionally match the term of financing with the life expectancy of the project. A stormwater treatment facility, for example, might be expected to perform adequately for 30 years; therefore, the community could issue bonds that have a term of up to 30 years. There are two categories of long-term bonds. Term bonds are loans for which the entire loan amount and interest are payable on the final maturity date. Serial bonds are similar to traditional home mortgages: the principal and interest are repaid in periodic installments over the life of the bond. Long-term bonds can be issued as general obligation bonds or as revenue bonds, as described below.

General obligation bonds are long-term municipal bonds that are backed by the full faith and credit of the state or local government. This means that the state or local government pledges to use all of its taxing and other revenue-raising powers to repay bond holders. Both state and local governments have used general obligation bonds to finance capital projects related to environmental programs, including purchases of environmentally sensitive lands.

Revenue bonds are long-term municipal bonds guaranteed solely by the dedication of project income or system funds (e.g., user fees from the infrastructure where capital costs are covered by the bond) rather than by a general tax. Both state and local governments have used revenue bonds to provide start-up capital for stormwater utilities and to finance environmental projects, including the renovation of wastewater treatment plants.

Bond banks, of which there are at least 11 across the country, are financial institutions created primarily to provide smaller communities access to the national bond market to finance infrastructure projects. Typically, a bond bank either sells bonds in the bond market and uses the proceeds to purchase bonds from local communities or buys bonds directly from local communities and pools several small issues into one large bond issue to be sold in the bond market. Small communities could take advantage of bond banks to finance environmental infrastructure projects.

Look to the Future... Pollutant Trading



Point and nonpoint source pollutant trading involves financing reductions in nonpoint source pollution in lieu of undertaking more expensive point source pollution reduction efforts. A trading program is intended to produce cost savings to point source dischargers while improving water quality. Implementing a trading program requires a waterbody identifiable as a watershed or segment, as well as a measurable combination of point sources and controllable nonpoint sources. There must be significant load reductions for which the cost per pound reduced for nonpoint source controls is lower than the cost for upgrading point source controls. Lastly, point source dischargers must face requirements to either upgrade facility treatment capabilities or trade for nonpoint source reductions in order to meet water quality goals.

Such a program allows the private sector to allocate its resources to reduce pollutants in the most cost-effective manner, and it encourages the development of a watershed-wide or basin-wide approach to water quality protection. Such a program also entails cooperation between agencies, however, and requires a

Pollutant Trading for Nutrients

In a North Carolina watershed, the Tar-Pamlico Basin Association (a coalition of point source dischargers) and state and regional environmental groups have proposed a two-phased nutrient management strategy that incorporates point and nonpoint source pollutant trading. The plan requires association members to finance nonpoint source reduction activities in the basin if their nutrient discharges exceed a base allowance.

system to arrive at trading ratios between point and nonpoint source controls.

Be Creative!

The State of Maryland has been imaginative in its acquisition of funding to restore the Chesapeake Bay. The Chesapeake Bay Trust was created in 1985 to bring the financial support of the business community and private donors together with the many community groups and educators that need financial assistance for their Bay projects. Maryland's programs exemplify successful implementation of innovative funding alternatives.

State lotteries are becoming a potential source of revenue for environmental programs. For

License Plates to Save the Bay

The State of Maryland has implemented a license plate program to fund its Chesapeake Bay Trust. More than 400,000 "Treasure the Chesapeake" license plates have been sold, raising more than $4 million. In the Baltimore area, automobile dealers offered Bay license plates at no cost to their new car and truck customers by paying the $10 fee in June and July 1992, raising $20,000 for the Trust.

Tax Checkoff to Fund Restoration and Conservation Programs

Maryland's tax checkoff for the Chesapeake Bay and Endangered Species Fund is included on the standard tax form. Taxpayers can contribute a portion of their taxes to the fund, which yielded a record $1.1 million in 1992. Divided equally between the Chesapeake Bay Trust and the Department of Natural Resources' Endangered Species Fund, the checkoff funds a variety of Bay restoration and conservation programs.

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Lottery Revenues

Kansas uses a portion of its lottery receipts to help finance its water resource management programs, including wetland protection activities. Kansas created the State Water Plan Fund in 1989, for which half of the revenues are derived from the state general fund and state lottery funds. The other half are derived from a system of fees on municipal water use, industrial water use, stockwater use, pesticides, fertilizers, and pollution fines and penalties. In Minnesota, voters approved state constitutional amendments establishing the Environmental and Natural Resources Trust Fund and a state lottery to finance the fund.

example, Kansas and Minnesota use lottery receipts to help finance natural resource management programs.

Comparing Your Options

Several funding alternatives may be available for a particular project. For example, the following four funding strategies to control solid waste could easily be adapted to fund nonpoint source programs: property taxes, tax incentives/disincentives, user fees, or tax surcharges. Funding for regional stormwater management facilities or a shoreline erosion control project could be obtained in similar ways.

Capital and operating costs and cost-effectiveness must be carefully analyzed before choosing a funding alternative. Legal, administrative, and political aspects and impacts of each alternative need to be considered. One must consider the legal workability and political attractiveness of a financing mechanism; the effort needed for implementation, including start-up costs and costs for ongoing collection and management of funds; the fairness of distribution of the funding burden among individuals; and the public's willingness to pay or to make a particular sector pay.

Four Funding Strategies to Control Solid Waste

Tax Incentive/Disincentive

Estherville, Iowa, uses the pay-by-the-bag approach to trash collection. This system gives households an incentive to recycle, compost, and change their buying habits to reduce the volume of waste they generate.

Property Tax

Fairfax City, Virginia, uses property taxes to finance trash collection. Residents are charged a flat annual amount that is not related to the volume or type of trash they discard.

User Fee

Hollywood, Florida, charges residents a standard monthly "fee" for solid waste management services. This establishes a direct link between those who use the services and those who pay for them.

Tax Surcharge

Oregon funds solid waste management through proceeds from the Bottle Bill, a law that requires consumers to pay a deposit on each container purchased. The deposit is refunded when the container is returned for recycling.

For Further Information . . .

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USEPA. 1988. *Financing Marine and Estuarine Programs: A Guide to Resources.* Office of Marine and Estuarine Protection. EPA Document No. 503-8-88-001.

For more information about Broward County Bond Issue, contact: Broward County Administrator's Office, 115 South Andrews Avenue, Rm 409, Ft. Lauderdale, FL 33301, ph. (305) 357-7354.

BOTTLE BILLS

For more information on bottle bills, contact: The Public Interest Research Group (PIRG) in your area, or PIRG National Headquarters, 215 Pennsylvania Avenue, SE, Washington, DC 20003, ph. (202) 546-9707.

CONGESTION TOLLS

World Resources Institute. 1992. *Green Fees: How a Tax Shift Can Work for the Environment and the Economy.*

For more information on congestion tolls, contact: World Resources Institute, 1709 New York Avenue, NW, Washington, DC 20006, ph. (202) 638-6300.

DUCK STAMPS

For more information on duck stamps, contact: Duck Stamp Program Manager, Maryland Department of Natural Resources,

Public Communications Office (D-4), Tawes State Office Building, Annapolis, MD 21402, ph. (410) 774-2035.

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For more information about Wisconsin's effluent discharge fee program, contact: Fee Program Manager, Wisconsin Department of Natural Resources, P.O. Box 7921, 101 South Webster Street, Madison, WI 53707, ph. (608) 267-7638.

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For more information on fees, contact: The Environmental Financial Advisory Board, c/o USEPA, Office of Administration and Resources Management (3304), 401 M Street, SW, Washington, DC 20460, ph. (202) 260-1020, fax (202) 260-0710.

For more information about Maryland's impact fee, contact: Director, Chesapeake Bay Local Government Advisory Committee, 777 North Capitol Street, NE, Suite 300, Washington, DC 20002, ph. (800) 446-5422.

For more information about Minnesota's onsite utility fee, contact: District Officer, Route 2, Box 319, Battle Lake, MN 56515, ph. (212) 864-5533.

For more information about the State of Washington's nonpoint source pollution control fee, contact: Shellfish Protection Team, Washington Department of Ecology, P.O. Box 47600, Olympia, WA 98504-7600, ph. (206) 459-6836.

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Government Printing Office. 1991. *Catalog of Federal Domestic Assistance.*

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USEPA. 1992. *Alternative Financing Mechanisms for Environmental Programs.* Final draft. Environmental Finance Program, Office of Administration and Resources Management.

For more information about the Chesapeake Bay Studies Program grant, contact: Chesapeake Bay Division, National Marine Fisheries Office of Habitat Protection, NOAA Chesapeake Bay Office, 410 Severn Avenue, Suite 107A, Annapolis, MD 21403, ph. (410) 280-1871.

LEASING/SELLING

USEPA. 1992. *Alternative Financing Mechanisms for Environmental Programs.* Final draft. Environmental Finance Program, Office of Administration and Resources Management.

USEPA. 1988. *Financing Marine and Estuarine Programs: A Guide to Resources.* Office of Marine and Estuarine Protection. EPA Document No. 503-8-88-001.

For more information on leasing/selling, contact: The Environmental Financial Advisory Board, c/o USEPA, Office of Administration and Resources Management (3304), 401 M Street, SW, Washington, DC 20460, ph. (202) 260-1020, fax (202) 260-0710.

For more information about Georgia's Shellfish Program, contact: The Shellfish Program, Georgia Department of Natural Resources, 1200 Glynn Avenue, Brunswick, GA 31523-9990, ph. (912) 264-7218.

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Apogee Research, Inc. 1990. *Financing State Wetlands Programs.* Office of Wetlands Protection, U.S. Environmental Protection Agency.

For more information on lottery revenues, contact: Wetlands Strategies and State Programs Branch, Office of Wetlands, Oceans and Watersheds, Wetlands Division (4502F), 401 M Street, SW, Washington, DC 20460, ph. (202) 260-7791.

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For more information about Iowa's system, contact: World Resources Institute, 1709 New York Avenue, NW, Washington, DC 20006, ph. (202) 638-6300.

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For more information on the wetland mitigation bank program in Broward County, contact: Broward County Department of Natural Resources Protection, 218 SW 1st Avenue, Fort Lauderdale, FL 33301, ph. (301) 519-1230.

SPECIAL LICENSE PLATES

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For more information on special license plates, contact: Office of the Governor, Governor's Chesapeake Bay Communications Office, State House, Annapolis, MD 21401, ph. (410) 974-5300, or Chesapeake Bay Trust, 60 West Street, Suite 200A, Annapolis, MD 21401, ph. (410) 974-2941.

STATE REVOLVING FUNDS

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USEPA. 1990. *Funding of Expanded Uses Activities by State Revolving Fund Programs: Examples and Program Recommendations.* Office of Water. EPA Document No. 430-09-90-006.

USEPA. 1988. *SRF Initial Guidance.* Office of Municipal Pollution Control.

For more information on state revolving funds, contact: Chief, Nonpoint Source Loan Unit, Division of Water Quality, State Water Resources Control Board, 901 P Street, P.O. Box 100, Sacramento, CA 95801, ph. (916) 657-1043.

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USEPA. 1992. *Storm Water Utilities: Innovative Financing for Storm Water Management.* Draft final report.

For more information on stormwater utilities, contact: Water Policy Branch, Office of Policy Analysis, Office of Policy, Planning and Evaluation, USEPA (2121), 401 M Street, SW, Washington, DC 20460, ph. (202) 260-2756.

For more information on stormwater utilities, contact: The Environmental Financial Advisory Board, c/o USEPA, Office of Administration and Resources Management (3304), 401 M Street, SW, Washington, DC 20460, ph. (202) 260-1020, fax (202) 260-0710.

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For more information on tax checkoffs, contact: Office of the Governor, Governor's Chesapeake Bay Communications Office, State House, Annapolis, MD 21401, ph. (410) 974-5300, or Chesapeake Bay Trust, 60 West Street, Suite 200A, Annapolis, MD 21401, ph. (410) 974-2941.

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USEPA. 1988. *Financing Marine and Estuarine Programs: A Guide to Resources.* Office of Marine and Estuarine Protection. Document No. 503-8-88-001.

For more information about the State of Washington's tobacco tax, contact: House Office of the Budget, Second Floor, House Office Building, MS AS33, Olympia, WA 98504, ph. (206) 786-7107, or House Ways and Means Committee, MS AS33, Olympia, WA 98504, ph. (206) 786-7136.

Notes

Additional Information on Selected Reference Materials

USEPA. 1992. *Alternative Financing Mechanisms for Environmental Programs*. Final draft. Office of Administration and Resources Management.

This report provides information to resolve two types of funding shortfalls: state capacity (program personnel) and capital infrastructure needs. This comprehensive encyclopedia of alternative financing mechanisms can be used as an information resource for states and local governments. It is intended to provide information about principal features of alternative financing mechanisms, their relative advantages and disadvantages (with particular attention given to administrative considerations), and some of the key questions and issues associated with their use.

For more information contact: U.S. EPA, Office of Administration and Resources Management, Office of the Comptroller, Resource Management Division (3304), 401 M Street, SW, Washington, DC 20460, (202) 260-1020.

U.S. EPA's Environmental Financing Information Network (EFIN)

EPA's Office of Water has opened the Environmental Financing Information Network (EFIN) to disseminate financial information to public entities. This electronic bulletin board system provides information on financing alternatives for state and local environmental programs and projects. You can use EFIN to ask your own questions about environmental financing approaches, publications, and activities. Answers will be provided by EPA staff and a wide audience of local government users.

For more information contact: U.S. EPA, EFIN Center, Environmental Finance Program, Resource Management Division (3304), 401 M Street, SW, Washington, DC 20460, (202) 260-0710.

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FOREWORD

This document contains proposed guidance specifying management measures for sources of nonpoint pollution in coastal waters. Nonpoint pollution is the pollution of our Nation's waters by runoff from the land surface. In the Coastal Zone Act Reauthorization Amendments of 1990, Congress recognized that nonpoint pollution is a key factor in the continuing degradation of many coastal waters, and established a new program to address this pollution.

The new program established by Congress recognizes that the solution to nonpoint pollution lies in State and local action. It calls for the development and implementation of State coastal nonpoint pollution programs. These State programs are to be developed in conformity with technical guidance developed by EPA on the best, economically achievable measures available to protect coastal waters from nonpoint pollution. This document proposes that "management measures guidance."

The proposed management measures guidance addresses five source categories of nonpoint pollution: agriculture, silviculture, urban, marinas, and hydromodification. A suite of management measures is provided for each source category. The number and type of systems identified per source category are based upon the range and diversity of substantively different subcategories, activities, and pollutants. In addition, the guidance contains a chapter that provides information on other tools available to address many source categories of nonpoint pollution; these include vegetated filter strips, forested buffer strips, and wetlands. EPA regards this proposed guidance as a significant beginning to a year-long process of refinement, ending with publication of the final guidance in May 1992. We welcome public comments, information and data relevant to this continuing effort.

EPA will also soon be publishing, jointly with the National Oceanic and Atmospheric Administration, proposed guidance for the approval of State programs that implement management measures. That guidance will explain more fully how the management measures guidance proposed today would be implemented in State programs. EPA encourages reviewers of this document to review and comment upon that forthcoming guidance as well.

Robert H. Wayland, III, Director,
Office of Wetlands, Oceans, and Watersheds

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CHAPTER 1

INTRODUCTION

I. BACKGROUND

This proposed guidance on management measures is required under section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990. It provides guidance to States and Territories on the types of management measures that should be included in State and Territorial coastal nonpoint pollution control programs. This Chapter explains in detail the statutory requirements, the approach used to develop management measures, and the process for developing final management measures guidance, and discusses issues related to State program development and approval. While the program development and approval issues discussed in this Chapter provide a framework for understanding the management measures guidance, the issues will be more fully developed in draft program guidance scheduled to be published for public comment in July 1991.

A. Nonpoint Source Pollution

1. What Is Nonpoint Source Pollution?

Nonpoint source pollution is the pollution of our nation's waters from diffuse sources. It is caused by rainfall or snowmelt moving over and through the ground and carrying natural and manmade pollutants into lakes, rivers, streams, wetlands, estuaries, other coastal waters, and ground water. (As discussed below, some diffuse sources are regulated under the NPDES program as point source discharges.)

A more detailed discussion of the range of nonpoint sources and their effects on water quality and riparian habitats is provided in subsequent chapters of this guidance.

2. National Efforts to Control Nonpoint Pollution

a. Nonpoint source program

During the first fifteen years of the national program to abate and control water pollution, EPA and the States have focused most of their water pollution control activities upon traditional "point sources", such as discharges through pipes from sewage treatment plants and industrial facilities. These point sources have been regulated by EPA and the States through the National Pollutant Discharge Elimination System (NPDES) permit program established by Section 402 of the Clean Water Act. Discharges of dredged and fill materials into wetlands have also been regulated by the U.S. Army Corps of Engineers and EPA under Section 404 of the Clean Water Act.

As a result of the above activities, the Nation has greatly reduced pollutant loads from point source discharges and has made considerable progress in restoring and maintaining water quality.

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However, the gains in controlling point sources have not solved all of the nation's water quality problems. Recent studies and surveys by EPA and by State water quality agencies indicate that the majority of the remaining water quality impairments in our nation's rivers, streams, lakes, estuaries, coastal waters, and wetlands result from nonpoint source pollution and other nontraditional sources, such as urban stormwater discharges and combined sewer overflows.

In 1987, given the progress achieved in controlling point sources, coupled with the growing national awareness of the increasingly dominant influence of nonpoint source pollution on water quality, Congress amended the Clean Water Act to focus greater national efforts on nonpoint sources.

In the Water Quality Act of 1987, Congress amended Section 101, "Declaration of Goals and Policy", to add the following fundamental principle:

> It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

More importantly, Congress enacted Section 319 of the Clean Water Act, which established a national program to control nonpoint sources of water pollution. Under Section 319, States address nonpoint pollution by assessing nonpoint source pollution problems and causes within the State; adopting management programs to control the nonpoint source pollution; and implementing the management programs. Section 319 provides for the issuance by EPA of grants to States to assist them in implementing those management programs or portions of management programs that have been approved by EPA.

b. National estuary program

EPA also administers the National Estuary Program under Section 320 of the Clean Water Act. This program focuses upon point and nonpoint pollution in geographically targeted, high-priority estuarine waters. In this program, EPA assists State, regional and local governments to develop comprehensive conservation and management plans that recommend priority corrective actions to restore estuarine water quality, fish populations, and other designated uses of the waters.

c. Pesticides program

Another program administered by EPA that controls some forms of nonpoint pollution is the pesticides program under the Federal Insecticide, Fungicide, and Rodenticide Act. Among other things, this program authorizes EPA to control pesticides that may threaten ground and surface water. This approach entails determining the pesticide's potential for leaching into ground and surface waters; if there is such potential, determining whether national-label restrictions will adequately address leaching concerns; if not, determining whether additional training required by restricted use classification for the pesticide will provide adequate protection; and if not, determining whether providing States with the opportunity to develop State Management Plans for the chemical will effectively address the contamination risk. In the event EPA cannot determine that State plans would sufficiently reduce the risks to human health and the environment (i.e., an unreasonable risk remains), then EPA would resort to national cancellation.

EPA's approach to State management is described in a proposed Pesticides and Ground-Water Strategy currently undergoing review by the Office of Management and Budget. The strategy describes the policies and regulatory approaches that the Agency will use to protect the Nation's ground-water resources from risks of contamination by pesticides. Linkage to and integration with other evolving EPA/State programs is critical in order to avoid duplication of effort while promoting related activities.

B. Coastal Zone Management

The Coastal Zone Management Act of 1972 established a program for States and Territories to voluntarily develop comprehensive programs to protect and manage coastal resources (including the Great Lakes). In order to receive federal approval and implementation funding, States and Territories had to demonstrate that they had programs, including enforceable policies, that were sufficiently comprehensive and specific to regulate land uses, water uses, and coastal development; and to resolve conflicts among competing uses. In addition, they had to have the authorities to implement the enforceable policies.

There are 29 federally approved State and Territorial programs. Despite institutional differences, each program must protect and manage important coastal resources, including: wetlands, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitats. Resource management and protection is accomplished in a number of ways through State laws, regulations, permits, and local plans and zoning ordinances.

While water quality protection is integral to the management of many of these coastal resources, it was not specifically cited as a purpose or policy of the original statute. The Coastal Zone Act Reauthorization Amendments of 1990 described below specifically charged State coastal programs, as well as State nonpoint source programs, with addressing nonpoint source pollution affecting coastal water quality.

C. Coastal Zone Act Reauthorization Amendments of 1990

1. Background and Purpose of the Amendments

On November 5, 1990, Congress enacted the Coastal Zone Act Reauthorization Amendments of 1990. These Amendments were intended to address several concerns, a major one of which is the impact of nonpoint source pollution on coastal waters. In Section 6202(a) of the Amendments, Congress made a set of findings; the following findings are pertinent here:

"1. Our oceans, coastal waters, and estuaries constitute a unique resource. The condition of the water quality in and around the coastal area is significantly declining. Growing human pressures on the coastal ecosystem will continue to degrade this resource until adequate actions and policies are implemented.

"2. Almost one-half of our total population now lives in coastal areas. By 2010, the coastal population will have grown from 80,000,000 in 1960 to 127,000,000 people, an increase of approximately 60 percent, and population density in coastal counties will be among the highest in the Nation.

"3. Marine resources contribute to the Nation's economic stability. Commercial and recreational fishery activities support an industry with an estimated value of $12,000,000,000 a year.

"4. Wetlands play a vital role in sustaining the coastal economy and environment. Wetlands support and nourish fishery and marine resources. They also protect the Nation's shores from storm and wave damage. Coastal wetlands contribute an estimated $5,000,000,000 to the production of fish and shellfish in the United States coastal waters. Yet, 50 percent of the Nation's coastal wetlands have been destroyed, and more are likely to decline in the near future.

"5. Nonpoint source pollution is increasingly recognized as a significant factor in coastal water degradation. In urban areas, storm water and combined sewer overflow are linked to major coastal problems, and in rural areas, runoff from agricultural activities may add to coastal pollution.

"6. Coastal planning and development control measures are essential to protect coastal water quality, which is subject to continued ongoing stresses. Currently, not enough is being done to manage and protect coastal resources.

. . . .

"8. There is a clear link between coastal water quality and land use activities along the shore. State management programs under the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.) are among the best tools for protecting coastal resources and must play a larger role, particularly in improving coastal zone water quality. . . ."

Based upon these findings, Congress declared that:

"It is the purpose of Congress in this subtitle [the Coastal Zone Act Reauthorization Amendments of 1990] to enhance the effectiveness of the Coastal Zone Management Act of 1972 by increasing our understanding of the coastal environment and expanding the ability of State coastal zone management programs to address coastal environmental problems." (Section 6202(b))

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2. State Coastal Nonpoint Pollution Control Programs

To address more specifically the impacts of nonpoint source pollution on coastal water quality, Congress enacted Section 6217, "Protecting Coastal Waters". This section provides that each State with an approved coastal zone management program must develop and submit to EPA and NOAA for approval a Coastal Nonpoint Pollution Control Program. The purpose of the program "shall be to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities."

Coastal nonpoint pollution control programs are not intended to supplant existing coastal zone management programs and nonpoint source management programs. Rather, they are to serve as an update and expansion of existing nonpoint source management programs and are to be coordinated closely with the existing coastal zone management programs. The legislative history indicates that the central purpose of section 6217 is to strengthen the links between Federal and State coastal zone management and water quality programs and to enhance State and local efforts to manage land use activities which degrade coastal waters and coastal habitats. The legislative history further indicates that State coastal zone and water quality agencies are to have co-equal roles, analogous to the sharing of responsibility between NOAA and EPA at the Federal level.

Section 6217(b) states that each State program must "provide for the implementation, at a minimum, of management measures in conformity with the guidance published under subsection (g) to protect coastal waters generally," and also to:

(1) Identify land uses which, individually or cumulatively, may cause or contribute significantly to a degradation of (a) coastal waters where there is a failure to attain or maintain applicable water quality standards or protect designated uses, or (b) coastal waters that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources;

(2) Identify critical coastal areas adjacent to coastal waters identified under the preceding paragraph;

(3) Implement additional management measures applicable to land uses and areas identified under paragraphs (1) and (2) above that are necessary to achieve and maintain applicable water quality standards and protect designated uses;

(4) Provide technical assistance to local governments and the public to implement management measures;

(5) Provide opportunities for public participation in all aspects of the program;

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(6) Establish mechanisms to improve coordination among State and local agencies and officials responsible for land use programs and permitting, water quality permitting and enforcement, habitat protection, and public health and safety; and

(7) Propose to modify State coastal zone boundaries as necessary to implement NOAA recommendations under Section 6217(e), which are based on findings that inland boundaries must be modified to more effectively manage land and water uses to protect coastal waters.

EPA is required to publish proposed management measures guidance under section 6217(g) by May 1991 and final guidance by May 1992. Within 30 months of EPA's publication of final guidance, States must develop and obtain EPA and NOAA approval of their coastal nonpoint pollution control programs. Failure to submit an approvable program (i.e., one that meets the requirements of section 6217(b)) results in a reduction of Federal grant dollars under the nonpoint source and coastal zone management programs. The reductions begin in Fiscal Year 1996 as a 10% cut, increasing to 15% in FY 1997, 20% in FY 1998, and 30% in FY 1999 and thereafter.

3. Management Measures Guidance

Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990 requires EPA to publish (and periodically revise thereafter), in consultation with NOAA, the Fish and Wildlife Service, and other Federal agencies, "guidance for specifying management measures for sources of nonpoint pollution in coastal waters." "Management measures" are defined in section 6217(g)(5) as:

> economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

The management measures guidance is to include at a minimum six elements set forth in section 6217(g)(2):

"(A) a description of a range of methods, measures, or practices, including structural and nonstructural controls and operation and maintenance procedures, that constitute each measure;

"(B) a description of the categories and subcategories of activities and locations for which each measure may be suitable;

"(C) an identification of the individual pollutants or categories or classes of pollutants that may be controlled by the measures and the water quality effects of the measures;

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"(D) quantitative estimates of the pollution reduction effects and costs of the measures;

"(E) a description of the factors which should be taken into account in adapting the measures to specific sites or locations; and

"(F) any necessary monitoring techniques to accompany the measures to assess over time the success of the measures in reducing pollution loads and improving water quality."

State coastal nonpoint pollution control programs must implement management measures that are in conformity with this management measures guidance.

The legislative history (Floor statement of Rep. Gerry Studds, House Sponsor of Section 6217, as part of debate on Omnibus Reconciliation Bill, October 26, 1990) confirms that, as indicated by the statutory language, the "management measures" approach is technology-based rather than water-quality based. That is, the management measures, in a manner analogous to the technology-based requirements previously established for point sources, are to be based upon technical and economic achievability, rather than on establishing cause and effect linkages between particular land use activities and particular water quality problems. Congress' rationale is that, with few exceptions, neither States nor EPA have the money or the time to create the complex monitoring programs that would be required to document a causal link between specific land use activities and specific water quality problems. Under the approach adopted by Congress, States will be able to concentrate their resources on developing and implementing measures that experts agree will reduce pollution significantly.

The legislative history indicates that the range of management measures anticipated by Congress is broad and may include, among other measures, use of buffer strips, setbacks, techniques for identifying and protecting critical coastal areas and habitats, soil erosion and sedimentation controls, and siting and design criteria for water-related uses such as marinas. However, Congress has cautioned that the management measures should not unduly intrude upon the more intimate land use authorities properly exercised at the local level.

The legislative history also indicates that the management measures guidance, while patterned to a degree after the point source effluent guidelines technology-based approach (see 40 CFR Parts 400-471 for examples of this approach), is not expected to have the same level of specificity as effluent guidelines. Congress has recognized that the effectiveness of a particular management measure at a particular site is subject to a variety of factors too complex to address in a single set of simple, mechanical prescriptions developed at the federal level. Thus, the legislative history indicates that EPA's guidance should offer State officials a number of options and permit them considerable flexibility in selecting management measures that are appropriate for their State.

An additional major distinction drawn in the legislative history between effluent guidelines for point sources and management measures guidance is that the management measures will not be directly or automatically applied to categories of nonpoint sources as a matter of Federal law.

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Instead, the measures must be established under State law, or under local authorities as described through the State coastal nonpoint pollution control program. The State program must provide for the implementation of management measures in conformity with the management measures guidance. Under section 306(d)(16) of the CZMA, coastal zone programs must provide for enforceable policies and mechanisms to implement the applicable requirements of the State coastal nonpoint pollution control program, including management measures.

II. DEVELOPMENT OF PROPOSED MANAGEMENT MEASURES GUIDANCE

A. Schedule and Process Used to Develop Proposed Guidance

1. Schedule

Congress established a six-month deadline (May 5, 1991) for publication of this proposed guidance, and an eighteen-month deadline (May 5, 1992) for publication of the final guidance.

Given the extremely tight statutory deadline for publishing proposed guidance, EPA has worked to make this proposed guidance as broad and comprehensive as possible. To assist the public in commenting on the proposal, we have included below a discussion of our plans for completing the guidance by May 1992. While significant revisions are likely over the course of the next twelve months, we hope that this proposed guidance clearly outlines EPA's direction and technical approach being considered for the final guidance, thereby providing for fair opportunity for review and comment by interested persons, organizations, and agencies.

2. Work Groups

To meet the tight statutory deadline and draw upon existing sources of technical nonpoint source expertise, EPA chose a work group approach to develop the guidance. Since the guidance is to address all significant categories of nonpoint sources that impact or could impact coastal waters (see Background), EPA drew upon expertise covering the very wide range of subject areas addressed in this guidance.

Because nonpoint experts tend to specialize in particular source categories, EPA decided to form work groups on a category basis. Thus, in consultation with NOAA, the U.S. Fish and Wildlife Service, and other Federal and State agencies, EPA established five work groups to develop this proposed guidance:

(1) Urban, Construction, Highways, Airports/Bridges, and Septic Systems
(2) Agriculture
(3) Forestry
(4) Marinas and Recreational Boating
(5) Hydromodification, Dams and Levees, Shoreline Erosion, and Wetlands

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A list of the members in each of these Federal-State workgroups is provided in Appendix A of this guidance.

3. Meetings

EPA focused its initial efforts on briefing various governmental and other groups on the scope of the new coastal legislation; obtaining a broad range of input on potential approaches to developing the management measures guidance; scoping out options for writing management measures; and inviting participation by various interested EPA and NOAA offices and other Federal and State agencies in the work groups.

Some of the groups that EPA met with to discuss potential approaches to implementing the new legislation include the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), the Coastal States Organization (CSO), several Federal agencies, and the Natural Resources Defense Council.

On January 16, 1991, EPA held the first work group meeting, attended by over 30 Federal and State agency staff with expertise in coastal nonpoint pollution issues. That meeting resulted in commitments for assistance and, in some cases, substantial participation in the effort, especially by USDA and NOAA. Each workgroup has held at least one meeting since February, 1991, with the agriculture work group meeting three times and the urban group holding a two-day meeting. Other groups have utilized teleconferencing for additional communication. Both Federal and State work group members have participated in drafting and reviewing this proposed guidance.

B. Scope and Contents of This Proposed Guidance

1. Categories of Nonpoint Sources Addressed

Many categories and subcategories of nonpoint sources could affect coastal waters and thus could potentially be addressed in this management measures guidance. Including all such sources in this proposed guidance would require more time than the tight statutory deadline allows. For this reason, Congressman Studds stated in his floor statement, "The Conferees expect that EPA, in developing its guidance, will concentrate on the large nonpoint sources that are widely recognized as major contributors of water pollution."

This proposed guidance thus focuses on five major categories of nonpoint sources that impair or threaten coastal waters nationally: (1) agricultural runoff; (2) urban runoff (including developing and developed areas); (3) silvicultural (forestry) runoff; (4) marinas and recreational boating; and (5) hydromodification, dams and levees, and shoreline erosion. EPA has also included management measures for wetlands, riparian areas, and filter strips that apply generally to various categories of sources of nonpoint pollution. Some categories that have not been addressed but may be responsible for nonpoint source pollution in some coastal waters include oil and gas operations; mining activities; land disposal of wastes; and in-place contamination

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(sediments). EPA intends to investigate these activities' impacts on coastal waters as time and resources allow. We welcome comments from the public on these and other categories that might appropriately be addressed in the management measures guidance.

2. Overlaps Between Nonpoint Sources and Point Sources

Historically, there have always been overlaps and ambiguity between programs designed to control nonpoint sources and point sources. The primary overlap occurs between the stormwater permit program (under section 402(p) of the Clean Water Act) and traditional urban runoff programs. Often, runoff may originate as a nonpoint source but ultimately be channelized and become a point source. A further complication arises because the Clean Water Act currently requires a permit for some municipal stormwater sources while postponing regulatory coverage of other (generally smaller) municipalities' storm water.

A second overlap occurs in connection with confined animal feeding operations. Concentrated animal feeding operations that meet particular size or other criteria are defined and regulated as point sources under the section 402 permit program. Other confined animal feeding operations are not currently regulated as point sources. Other overlaps may occur with respect to aspects of mining operations, oil and gas extraction, land disposal, and other activities.

EPA intends that the coastal nonpoint pollution control programs to be developed by the States apply only to sources that are not currently required to apply for and receive an NPDES permit, and that the management measures similarly apply only to sources that are not required to apply for and receive an NPDES permit. In this proposed guidance, EPA has attempted to avoid addressing activities that are clearly regulated point source discharges. However, for pollution sources for which there may be overlap or ambiguity, EPA has chosen to err on the side of inclusiveness in this proposed guidance and to include management measures to address those sources.

For example, the management measures guidance for marinas does not address pollution from vessels, including marine sanitation devices, which are regulated as point sources under sections 312 and 402 of the Clean Water Act. Nor does it address construction sites exceeding five acres in size, which are regulated under section 402 of the Act. On the other hand, the guidance does include urban runoff management measures. These will apply only to stormwater discharges that are not required to apply for and receive stormwater permits; however, they include some of the same measures that may be addressed in such stormwater permits. Readers should also note that a stormwater discharge that is currently exempt from permit requirements may be required to obtain a permit under section 402(p)(2)(E) of the Clean Water Act if EPA or a State determines that it contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. Additional stormwater discharges may also be regulated as point sources under section 402(p)(6).

EPA will continue to evaluate overlapping areas and welcomes comment on our proposed attempts to deal with these areas.

3. Contents of This Proposed Guidance

This proposed guidance includes, for the five source categories addressed to date, the following:

(1) A specification of management measures;

(2) A description of the categories and subcategories of activities and locations for which each measure may be suitable;

(3) An identification of the individual pollutants or categories or classes of pollutants that may be controlled by the measures;

(4) A description of the water quality effects of the measures;

(5) Information regarding pollution reductions achievable with the management measures;

(6) Information on costs of the measures; and

(7) A description of some factors which should be taken into account in adapting the measures to specific sites or locations.

Due to the extremely tight time constraints imposed by the statute, EPA could not include detailed information on all of the items identified above, most notably pollutant reduction effectiveness and cost data. EPA will endeavor over the next year to obtain additional information for inclusion in the final guidance.

C. Development of Final Guidance: Request for Comments

Much needs to be accomplished between now and May 1992. EPA intends to examine and evaluate various data sources, including those listed in references listed at the end of many of the chapters of this document. In addition, EPA has existing, yet incomplete, data bases regarding the effectiveness of agricultural and urban management practices, and we will use this information to the extent possible. These data bases include information regarding the study conditions, practices applied, and pollutant reductions achieved. Other literature will be accessed through existing libraries of nonpoint source publications, including information maintained by Universities, other agencies, and State government. EPA will rely primarily on those articles published in the peer-reviewed technical literature, but will use other reliable sources as necessary.

EPA solicits comments on the proposed guidance, including additional information and supporting data on the measures specified in this guidance as well as additional management measures that may be as effective in controlling nonpoint source pollution. In particular, EPA requests the following:

(1) Information on the activities and locations for which each measure may be suitable and on factors which should be taken into account in adapting the measures to specific sites or locations.

(2) Information on the pollutants that may or may not be controlled by the measure.

(3) Data regarding the pollutant reduction effectiveness of the measures.

(4) Data regarding the costs of each measure.

EPA also welcomes comments on the general approach used in the proposed guidance, including the level of detail used to describe management measures.

Comments on this guidance should be mailed, within 120 days of publication of the Federal Register notice announcing the availability of this proposed guidance, to Steven Dressing, Assessment and Watershed Protection Division (WH-553), Office of Water, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, DC 20460.

The review comments received as a result of public notice will be assessed and summarized. EPA will draw upon the information provided through public review and comment, the technical materials referenced throughout this proposed guidance, and other expertise as available to make final determinations as to the scope and content of the guidance.

III. TECHNICAL APPROACH TAKEN IN DEVELOPING THIS GUIDANCE

A. The Nonpoint Source Pollution Process

Nonpoint source pollutants are transported to surface water by a variety of means, including runoff and ground-water infiltration. Ground water and surface water are both considered part of the same hydrologic cycle when designing management measures. Ground-water contributions of pollutant loadings to surface waters in coastal areas are often very significant. The transport of nonpoint source pollutants to coastal waters through ground-water discharge is governed by physical and chemical properties of the water, pollutant, soil, and aquifer. Appendix B of the proposed guidance contains a discussion of the effects of various nonpoint source management practices on ground water.

1. Source Control

Source control is the first opportunity in any nonpoint source control effort. Source control methods very for different types of nonpoint source problems. Examples of source control include:

(1) Reducing or eliminating the introduction of pollutants to a land area. Examples include reduced nutrient and pesticide application.

(2) Preventing non-introduced pollutants from leaving the site during land-disturbing activities. Examples include conservation tillage; planning forest road construction to minimize erosion; siting marinas adjacent to deep waters to eliminate or minimize the need for dredging; and managing grazing to protect against overgrazing and the resulting increased soil erosion.

(3) Preventing interaction between precipitation and introduced pollutants. Examples include installing gutters and diversions to keep clean rainfall away from barnyards; diverting rainfall runoff from areas of land disturbance at construction sites; and timing chemical applications or logging activities based upon weather forecasts or seasonal weather patterns.

(4) Protecting riparian habitat and other sensitive areas. Examples include protection and preservation of riparian zones, shorelines, wetlands, and highly erosive slopes.

(5) Protecting natural hydrology. Examples include the maintenance of pervious surfaces in developing areas (conditioned based upon ground-water considerations); riparian zone protection; and water management.

2. <u>Delivery Reduction</u>

Pollution prevention often involves delivery reduction (intercepting pollutants prior to delivery to the receiving water) in addition to appropriate source control measures. Management measures include delivery reduction practices to achieve the greatest degree of pollutant reduction economically achievable, as required by the statute.

Delivery reduction practices intercept pollutants leaving the source by capturing the runoff or infiltrate, followed either by treating and releasing the effluent or by permanently keeping the effluent from reaching a surface or ground water resource.

By their nature, delivery reduction practices often bring with them side effects that must be accounted for. For example, management practices that intercept pollutants leaving the source may reduce runoff, but also increase infiltration to ground water. For example, infiltration basins trap runoff and allow for its percolation. These devices, although highly successful at controlling suspended solids, may not, because of their infiltration properties, be suitable for use in areas with high ground-water tables and nitrate or pesticide residue problems.

The performance of delivery reduction practices is to a large extent dependent on suitable designs, operational conditions, and proper maintenance. For example, filter strips may be effective for controlling particulate and soluble pollutants where sedimentation is not excessive,

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but may be overwhelmed by high sediment input. In many cases, filter strips are used as pretreatment or supplemental treatment for other practices within a management system.

These examples illustrate that the combination of source control and delivery reduction practices, and the application of those practices as components of management measures, are dependent upon site-specific conditions. Technical factors that may affect the suitability of management measures include, but are not limited to, land use, climate, size of drainage area, soil permeability, slopes, depth to water table, space requirements, the type and condition of the water resource to be protected, depth to bedrock, and the pollutants to be addressed. In the proposed management measure guidance below, some of these factors are discussed as they affect the suitability of particular measures. EPA expects to expand this aspect of management measures in the final guidance.

B. Management Measures as Systems

Technical experts who design and implement effective nonpoint source control measures do so from a management systems approach as opposed to an approach that focuses on individual practices. That is, the pollutant control achievable from any given management system is viewed as the sum of the parts, taking into account the range of effectiveness associated with each single practice, the costs of each practice, and the resulting overall cost and effectiveness. Some individual practices may not be very effective alone, but, in combination with others, may provide a key function in highly effective systems. This is analogous to the use of treatment "trains," or series of treatment steps, in most point source wastewater treatment systems.

Therefore, this guidance adopts the approach of specifying management measures (defined by 's the "best available...") as systems of management practices. This is primarily reflected in two ways: (1) the management measures are usually presented as systems, and (2) for those sources that generate pollutants from a number of somewhat discrete activities or unit areas the guidance includes management measures for each activity or area.

For example, the agriculture category includes separate management measures for sediment control on agricultural land; nutrient management; pesticide management; irrigation management; and livestock management. Taken together, however, these measures constitute comprehensive management measures that can address a wide range of farm operations, several of which are frequently found on the same farm.

C. Distinction Between Management "Measures" and "Practices"

Readers should note that the statute provides that State programs need to be "in conformity" only with "management measures", not with "management practices". The "management measures" contained in this guidance are the heart of the guidance. The "practices" listed in the guidance are provided strictly for informational purposes; they are designed to provide ideas on effective tools to achieve the management measures. However, the selection of these or other practices is within the discretion of the State and managers of the sources of nonpoint pollution, provided that the selected set of practices achieves the management measure.

Since nonpoint source pollutants have a limited number of pathways by which they reach water resources, the practices that constitute management measures for the various source categories may be similar in several cases. For example, filter strips of one sort or another are used to address a variety of sources, including agricultural, forestry, and urban sources. At the same time, the filter strip design specifications, operation and maintenance, and pollutant reductions for each of these sources and specific activities within these source categories may vary considerably, however. In this proposed guidance, filter strips are addressed in the final chapter as a multi-source management measure. Similarly, the water-quality benefits of protecting and restoring coastal wetlands apply across many categories of nonpoint sources and are thus addressed in the final chapter. EPA may identify other management measures in the final guidance that can be applied to more than one source category.

D. Management Measures: Adaptation to Local Conditions

It is generally not possible to prescribe a highly specific management measure that will be uniformly applicable nationally or regionally. For example, when designing erosion and sediment control systems on agricultural lands, one considers soil types, cropping patterns, precipitation patterns, slopes, depth to water table, and other factors to determine the proper system for each parcel of land. Similarly, in determining management measures for developing urban areas, a local community might consider transportation system needs, land use, soils, slopes, precipitation patterns, permeability, rate of growth, and other factors. The multitude of combinations of site-specific factors that arise across the nation, within States, and even within watersheds, makes it impractical to develop a list of specific management measures that is most effective to control all of the existing and potential nonpoint source problems affecting our coastal waters.

Rather than developing an exhaustive list of specific management measures (each of which is a system of practices) tailored to all scenarios (an impossible task), or even a defined subset of possible scenarios, EPA proposes to specify management measures in a manner that can be applied on a broader scale to categories of nonpoint sources. By identifying measures that reflect best achievable pollutant reductions, yet allowing for approaches that achieve equivalent or better pollutant control, EPA's proposal enables adaptation to site-specific conditions. This adaptation would occur through flexible application of management measures contained in State coastal nonpoint pollution control programs approved by NOAA and EPA.

This proposed guidance provides a suite of management measures for each source category. The number and type of systems identified per source category are based upon the range and diversity of substantively different subcategories, activities, and pollutants.

EPA used a consistent approach to determine the number and type of management measure systems needed under each category. We first determined the range of subcategories and activities that fall under each source, and how they related to each other. We then identified the types of nonpoint source pollution and impacts that could be caused by each subcategory and activity, as well as by combinations of subcategories and activities. This step is key to preventing pollution at the source. Management measures were then identified based upon several factors, including the types of pollutants, pollutant fate and transport, and land management patterns and opportunities.

Pollution prevention was always considered as the first component of management measures. Pollutant delivery reduction measures were typically added only after it was determined that additional control was necessary to reach the greatest degree of pollutant reduction economically achievable.

For each management measure, a list of management practices that can be used in designing an equivalent or better system is provided. The list of practices reflects the best available set of practices, or components of best available systems, but is not all-inclusive of those practices that could be used to develop systems that are equivalent to or better than specified management measures.

The pollutant reductions that can be achieved using the specified management measures are also described in this guidance, quantitatively wherever possible. These reductions serve as the benchmarks for equivalent or better management measures. Pollutant reductions achievable with the management practices listed are also given to the extent data are available.

The proposed guidance also describes factors that need to be taken into account in adapting the systems to specific sites or locations. These factors are illustrative of conditions that may lead to (1) selection of equivalent or better management measures for any given application, (2) special design considerations, or (3) special operation and maintenance considerations. As for other aspects of the proposed guidance, EPA intends to expand this information in the final guidance.

E. Pollution Reduction Estimates

Estimates of pollution reduction are provided for the management measures and a subset of the management practices contained in this proposed guidance. All estimates provided are based upon data available to EPA, but EPA has to date performed little or no analysis of these data due to the tight statutory deadline for proposal. Therefore, the estimates provided should be considered only indicative of the types of estimates that will be given in the final guidance, but should not be considered best estimates at this time.

EPA expects during the coming year to assemble and analyze additional pollutant reduction data on the effectiveness of various practices and measures; improve its understanding of the site-specific variability of pollutant reduction estimates by identifying factors that appear to cause differences in reductions; and characterize reduction results more rigorously. EPA will also examine the specific practices to determine if differences in design or application affected the study results. For example, pipe outlet terraces may have a very different impact upon ground water than terraces with no pipe outlets. Further, pipe outlet terraces on soils underlain by carbonate rock may have very different effects than terraces underlain by noncarbonate rocks.

In many cases, EPA was unable to obtain or analyze data that would enable EPA to estimate pollutant reduction effects of proposed management measures. EPA intends to do considerable work in the coming year to develop such quantitative information and welcomes commenters' ideas and data in this regard.

F. Costs, Economic Achievability, and Net Economic Benefits of Proposed Management Measures

A limited amount of cost information is provided in various chapters of this proposed guidance. The cost data, like the pollutant reduction effects estimates provide a preliminary indication of the type and range of estimates likely to appear in the final guidance, but should not be considered final or best estimates at this time. EPA has also prepared a preliminary scoping analysis of the net economic benefits of management measures for coastal waters.

Congress defined "management measures" to mean "economically achievable measures ... which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives. Thus the management measures must be "economically achievable".

Congress has not defined the term "economically achievable"; nor has it explained the term in legislative history. However, as noted previously, the legislative history indicates that the management measures approach of Section 6217 is "patterned" after the "best available technology economically achievable" (BAT) approach used in the Clean Water Act for point sources. Thus, the meaning of "economically achievable" would seem to be its historical interpretation in the point source program.

It is unclear that "economically achievable" would be interpreted precisely the same way for nonpoint source management measures guidance as it has been for point source BAT regulations. Indeed, there are important distinctions between the "management measures" guidance and BAT regulations that clearly limit the extent to which economic achievability can be assessed and factored into a general analysis of proposed guidance. These distinctions relate to the more extensive flexibility inherent in implementing nonpoint source management measures.

The ability of a particular management measure to deal with nonpoint source pollution from a particular site is subject to a variety of factors (e.g., geography, geology, soils, hydrology, and production methods) too complex to address in a single set of simple, mechanical prescriptions developed at the federal level. Thus, Congress indicated the need to provide in the management measures guidance considerable flexibility for local selection of management measures. Furthermore, unlike BAT regulations, the management measures guidance is not directly applicable to nonpoint sources, but, rather, will be directly implemented only through state programs developed in conformity with the guidance. These considerations make it very difficult to predict the costs and economic impacts of management measures that will ultimately be developed, applied, and implemented on a localized basis.

Many of the proposed management measures are generally regarded as low-cost, yet highly effective. Examples include agricultural measures such as sediment control and nutrient management. Others are more expensive, yet are widely practiced (e.g., animal waste controls and construction of vegetative filter strips). Further, it should be noted that significant cost-share assistance is available to farmers from a variety of federal and state programs to assist in the implementation of the agricultural management measures.

The exceptionally tight six-month statutory deadline, coupled with the analytical limitations outlined above, have precluded a formal economic analysis. To assist readers in evaluating the effect of this guidance, EPA has prepared a preliminary net benefits analysis of nonpoint source management measures for coastal waters. This preliminary analysis indicates that implementation of nonpoint pollution management measures in coastal areas may yield significant net economic benefits. EPA solicits comments on this preliminary benefits analysis.

Commenters are also invited to identify particular management measures that they believe are or are not economically achievable; provide information or analyses to support their comments; and suggest alternative analytical methodologies that they believe would be useful in determining economic achievability. Commenters are also invited to suggest methods for analyzing economic achievability in a manner that overcomes the analytical limitations outlined above and that could be performed rapidly, consistent with the May 1992 deadline for publication of final management measures guidance.

IV. ISSUES TO BE ADDRESSED IN PROGRAM GUIDANCE

A complete understanding of the proposed management measures depends on a consideration of how they will be implemented in State programs. As described in "Background", each State Coastal Nonpoint Pollution Control Program (CNPCP) must "provide for the implementation, at a minimum, of management measures in conformity with the guidance published under subsection (g) to protect coastal waters generally,...." States will implement the CNPCP through amendments to their existing State nonpoint source program under section 319 of the Clean Water Act (as amended in 1987) and their Coastal Zone Management Program.

EPA and NOAA plan to publish draft state program development and approval guidance in August 1991. This guidance will address the key issues of how the management measures are to be implemented in State programs, as well as other program requirements. States and other interested parties will be given the opportunity to review and comment on the guidance at that time. The agencies expect to publish final state program guidance in May 1992.

We recognize that many reviewers of the proposed management measures guidance will wish to understand how these measures will apply programmatically as they evaluate and comment upon the measures. Therefore, to assist readers to consider the proposed measures in the broader implementation context, pending publication of the proposed state program guidance, we identify below some of the key management measures implementation issues that EPA and NOAA expect to address in the proposed program guidance, along with an indication of the range of options being considered.

A. State Conformity with Management Measures Guidance

Section 6217 assigns to the States the responsibility for developing and implementing management measures "in conformity" with the subsection (g) guidance. The interpretation of this requirement is key in that it will prescribe the degree of discretion that States will have in developing alternative management measures and targeting specific sources and areas. NOAA and EPA are currently developing programmatic guidance which will explain how the Agencies will make decisions with respect to whether State programs are "in conformity with" the guidance.

Some options currently under consideration are:

(1) States could be required to implement the specified management measures for all sources that contribute nonpoint source pollution to coastal waters.

(2) States could be required to implement either the specified management measures or tailored management measures that are equivalent in performance to the specified management measures for all sources that contribute nonpoint source pollution to coastal waters.

(3) States could be required to identify significant sources of nonpoint pollution and implement the specified management measures, or equivalent State management measures, as necessary to protect and restore coastal water quality.

(4) States could be required to develop performance requirements to determine where to implement the specified management measures, or equivalent State management measures, to guarantee protection of coastal waters, on a case-by-case basis.

B. Applicability of Management Measures to Individual Sources

A major issue in the implementation of management measures is whether the management measures should be required by State programs for all sources or only for a subset of sources or geographic areas that are determined to be significant sources of nonpoint source pollution. The most stringent approach would require that every land owner or manager should implement a minimum set of management measures to prevent nonpoint source pollution, without first

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estimating the extent of a coastal water quality problem or threat and the land's relationship to the problem or threat. This approach would parallel the highly effective point source program, in which uniform BAT controls applicable to all sources in a particular category has led to relatively rapid progress in the treatment of point source discharges. The approach also establishes equal requirements for all competing producers.

A potential pitfall of this approach is that costs and pollutant reduction effects cannot readily be taken into account by States in developing management measures appropriate to individual sources or classes of activities. By requiring minimum measures of all land owners or managers, the agencies may thus impose unnecessary costs and requirements upon those that do not contribute to nonpoint source problems or the threat of such. Furthermore, a broadly uniform approach may divert implementing agencies' efforts from focussing on the primary problems that contribute most significantly to coastal water quality problems.

Between the two extreme options (applying management measures to all sources, and applying management measures only to sources demonstrated to have particular well-defined impacts on coastal waters) lie certain intermediate options. For example:

(1) A tiered approach could set different levels of minimum control based upon the extent and type of the problem, and the likelihood that any given land area or class of sources might contribute to the problem. (Readers should note that section 6217(b)(3) already provides for additional management measures to address critical coastal areas and land uses. See the next section below.)

(2) A targeted approach that identifies certain areas or classes of sources for treatment, while leaving others untreated, presents a similar way to achieve effective control at lower cost within each tier.

(3) A tiering or targeting approach could use tiering or targeting not to distinguish among different sources' control requirements, but rather to prioritize and schedule State implementation activities.

C. Land Uses and Critical Coastal Areas

Section 6217(b) requires that states identify land uses which, individually or cumulatively, may cause or contribute significantly to a degradation of (a) coastal waters where there is a failure to attain or maintain applicable water quality standards or protect designated uses, or (b) coastal waters that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources. The section also requires states to identify critical coastal areas adjacent to the coastal waters identified above. Finally, the section requires that the state coastal nonpoint pollution control program provide for implementation of additional management measures that are necessary to achieve and maintain applicable water quality standards.

Unlike the management measures specified in this guidance, the implementation of these additional measures is tied directly to water quality standards and designated uses of coastal waters. EPA and NOAA will work with the states to determine the scope and application of these additional management measures and their relationship to the measures developed in accordance with section 6217(g).

D. Conclusion

EPA reminds readers that the above issues, together with other implementation issues, will be addressed in forthcoming State program approval guidance, scheduled for publication in draft form in August 1991. The brief discussion above has been intended to assist the public in understanding related implementation issues as they review and comment upon the proposed management measures guidance. However, we request that commenters on this proposed management measures guidance focus their comments upon the technical soundness of the proposed management measures and reserve implementation-related considerations until the forthcoming State program approval guidance is published for public comment.

V. REQUEST FOR INFORMATION AND COMMENTS

EPA is soliciting comments on the proposed guidance on management measures to control coastal nonpoint pollution. We are seeking additional information and supporting data on the measures specified in this guidance and on additional measures that may be as effective or more effective in controlling nonpoint source pollution. The following information is sought by EPA in preparing the final guidance:

(1) Information on the activities and locations for which each measure may be suitable and information on factors which should be taken into account in adapting the measures to specific sites or locations;

(2) Information on the pollutants that may or may not be controlled by the measures;

(3) Data regarding the pollution reduction effects of the measures;

(4) Data regarding the costs of each measure; and

(5) Appropriate monitoring techniques for each resource.

EPA also welcomes comments on the general approach used in the proposed guidance, including the level of detail used to describe management measures. As mentioned above, EPA requests that commenters focus their comments upon the technical soundness of the proposed management measures guidance and reserve implementation-related considerations until the forthcoming state program approval guidance is published for public comment.

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CHAPTER 2. AGRICULTURAL MANAGEMENT MEASURES

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CHAPTER 2

AGRICULTURAL MANAGEMENT MEASURES

I. INTRODUCTION

This chapter specifies management measures for agricultural sources of nonpoint pollution. Agriculture is the nation's largest contributor of nonpoint source pollution. In coastal waters, its effect varies regionally. In some coastal waters, agriculture has been identified as the single largest contributor of sediment, nutrients, and other pollutants of concern. For example, agricultural runoff has been identified as the leading source of pollution in the Chesapeake Bay and in other estuaries. Thus, applying management measures to control agricultural nonpoint pollution is an essential component of a State program to protect coastal waters from nonpoint pollution.

II. POLLUTANTS THAT CAUSE AGRICULTURAL NONPOINT SOURCE POLLUTION*

The primary agricultural nonpoint source pollutants are nutrients, sediment, animal wastes, salts, and pesticides. These pollutants' effects on water quality are discussed below.

A. Nutrients

Nitrogen and phosphorus are the two major nutrients from agricultural land that degrade water quality. All plants, whether land based, aerial, or aquatic, require nutrients for growth. In an aquatic environment, nutrient availability usually limits plant growth. Nitrogen and phosphorus generally are present at background or natural levels below 0.3 and 0.05 mg/l, respectively. When these nutrients are introduced into a stream, lake, or estuary at higher rates, aquatic plant productivity may increase dramatically. This process, referred to as cultural eutrophication, may adversely affect the suitability of the water for other uses.

Increased aquatic plant productivity results in additional organic material being added to the system that eventually dies and decays. The decaying organic matter produces unpleasant odors and depletes the oxygen supply required by aquatic organisms. Excess plant growth also may interfere with recreational activities such as swimming and boating. Depleted oxygen levels,

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* This section on Pollutants that Cause Agricultural Nonpoint Source Pollution is adapted from: USDA, Soil Conservation Service. 1983. Water Quality Field Guide. SCS-TP-160, Washington, D.C.

especially in colder bottom waters where dead organic matter tends to accumulate, will reduce the quality of fish habitat and encourage the propagation of fish which are adapted to less oxygen or to warmer surface waters. Highly enriched waters will stimulate algae production, with consequent increased turbidity and color. Algae growth is also believed to be harmful to coral reefs (e.g., Florida coast). Furthermore, the increased turbidity results in less sunlight penetration and availability to submerged aquatic vegetation (SAV). Since SAV provides habitat for small or juvenile fish, the loss of SAV has severe consequences for the food chain. Chesapeake Bay is an example where nutrients are believed to have contributed to SAV loss.

B. <u>Nitrogen</u>

All forms of transported nitrogen are potential contributors to eutrophication in lakes, estuaries, and some coastal waters. In general, though not all cases, nitrogen availability is the limiting factor for plant growth in marine ecosystems. Thus, the addition of nitrogen can have a significant affect on the natural functioning of marine ecosystems.

In addition to eutrophication, excessive nitrogen causes other water quality problems. Dissolved ammonia at concentrations above 0.2 mg/l may be toxic to fish, especially trout. Nitrates in drinking water are potentially dangerous, especially to newborn infants. Nitrate is converted to nitrite in the digestive tract, which reduces the oxygen-carrying capacity of the blood (methemoglobinemia), resulting in brain damage or even death. The U.S. Environmental Protection Agency has set a limit of 10 mg/l nitrate-nitrogen in water used for human consumption (Robillard, et al., 1981).

Nitrogen is naturally present in soils but must be added to increase crop production. Nitrogen is added to the soil primarily by applying commercial fertilizers and manure, but also by growing legumes (biological nitrogen fixation) and incorporating crop residues. Not all nitrogen that is present in or on the soil is available for plant use at any one time. Organic nitrogen normally constitutes the majority of the soil nitrogen. It is slowly converted (2 to 3 percent per year) to the more readily plant available inorganic ammonium or nitrate.

The chemical form of nitrogen affects its impact on water quality. The most biologically important inorganic forms of nitrogen are ammonium (NH_4+), nitrate (NO_3-), and nitrite (NO_2). Organic nitrogen occurs as particulate matter, in living organisms, and as detritus. It occurs in dissolved form in compounds such as amino acid, amines, purines, urea, etc.

Nitrate-nitrogen is highly mobile and can move readily below the crop root zone, especially in sandy soils. It can also be transported with surface runoff, but not generally in large quantities. Ammonium on the other hand, becomes adsorbed by the soil and is lost primarily with eroding sediment. Even if nitrogen is not in a readily available form as it leaves the field, it can convert to an available form later.

C. Phosphorus

The phosphorus content in most soils is low, between 0.01 and 0.2 percent by weight. Most of this is unavailable for plant uptake. Manure and fertilizers are used to increase the level of available phosphorus in the soil to promote plant growth. If runoff and erosion occur, some of the applied phosphorus can reach nearby bodies of water. High-intensity storms increase the loss of particulate inorganic phosphorus from croplands because this form of phosphorus is associated with eroding sediments.

Phosphorus can be found in the soil in dissolved, colloidal, or particulate forms. Dissolved inorganic phosphorus (orthophosphate phosphorus) is probably the only form directly available to algae. Algae consume dissolved inorganic phosphorus and convert it to the organic form. Phosphorous is rarely found in concentrations high enough to be toxic to higher organisms.

Phosphorus unavailable in the soil system may erode with soil particles and later be released when the bottom sediment of a stream becomes anaerobic, creating water quality problems. While phosphorus typically plays the controlling role in freshwater systems, in some estuarine systems, both nitrogen and phosphorus can limit plant growth. Thus, the addition of phosphorus as a nonpoint source pollutant can have an adverse effect in both freshwater and estuarine systems.

D. Sediment

Sediment is the result of erosion. It is the solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site or origin by air, water, gravity, or ice. The types of erosion associated with agriculture that produce sediment are: (1) sheet and rill erosion and (2) gully erosion. Sediments from different sources vary in the kinds and amounts of pollutants that are adsorbed to the particles. For example, sheet and rill erosion mainly move soil particles from the surface or plow layer of the soil. Eroded soil is either redeposited on the same field or transported from the field in runoff.

Sediment which originates from surface soil will have a higher pollution potential than that from subsurface soils. The topsoil of a field is usually richer in nutrients and other chemicals because of past fertilizer and pesticide applications, as well as nutrient cycling and biological activity. Topsoil is also more likely to have a greater percentage of organic matter. Sediment from gullies and streambanks usually carries less adsorbed pollutants than sediment from surface soils.

Sediment from cropland usually contains a higher percentage of finer and less dense particles than the soil from which it originates. Large particles are more readily detached from the soil surface because they are less cohesive. They will also settle out of suspension more quickly because of their size. Organic matter is not easily detached because of its cohesive properties, but once detached it is easily transported because of its low density. Clay particles and organic residues will remain suspended for longer periods and at slower flow velocities. This selective erosion process can increase overall pollutant delivery, because small particles have a much

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greater adsorption capacity per mass than larger particles. As a result, eroding sediments generally contain higher concentrations of phosphorus, nitrogen, and pesticides than the original soil.

Sediment affects the use of water in many ways. Suspended solids reduce the amount of sunlight available to aquatic plants, cover fish spawning areas and food supplies, smother coral reefs, and clog the filtering capacity of filter feeders and the gills of fish. This reduces fish, shellfish, coral and plant populations, and decreases the overall productivity of lakes, streams, estuaries, and coastal waters. Turbidity interferes with feeding habits of fish. Recreation is limited because of the decreased fish population and the water's unappealing, turbid appearance. Turbid water reduces visibility, thus it is less safe for swimming.

Chemicals such as some pesticides, phosphorus, and ammonium are transported with sediment in an adsorbed state. Changes in the aquatic environment, such as a lower concentration in the overlying waters or the development of anaerobic conditions in the bottom sediments, can cause these chemicals to be released from the sediment. Adsorbed phosphorus transported by the sediment may not be immediately available for aquatic plant growth but does serve as a long-term contributor to eutrophication.

E. Animal Wastes

Animal wastes (manure) includes the fecal and urinary wastes of livestock and poultry, process water (such as from a milking parlor), and the feed, bedding, litter, and soil with which they become intermixed. Animal wastes can contribute nutrients, organic materials, and pathogens to receiving waters.

Manure will be more easily removed in runoff when applied to the soil surface than when incorporated in the soil. Spreading manure on frozen ground or snow can result in high concentrations of nutrients being transported from the field during rainfall or snowmelt. The problems associated with nitrogen and phosphorus, as discussed in the section **Nutrients**, also apply to animal wastes. If sufficient manure is applied to meet the nitrogen needs of a crop, phosphorus will generally be in excess. The soil generally has the capacity to adsorb any phosphorus leached from manure applied on land. However, as previously mentioned, nitrates are easily leached through soil into ground water or to return flows, and phosphorus can be transported by eroded soil.

The demand for oxygen exerted by carbonaceous materials (individually or in combination with nitrogen) can deplete dissolved oxygen supplies in water, resulting in anoxic or anaerobic conditions. When the decomposition process causes water to become anaerobic, methane, amines, and sulfide are produced. The water acquires an unpleasant odor, taste, and appearance and becomes unfit for drinking, and for fishing and other recreational purposes.

Animal diseases can be transmitted to humans through contact with animal feces. Runoff from fields receiving manure will contain extremely high numbers of bacteria if the manure has not been incorporated or the bacteria have not been subject to stress. Pathogen contamination from animal waste has been responsible for shellfish contamination in some coastal waters. However, bacteria levels in receiving waters may be attributed in some cases to either agricultural runoff or septic systems, and determination of actual sources is difficult.

Conditions which cause a rapid dieoff of bacteria are low soil moisture, low pH, high temperatures, and direct solar radiation. Manure storage generally promotes dieoff, although pathogens can remain dormant at certain temperatures. Composting the wastes is quite effective in decreasing the number of pathogens.

F. Salts

Salts are a product of the natural weathering process of soil and geologic material. They are present in varying degrees in all soils and in freshwater, coastal/estuarine waters, and ground waters.

In soils that have poor subsurface drainage, high salt concentrations are created within the root zone where most water extraction occurs. The accumulation of soluble and exchangeable sodium leads to soil dispersion, structure breakdown, decreased infiltration, and possible toxicity; thus, salts often become a serious problem on irrigated land, both for continued agricultural production and for water quality considerations. High salt concentrations in streams can harm freshwater aquatic plants just as excess soil salinity damages agricultural crops. While salts are generally a more significant pollutant for freshwater ecosystems than for saline ecosystems, they may also adversely affect anadromous fish, which while living in coastal and estuarine waters most of their lives, depend on freshwater systems near the coast for crucial portions of their life cycle.

The movement and deposition of salts depend on the amount and distribution of rainfall and irrigation, the soil and underlying strata, evapotranspiration rates, and other environmental factors. In humid areas, dissolved mineral salts have been naturally leached from the soil and substrata by rainfall. In arid and semiarid regions, salts have not been removed by natural leaching and are concentrated in the soil. Soluble salts in saline and sodic soils consist of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, and chloride ions. They are fairly easily leached from the soil. Sparingly soluble gypsum and lime also occur. The amounts present range from traces to more than 50 percent of the soil mass. The total dissolved solids of ions in ground water and streams include the soluble ions mentioned above. Irrigation water, whether from ground water or surface water sources, has a natural base load of dissolved mineral salts. As the water is consumed by plants or lost to the atmosphere by evaporation, the salts remain and become concentrated in the soil. This is referred to as the "concentrating effect."

The total salt load carried by irrigation return flow is the sum of the original salt in the applied water resulting from the concentrating effect plus salt pick-up. Irrigation return flows provide the means for conveying the salts to the receiving streams or ground-water reservoirs. If the

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amount of salt in the return flow is low in comparison to the total stream flow, water quality may not be degraded to the extent that use is impaired. However, if the process of water diversion for irrigation and the return of saline drainage water is repeated many times along a stream or river, water quality will be progressively degraded for downstream irrigation use as well as for other uses.

G. Pesticides

Pesticides--insecticides, herbicides, fungicides, miticides, nematicides, etc.--are used extensively in agriculture to control plant pests and enhance production. However, despite the documented benefits, these chemicals may, in some instances, endanger surface and ground water and ultimately human health.

Pesticides may harm the environment by eliminating or reducing populations of desirable organisms, including endangered species. Some types of pesticides or their metabolites are resistant to degradation. These pesticides or their degradation products may persist and accumulate in the aquatic ecosystems. The entire food chain, including man, can be affected. Sublethal effect include the behavioral and structural changes of an organism that jeopardize its survival. For example, certain pesticides have been found to inhibit bone development in young fish or affect reproduction by inducing abortion.

Herbicides in the aquatic environment can destroy the food source for higher organisms, which may then starve. Also, decaying plant matter causes a reduction in dissolved oxygen.

Sometimes a pesticide is not toxic by itself, but is lethal in the presence of other pesticides. This is referred to as a synergistic effect and may be difficult to predict or evaluate. Bioconcentration is a phenomenon that occurs if an organism ingests more a pesticide than it excretes. During its lifetime, the organism will accumulate a higher concentration of that pesticide than is present in the surrounding environment. When the organism is eaten by another animal higher in the food chain, the pesticide will then be passed to that animal and up the food chain.

The amount of field-applied pesticide that leaves a field in the runoff and enters a stream primarily depends on:

(1) The intensity and duration of rainfall; and

(2) The length of time between pesticide application and rainfall occurrence.

Pesticide losses are largest when rainfall is intense and occurs shortly after pesticide application, a condition for which water runoff and erosion losses are also greatest.

The rate of pesticide movement through the soil profile to ground water is inversely proportional to the pesticide "adsorption partition coefficient" or K (defined as a measure of the sorption phenomenon, whereby a pesticide is divided between the soil and water phase). The larger the

K the slower the movement and the greater the quantity of water required to leach the pesticide to a given depth. In general, it appears that only pesticides with K values less than 0.5 ml/g, water solubilities greater than 100 mg/l, and/or long half-lives pose a serious threat to deep ground-water resources.

Pesticides can be transported to receiving waters either in dissolved form or attached to sediment. Dissolved pesticides may be leached to ground-water supplies. Pesticides have varying characteristics as to degradation and the percent to which they will attach to sediment.

III. REQUEST FOR COMMENTS

In Chapter 1 of this guidance (Introduction), EPA has generally requested submission of comments, information and data on relevant management practices, their effectiveness, and their costs. We also request specific comment on the following aspects of the agricultural management measures:

Erosion and Sediment Control. In Section IV.A below, EPA sets forth the management measure for Erosion and Sediment Control. This measure consists in major part of reducing erosion as close to zero as possible, but no greater than the lesser of (1) T, or (2) the erosion produced after application of conservation tillage. T is the soil loss tolerance of the Universal Soil Loss Equation, used by soil conservationists to estimate the maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely. There are five classes of T factors ranging from 1 ton per acre per year for shallow or otherwise fragile soils to 5 tons per acre per year for deep soils that are least sensitive to damage by erosion.

T does not address the acceptability of a particular rate of erosion from a water quality perspective, nor does it necessarily reflect the reduced rate of erosion that can be accomplished through application of the best available control measures that are economically achievable. For example, Wisconsin is currently using a T-1 standard (which allows one less ton per acre of soil loss than a T standard allows) in its water quality program to address agricultural erosion. It may be that T-1 more accurately reflects the best available measures for erosion control.

EPA has attempted in this proposed guidance to partially compensate for the shortcomings of T as a management measure to protect water quality by specifying conservation tillage as an alternative management measure where it yields less erosion. However, this measure too may not reflect the best available measure that is economically achievable. Indeed, given the low net costs associated with conservation tillage in many contexts, it may be that additional management measures that would provide substantial incremental pollutant reduction benefits that reduce the delivery of pollutants (e.g., contour farming and/or vegetated filter strips) would be achievable.

EPA requests comment on the above issues and on options available to address them.

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Nutrient and Pesticide Management. Two of the agricultural management measures, nutrient and pest management, do not actually specify the measures to be taken "on the ground", but rather define broad goals ("eliminate excess nutrient use"; "eliminate application of excess pesticides") and then describe a process of evaluating certain relevant considerations.

EPA requests comment on whether the nutrient and pesticide management measures are sufficiently specific to assure that compliance with them would achieve the desired water quality objectives. If not, what additional specific practices could be added that are generally achievable and add significant pollutant reduction effectiveness?

IV. SOURCES OF AGRICULTURAL NONPOINT POLLUTION

EPA has identified six major categories of sources of agricultural nonpoint pollution that affect coastal waters. These are: erosion from cropland; confined animal facilities; the application of nutrients to cropland; the application of pesticides to cropland; land used for grazing; and irrigation of cropland.

Each of these source categories are addressed separately in the following section of this chapter. For each source the following items are identified: the pollutants that result from these sources; the management measures representing the best available systems of practices economically achievable to reduce off-site delivery of these pollutants; a performance expectation for the management measures; and some preliminary information on the pollutant reduction effectiveness and cost of the measures and, in some cases, the particular practices that comprise the measure.

V. MANAGEMENT MEASURES

In this section, the management measures that represent systems of practices which reflect the best available, economically achievable, nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives are specified for each of the major sources of agricultural nonpoint source pollution. Major sources of agricultural nonpoint source pollution include:

(1) Agricultural land needing treatment for erosion control;

(2) Concentrated animal production facilities;

(3) Land receiving nutrients from sources such as commercial fertilizers, animal wastes, and sludge;

(4) Land receiving pesticide applications;

(5) Land used for grazing; and

(6) Irrigated lands.

Each of these sources is addressed separately in the following section and the following items are discussed for each of the sources:

(1) Where the management measures should be utilized or where they are applicable (for example, the erosion and sediment control management measures are utilized on all agricultural lands and the pesticide management measures are utilized on all agricultural lands that have pesticides applied to them);

(2) Pollutants associated with each source such as nutrients, sediment, salts, etc.;

(3) The management measures which represent the best available systems of practices economically achievable to reduce off-site delivery of the pollutants resulting from each source (in some cases a performance expectation is specified and variety of practices may be used to achieve the performance expectation; in other cases, particular practices are specified);

(4) Information on management practices that are available as tools to achieve the management measures.

(5) Preliminary information on the pollutant reduction effectiveness of the management measures;

(6) Preliminary information on the cost of the management measures; and

(7) Operation and maintenance information.

Several agricultural sources may need to be addressed on a given piece of agricultural land in the coastal zone to protect water quality. For example, in some cases, erosion and sediment control measures, nutrient management measures as well as pesticide management measures will be needed i.e., systems of management measures. In other areas, depending on site-specific conditions, only one source may need to be addressed.

A. Erosion and Sediment Control

1. Management Measure Applicability

This management measure is to be utilized on all agricultural lands, including all land that is converted from other land uses to agricultural land. Agricultural lands include, but are not limited to:

- Cropland, dryland;
- Cropland, irrigated;
- Range and pastureland;
- Orchards;
- Specialty crop production; and
- Nursery crop production.

Those agricultural lands that also meet the applicability definitions of the concentrated animal facility management measure; nutrient management measure; pesticide management measures; grazing management measure; irrigation water management measure; or other management measures are also subject to those management measures.

2. Pollutants Produced by Soil Erosion and Transported by Runoff and Sediment

Runoff water from agricultural land may transport the following types of pollutants:

- Sediment and particulate organic solids;

- Particulate bound nutrients, chemicals and metals, such as phosphorus, organic nitrogen, a portion of applied pesticides, and a portion of the metals applied with some organic wastes and found naturally within the soil;

- Soluble nutrients, such as nitrogen, a portion of the phosphorus, a portion of the applied pesticides, a portion of the soluble metals and many other major and minor nutrients;

- Salts; and

- Bacteria, viruses and other microorganisms.

3. Management Measure for Erosion and Sediment Control

The management measure for erosion and sediment control on agricultural lands is a combination of practices that (1) control gully erosion, (2) protect wetlands and riparian zones, and (3) minimize the detachment and transport of soil by water, wind, ice, or gravity such that the average annual erosion rate (expressed as tons per acre per year, or T/Ac/Yr) is as close to zero as feasible (taking cost into account), but is in no case greater than the lesser of (a) "T" (the soil loss tolerance value* for the soil series in the field) or the average annual erosion rate achieved with conservation tillage.

EPA recognizes that USDA is changing from the Universal Soil Loss Equation to the USDA-Water Erosion Prediction Project (WEPP) model (Laflen et. al., 1991) now scheduled for FY 92. The WEPP system will not only estimate the erosion to a tolerable rate for productivity maintenance, but will estimate on-site deposition to prevent excessive adverse effects from deposition, sediment yield from fields to allowable rates that prevent excessive off-site sedimentation, and sediment yield from fields to prevent excessive degradation of off-site water quality. It will also estimate sediment characteristics needed to develop erosion control plans for improvements in downstream water quality. EPA will track developments regarding WEPP, particularly as they apply to this management measure.

4. Erosion and Sediment Control Management Practices

Following is a list of management practices for agricultural erosion and sediment control that are available as tools to achieve the erosion and sediment control management measure. Under each management practice, the U.S. Soil Conservation Service (SCS) practice number and a definition are provided. The list of practices included in this section is not exhaustive and does not preclude States or local agencies from developing special management measures in cooperation with the appropriate technical agency within the State for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as that provided by the management measure specified in this guidance. There may also be State or local standards that would require additional practices.

Conservation cover (327)
Establishing and maintaining perennial vegetative cover to protect soil and water resources on land retired form agricultural production.

The purpose is to reduce soil erosion and sedimentation, improve water quality, and create or enhance wildlife habitat.

Conservation cropping sequence (328)
An adapted sequence of crops designed to provide adequate organic residue for maintenance or improvement of soil tilth.

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*The "T" factor is the soil loss tolerance of the Universal Soil Loss Equation. It is defined as the maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely. There are five classes of T factors ranging from 1 ton per acre per year for shallow or otherwise fragile soils to 5 tons per acre per year for deep soils that are least sensitive to damage by erosion.

The purpose of this practice is to improve or maintain good physical, chemical, and biological conditions of the soil; help reduce erosion; improve water use efficiency and water quality; improve wildlife habitat; or break reproduction cycles of plant pests.

<u>Conservation tillage (329)</u>
Any tillage or planting system that maintains at least 30 percent of the soil surface covered by residue after planting to reduce soil erosion by water; or where soil erosion by wind is the primary concern, maintains at least 1,000 pounds of flat, small grain residue equivalent on the surface during the critical erosion period.

The purpose is to reduce soil erosion; help maintain or develop good soil tilth, efficient moisture use, and cover for wildlife.

<u>Contour systems</u>

<u>Contour farming (330)</u>
Farming sloping land in such a way that preparing land, planting, and cultivating are done on the contour. This includes following established grades of terraces or diversions.

The purpose is to reduce erosion and control water.

<u>Contour orchard and other fruit area (331)</u>
Planting orchards, vineyards, or small fruits so that all cultural operations are done on the contour.

The purpose is to reduce soil and water loss, to better control and use water, and to operate farm equipment more easily.

<u>Cover and green manure crop (340)</u>
A crop of close-growing grasses, legumes or small grain grown primarily for seasonal protection and soil improvement. It usually is grown for 1 year or less, except where there is permanent cover as in orchards.

The purpose is to control erosion during periods when the major crops do not furnish adequate cover; add organic material to the soil; and improve infiltration, aeration, and tilth.

<u>Critical area planting (342)</u>
Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).

The purpose is to stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources.

Crop residue use (344)
Using plant residues to protect cultivated fields during critical erosion periods.

The purpose is to conserve soil moisture, increase soil infiltration, reduce soil loss, and improve soil tilth.

Delayed seed bed preparation (354)
Any cropping system in which all of the crop residue and volunteer vegetation are maintained on the soil surface until approximately 3 weeks before the succeeding crop is planted, thus shortening the bare seedbed period on fields during critical erosion periods.

The purpose is to reduce soil erosion by maintaining soil cover as long as practical to minimize raindrop splash and runoff during the spring erosion period. Other purposes include moisture conservation, improved water quality, increased soil infiltration, improved soil tilth, and food and cover for wildlife.

Diversion (362)
A channel constructed across the slope with a supporting ridge on the lower side.

The purpose is to divert excess water from one area for use or safe disposal in other areas.

Field border (386)
A strip of perennial vegetation established at the edge of a field by planting or by converting it from trees to herbaceous vegetation or shrubs.

The purpose is to control erosion, protect edges of fields that are used as "turnrows" or travel lanes for farm machinery, reduce competition from adjacent woodland, provide wildlife food and cover, or improve the landscape.

Filter strip (393)
A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater.

The purpose is to remove sediment and other pollutants from runoff or wastewater by filtration, deposition, infiltration, absorption, decomposition, and volatilization, thereby reducing pollution and protecting the environment.

Grade stabilization structure (410)
A structure used to control the grade and head cutting in natural or artificial channels.

The purpose is to stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to enhance environmental quality and reduce pollution hazards.

Grassed waterway (412)
A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

The purpose is to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding, and to improve water quality.

Grasses and legumes in rotation (411)
Establishing grasses and legumes or a mixture of them and maintaining the stand for a definite number of years as part of a conservation cropping system.

The purpose is to produce forage for hay, silage, seed, or grazing; reduce soil and water loss; maintain a favorable level of organic matter; and improve soil productivity.

Sediment basins (350)
A basin constructed to collect and store debris or sediment.

The purpose is to preserve the capacity of reservoirs, ditches, canals, diversions, waterways, and streams; to prevent undesirable deposition on bottom lands and developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural wastes, and other detritus material.

Stripcropping systems

Contour stripcropping (585)
Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow or a strip of grass is alternated with a close-growing crop.

The purpose is to reduce erosion and control water.

Field stripcropping (586)
Growing crops in a systematic arrangement of strips or bands across the general slope (not on the contour) to reduce water erosion. The crops are arranged so that a strip of grass or a close-growing crop is alternated with a clean-tilled crop or fallow.

The purpose is to help control erosion and runoff on sloping cropland where contour stripcropping is not practiced.

Terraces (600)
An earthen embankment, a channel, or combination ridge and channel constructed across the slope.

The purpose is to: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in the runoff water, (4) improve water quality, (5) intercept and conduct surface runoff at a nonerosive velocity to a stable outlet, (6) retain runoff for moisture conservation, (7) prevent gully development, (8) re-form the land surface, (9) improve farmability, or (10) reduce flooding.

Water and sediment control basin (638)
An earthen embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin.

The purpose is to: improve farmability of sloping land; reduce watercourse and gully erosion; trap sediment; reduce and manage onsite and downstream runoff; and improve downstream water quality.

Wetland and Riparian Zone Protection
Wetlands and riparian zone protection practices are described in Chapter 7.

5. Effectiveness Information

Following is information to illustrate the pollution reductions that can be achieved from installation of some of the management practices that may be used to implement this management measure. Two tables (Tables 2-1 and 2-2) are presented to show the variability in effectiveness information as reported by different sources. Also, general, qualitative information of the effectiveness of selected management practices is included in Table 2-3.

The information contained herein is primarily practice-oriented, yet EPA seeks data regarding the overall effectiveness of management measures, or systems of practices. To this end, EPA is continuing to collect and analyze more information regarding pollutant reductions, and solicits comments regarding information sources to utilize.

USDA estimates that the level of erosion control provided for by the specified management measure ("T") will result in an average annual savings of 9 Tons/Ac/Yr in the 28 coastal States. This will be achieved by bringing average erosion rate down from 11.4 Tons/Ac/Yr to an of 4.5 Tons/Ac/Yr ("T" values).

6. Cost Information

Cost estimates for control of erosion and sediment transport from agricultural lands are provided in Tables 2-4, 2-5, and 2-6. The costs in Table 2-4 are based upon experiences in the Chesapeake Bay Program, but are illustrative of the costs that could be incurred in coastal areas across the Nation. The costs in Table 2-5 are based on modeling runs for Indiana. The costs in Table 2-6 are national summaries provided by the USDA, and represent costs on a much broader scale. Only the costs in Table 2-5 represent net costs to the landowner or operator. It

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Table 2-1. Estimated Pollutant Reductions for Selected Management Practices

Practice	Runoff Volume Reduction (%)	Sediment Load Reduction (%)	Total P Load Reduction (%)	Total N Load Reduction (%)
Conservation tillage	up to 40	up to 50	up to 45	NA
Stripcropping	up to 85	up to 75	NA	NA
Grassed water ways[1]	NA	up to 65	up to 50	up to 30
Diversions[2]	NA	up to 40	up to 45	up to 20
Sediment retention and Water control structures	NA	up to 65	NA	up to 30[3]
Grassed filter strips	NA	85-90	50	NA

SOURCE: New York Department of Environmental Conservation, 1990.
NOTE: All reductions are relative to conventional (moldboard plow) tillage.

[1] This is a transport practice. Reductions are based upon modeling.
[2] Reductions are based upon modeling.
[3] Particulate organic nitrogen.

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Table 2-2. Estimated Pollutant Reductions for Selected Management Practices

Practices	Runoff Volume Reduction	Sediment Load Reduction	Total P Load Reduction	Total N Load Reduction
	% unless otherwise noted			
Conservation tillage system	NA	30 to 90	35 to 90	50 to 80
Stripcropping systems	NA	up to 75	up to 50	NA
Contour and across slope tillage	NA	50 to 90	35 to 60	NA
Terrace systems	NA	90	75	NA
Sod waterways	NA	70	50	NA
Cover crops	NA	40 to 60	30 to 50	NA
Permanent Veg. Cover on Critical areas	NA	95	50	NA
Permanent Veg. Cover	NA	less than 1 T/Ac/Yr delivered	very high	NA
Reforestation of Erodible Crop and Pastureland	NA	less than 1 T/Ac/Yr delivered	very high	NA
Buffer/Filter strips	NA	70	50	NA
Water/Sediment control basins	NA	NA	NA	NA
Sediment basin	NA	60	40	NA
Diversions	NA	25	23	NA
Crop residue use	NA	NA	NA	NA
Grade stabilization structure	NA	5	NA	NA
Contour & across slope cropping	NA	up to 50[1]	up to 35	NA

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.
NOTE: All reductions are relative to conventional (moldboard plow) tillage.
[1] Up to 50% on 2-6% slopes, but less than 10% on 18-24% slopes.

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Table 2-3. Water Quality Statement for Selected Management Practices

Practice	Water Quality Statement
Conservation cover (327)	Agricultural chemicals are usually not applied to this cover in large quantities and surface and ground water quality may improve where these material are not used. Ground cover and crop residue will be increased with this practice. Erosion and yields of sediment and sediment related stream pollutants should decrease. Temperatures of the soil surface runoff and receiving water may be reduced. Effects will vary during the establishment period and include increases in runoff, erosion and sediment yield. Due to the reduction of deep percolation, the leaching of soluble material will be reduced, as will be the potential for causing saline seeps. Long-term effects of the practice would reduce agricultural nonpoint sources pollution to all water resources.
Conservation croppping sequence (328)	This practice reduces erosion by increasing organic matter, resulting in a reduction of sediment and associated pollutants to surface waters. Crop rotations that improve soil tilth may also disrupt disease, insect and weed reproduction cycles, reducing the need for pesticides. This removes or reduces the availability of some pollutants in the watershed. Deep percolation may carry soluble nutrients and pesticides to the ground water. Underlying soil layers, rock and unconsolidated parent material may block, delay, or enhance the delivery of these pollutants to ground water. The fate of these pollutants will be site specific, depending on the crop management, the soil and geologic conditions.
Conservation tillage (329)	This practice reduces soil erosion, detachment and sediment transport by providing soil cover during critical times in the cropping cycle. Surface residues reduce soil compaction from raindrops, preventing soil sealing and increasing infiltration. This action may increase the leaching of agricultural chemical into the ground water.

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Table 2-3. (Continued)

Practice	Water Quality Statement
	In order to maintain the crop residue on the surface it is difficult to incorporate fertilizers and pesticides. This may increase the amount of these chemicals in the runoff and cause more surface water pollution. The additional organic material on the surface may increase the bacterial action on and near the soil surface. This may tie-up and then breakdown many pesticides which are surface applied, resulting in less pesticide leaving the field. This practice is more effective in humid regions. With a no-till operation the only soil disturbance is the planter shoe and the compaction form the wheels. The surface applied fertilizers and chemicals are not incorporated and often are not in direct contact with the soil surface. This condition may result in a high surface runoff of pollutants (nutrient and pesticides). Macropores develop under a no-till system. They permit deep percolation and the transmittal of pollutants, both soluble and insoluble to be carried into the deeper soil horizons and into the ground water. Reduced tillage systems disrupt or bread down the macropores, incidentally incorporate some of the materials applied to the soil surface, and reduce the effects of wheeltrack compaction. The results are less runoff and less pollutants in the runoff.
Contour farming (330)	This practice reduces erosion and sediment production. Less sediment and related pollutants may be transported to the receiving waters. Increased infiltration may increase the transportation potential for soluble substances to the ground water.

Table 2-3. (Continued)

Practice	Water Quality Statement
Contour orchard and other fruit area (331)	Contour orchards and fruit areas may reduce erosion, sediment yield, and pesticide concentration in the water lost. Where inward sloping benches are used, the sediment and chemicals will be trapped against the slope. With annual events, the bench may provide 100 percent trap efficiency. Outward sloping benches may allow greater sediment and chemical loss. The amount of retention depends on the lope of the bench and the amount of cover. In addition, outward sloping benches are subject to erosion form runoff from benched immediately above them. Contouring allows better access to rills, permitting maintenance that reduces additional erosion. Immediately after establishment, contour orchards may be subject to erosion and sedimentation in excess of the now contoured orchard. Contour orchards require more fertilization and pesticide application than did the native grasses that frequently covered the slopes before orchards were started. Sediment leaving the site may carry more adsorbed nutrients and pesticides than did the sediment before the benches were established from uncultivated slopes. If contoured orchards replace other crop or intensive land use, the increase or decrease in chemical transport from the site may be determined by examining the types and amounts of chemical used on the prior land use as compared to the contour orchard condition. Soluble pesticides and nutrients may be delivered to and possibly through the root zone in an amount proportional to the amount of soluble pesticides applied, the increase in infiltration, the chemistry of the pesticides, organic and clay content of the soil, and amounts of surface residues. Percolating water below the root zone may carry excess solutes or may dissolve potential pollutants as they move. In either case, these solutes could reach groundwater supplies and/or surface downslope from the contour orchard area. The amount depends on soil type, surface water quality, and the availability of soluble material (natural or applied).

Table 2-3. (Continued)

Practice	Water Quality Statement
Cover and green manure crop (340)	Erosion, sediment and adsorbed chemical yields green manure could be decreased in conventional tillage systems crop because of the increased period of vegetal cover. Plants will take up available nitrogen and prevent its undesired movement. Organic nutrients may be added to the nutrient budget reducing the need to supply more soluble forms. Overall volume of chemical application may decrease because the vegetation will supply nutrients and there may be allelopathic effects of some of the types of cover vegetation on weeds. Temperatures of ground and surface waters could slightly decrease.
Critical area planting (324)	This practice may reduce soil erosion and sediment delivery to surface waters. Plants may take up more of the nutrients in the soil, reducing the amount that can be washed into surface waters or leached into ground water. During grading, seedbed preparation, seeding, and mulching, large quantities of sediment and associated chemicals may be washed into surface waters prior to plant establishment.
Crop residue use (344)	When this practice is employed, raindrops are intercepted by the residue reducing detachment,use oil dispersion, and soil compaction. Erosion may be reduced and the delivery of sediment and associated pollutants to surface water may be reduced. Reduced soil sealing, crusting and compaction allows more water to infiltrate, resulting in an increased potential for leaching of dissolved pollutants into the ground water.

Table 2-3. (Continued)

Practice	Water Quality Statement
	Crop residues on the surface increases the microbial and bacterial action on or near the surface. Nitrates and surface-applied pesticides may be tied-up and less available to be delivered to surface and ground water. Residues trap sediment and reduce the amount carried to surface water. Crop residues promote soil aggregation and improve soil tilth.
Diversion (362)	This practice will assist in the stabilization of a watershed, resulting in the reduction of sheet and rill erosion by reducing the length of slope. Sediment may be reduced by the elimination of ephemeral and large gullies. This may reduce the amount of sediment and related pollutants delivered to the surface waters.
Field border (386)	This practice reduces erosion by having perennial vegetation on an area of the field. Field borders serve as "anchoring points" for contour rows, terraces, diversions, and contour strip cropping. By elimination of the practice of tilling and planting the ends up and down slopes, erosion from concentrated flow in furrows and long rows may be reduced. This use may reduce the quantity of sediment and related pollutants transported to the surface waters. When the field borders are located such that runoff flows across them in sheet flow, they may cause the deposition of sediment and prevent it from entering the surface water. Where these practice are between cropland and a stream or water body, the practice may reduce the amount of pesticide application drift from entering the surface water.
Filter strip (393)	Filter strips for sediment and related pollutants meeting minimum requirements may trap the coarser grained sediment. They may not filter out soluble or suspended fine-grained materials. When a storm caused runoff in excess of the design runoff, the filter may be flooded and

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Table 2-3. (Continued)

Practice	Water Quality Statement
	may cause large loads of pollutants to be released to the surface water. This type of filter requires high maintenance and has a relative short service life and is effective only as long as the flow through the filter is shallow sheet flow. Filter strip for runoff form concentrated livestock areas may trap organic material, solids, materials which become adsorbed to the vegetation or the soil within the filter. Often they will not filter out soluble materials. This type of filter is often wet and is difficult to maintain. Filter strips for controlled overland flow treatment of liquid wastes may effectively filter out pollutants. The filter must be properly managed and maintained, including the proper resting time. Filter strips on forest land may trap coarse sediment, timbering debris, and other deleterious material being transported by runoff. This may improve the quality of surface water and has little effect on soluble material in runoff or on the quality of ground water. All types of filters may reduce erosion on the area on which they are constructed. Filter strips trap solids from the runoff flowing in sheet flow through the filter. Coarse-grained and fibrous materials are filtered more efficiently than fine-grained and soluble substances. Filter strips work for design conditions, but when flooded or overloaded they may release a slug load of pollutants into the surface water.

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Table 2-3. (Continued)

Practice	Water Quality Statement
Grade stabilization structure (410)	Where reduced stream velocities occur upstream and downstream from the structure, streambank and streambed erosion will be reduce. This will decrease the yield of sediment and sediment-attached substances. Structures that trap sediment will improve downstream water quality. The sediment yield change will be a function of the sediment yield to the structure, reservoir trap efficiency and of velocities of released water. Ground water recharge may affect aquifer quality depending on the quality of the recharging water. If the stored water contains only sediment and chemical with low water solubility, the ground water quality should not be affected.
Grassed waterway (412)	This practice may reduce the erosion in a concentrated flow area, such as in a gully or in ephemeral gullies. This may result in the reduction of sediment and substances delivered to receiving waters. Vegetation may act as a filter in removing some of the sediment delivered to the waterway, although this is not the primary function of a grassed waterway. Any chemicals applied to the waterway in the course of treatment of the adjacent cropland may wash directly into the surface waters in the case where there is a runoff event shortly after spraying. When used as a stable outlet for another practice, waterways may increase the likelihood of dissolved and suspended pollutants being transported to surface waters when these pollutants are delivered to the waterway.

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Table 2-3. (Continued)

Practice	Water Quality Statement
Grasses and legumes in rotation (411)	Reduced runoff and increased vegetation may lower erosion rates and subsequent yields of sediment and sediment-attached substances. Less applied nitrogen may be required to grow crops because grasses and legumes will supply organic nitrogen. During the period of the rotation when the grasses and legumes are growing, they will take up more phosphorus. Less pesticides may similarly be required with this practice. Downstream water temperatures may be lower depending on the season when this practice is applied. There will be a greater opportunity for animal waste management on grasslands because manures and other wastes may be applied for a longer part of the crop year.
Sediment basin (350)	Sediment basins will remove sediment, sediment- associated materials and other debris from the water which is passed on downstream. Due to the detention of the runoff in the basin, there is an increased opportunity for soluble materials to be leached toward the ground water.
Contour stripcropping (585)	This practice may reduce erosion and the amount of sediment and related substances delivered to the surface waters. The practice may increase the amount of water which infiltrates into the root zone, and, at the time there is an overabundance of soil water, this water may percolate and leach soluble substances into the ground water.
Field stripcropping (586)	This practice may reduce erosion and the delivery of sediment and related substances to the surface waters. The practice may increase infiltration

Table 2-3. (Continued)

Practice	Water Quality Statement
	and, when there is sufficient water available, may increase the amount of leachable pollutants moved toward the ground water. Since this practice is not on the contour there will be areas of concentrated flow, from which detached sediment, adsorbed chemicals and dissolved substances will be delivered more rapidly to the receiving waters. The sod strips will not be efficient filter areas in these areas of concentrated flow.
Terraces (600)	This practice reduces the slope length and the amount of surface runoff which passes over the area downslope from an individual terrace. This may reduce the erosion rate and production of sediment within the terrace interval. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water which enhance surface water quality.Terraces may intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thus, reducing the occurrence of ephemeral and classic gullies and the resulting sediment. Increases in infiltration can cause a greater amount of soluble nutrients and pesticides to be leached into the soil. Underground outlets may collect highly soluble nutrient and pesticide leachates and convey runoff and conveying it directly to an outlet, terraces may increase the delivery of pollutants to surface waters. Terraces increase the opportunity to leach salts below the root zone in the soil. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient, salt, and pesticide pollutants to surface or ground waters.
Water and sediment control basin (638)	The practice traps and removes sediment and sediment-- attached substances from runoff. Trap control efficiencies for sediment and total phosphorus, that are transported by runoff, may exceed 90 percent in silt loam soils. Dissolved substance, such as nitrates, may be removed

Table 2-3. (Continued)

Practice	Water Quality Statement
	from discharge to downstream areas because of the increased infiltration. Where geologic condition permit, the practice will lead to increased loadings of dissolved substances toward ground water. Water temperatures of surface runoff, released through underground outlets, may increase slightly because of longer exposure to warming during its impoundment.

SOURCE: Soil Conservation Service, 1988.

Table 2-4. Cost Estimates for Selected Management Practices From Chesapeake Bay Installations

Practice	Total Acres Treated[1]	Total Cost (1990 Dollars)	Annual Cost ($/Ac/Yr)[2]	Practice Life Span
Conservation Tillage	20,627	371,704	18.1[3]	1
Stripcropping	4,754	213,941	11.9	5
Terraces	812	175,925	35.3	10
Grassed Water Ways	4,311	2,488,144	94.0	10
Diversions	615	153,516	40.6	10
Sediment Retention Water control Structures	21,190	3,952,752	30.5	10
Grassed Filter Strips	4,351	44,206	2.7	5
Permanent Veg. Cover on Cr. Areas	18,041	627,368	9.2	5
Reforestation of Crop and Pastureland	4,658	677,069	23.6	10
Cover Crops	1,845	20,022	10.9	1

SOURCE: U.S. Environmental Protection Agency, Chesapeake Bay Program, 1991.

[1] Total acres treated is the actual area upon which the practice is applied. Some practices, such as filter strips and diversions, actually serve or benefit several times more acreage than is treated, so cost per acre served or benefitted can be substantially lower, and cost per ton of sediment "saved" can also be much lower.

[2] Annual cost is calculated as total amortized cost (10%) over life span of practice, divided by (acres treated x life span).

[3] Net costs are often much lower than this, frequently being negative.

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Table 2-5. Effects of Three Tillage Systems on Returns in Indiana

Crop/Tillage	Poorly Drained Soils	Somewhat Poorly Drained Soils	Well Drained Soils
	Dollar Values are Returns per Acre[1]		
Continuous Corn			
Moldboard	$34.32	$16.74	$7.69
Ridge	$49.36	$33.16	$30.26
No-Till	$31.11	$25.58	$29.31
Rotation Corn			
Moldboard	$79.20	$54.26	$34.18
Ridge	$94.30	$63.76	$54.41
No-Till	$90.49	$62.81	$53.51
Rotation Soybeans			
Moldboard	$94.10	$65.90	$40.15
Ridge	$104.55	$74.90	$58.85
No-Till	$810.00	$64.95	$57.90

SOURCE: Griffith et al., 1986.
[1] Returns (profit) to land, labor, and management.

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Table 2-6. Summary of Costs for Selected Practices Applied for Erosion Control as a Primary Purpose

System Number and Name (Systems are combinations of SCS practices - see Appendix 2-A)	Total Cost Per Ton of Soil Saved (1990, amortized $)
SL1 Permanent Vegetative Cover Establishment	0.92
SL2 Permanent Vegetative Cover Improvement	1.05
SL3 Stripcropping System	0.71
SL4 Terrace Systems	0.85
SL5 Diversions	0.84
SL7 Windbreak Restoration or Establishment	0.32
SL8 Cropland Protective Cover	3.48
SL11 Permanent Vegetative Cover on Critical Area	1.41
SL13 Contour Farming	0.30
SL14 Reduced Tillage Systems	1.58
SL15 No-Till System	0.83
WP1 Sediment Retention or Water Control Structure	1.78
WP2 Stream Protection	2.84
WP3 Sod Waterways	1.81
WL1 Permanent Wildlife Habitat	2.09

Source: U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 1991.

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is important to note that for some practices such as conservation tillage the net costs often approach zero and in some cases can be negative due to the savings in labor and energy.

For example, modeling has been used to demonstrate that in Minnesota (Conservation Tillage Information Center, 1986) the return over total cost (i.e., total profit) increases for corn after beans when changing from moldboard plow ($8.52/Ac) to chisel till ($18.09/Ac), ridge till ($28.71), or no-till ($27.80). Similarly, modeling has shown that the relative cost (1982 dollars) for no-till versus conventional tillage in Indiana can vary from losses of $27.87/Ac to savings of $18.13/Ac (Griffith, 1983).

The net cost of conservation tillage depends upon several factors, including crops, soils, and climate. For example, a modeling study for a 750-acre cash grain operation in central Indiana (Griffith et al., 1986) compared projected returns for moldboard plowing, ridge tillage, and no-till planting for poorly drained soils (Group I), somewhat poorly drained soils (Group II), and well-drained soils (Group III). The results are given in Table 2-5 Either no-till or ridge till provides greater returns than moldboard in all nine scenarios, while moldboard provides a greater return than either no-till or ridge till in only three of nine scenarios.

Cost estimates for practices to control erosion and sediment on agricultural lands are also taken from the U.S. Department of Agriculture (USDA, Agricultural Stabilization and Conservation Service, 1991). Cost estimates reported by USDA are given by primary purpose, type of agreement (long term agreement or regular Agricultural Conservation Program (ACP)), and as overall estimates. The costs reported in Table 2-6 are for the primary purpose of erosion control, and long-term agreements and regular ACP agreements are lumped. The components of each practice are given in Appendix 2-A.

The cost to install stripcropping systems (practice SL3) for the primary purpose of erosion control was about $300 per acre treated in 1990. This cost is not amortized. Practice SL3 decreased the average annual erosion rate from 11 to 4.2 T/Ac/Yr, a reduction of 62 percent.

The cost to install permanent vegetative cover on critical areas (practice SL11) for the primary purpose of erosion control was about $152.00 per acre served in 1990. This cost is not amortized. Practice SL11 decreased the average annual erosion rate from 31 to 2.1 T/Ac/Yr, a reduction of 93 percent.

The cost to install contour farming (practice SL13) for the primary purpose of erosion control was about $200 per acre treated in 1990. This cost is not amortized. Practice SL13 decreased the average annual erosion rate from 18 to 6 T/Ac/Yr, a reduction of 67 percent.

The cost to install reduced tillage systems (practice SL14) for the primary purpose of erosion control was about $100 per acre treated in 1990. This cost is not amortized. Practice SL14 decreased the average annual erosion rate from 12 to 3.7 T/Ac/Yr, a reduction of 69 percent.

The cost to install no-till systems (practice SL15) for the primary purpose of erosion control was about $25.00 per acre treated in 1990. This cost is not amortized. Practice SL15 decreased the average annual erosion rate from 12 to 3.7 T/Ac/Yr, a reduction of 69 percent.

7. Operation and Maintenance

Operation:

Most structural practices for erosion and sediment control are designed to operate without human intervention. Water table control structures for example, would require some "operation" to change the water level in the system. Management practices such as conservation tillage, on the other hand, do require "operation" each time they are used. They must be factored into each field operation that takes place to produce the crop, in order to ensure that they are not destroyed. Extreme care must be used to ensure that herbicides are not applied to any practice that uses a permanent vegetative cover, such as waterways and filter strips.

Maintenance:

Structural practices such as diversions, grassed waterways and other practices that require grading and shaping may need to be repaired to maintain the original design; they may also need reseeding to maintain the vegetative cover. Trees and brush should not be allowed to grow on berms, dams or other structural embankments. Sediment retention basins will need to be cleaned to maintain the design volume and efficiency.

Filter strips and field borders need to be maintained to prevent channelization of flow and the resulting short-circuiting of filtering mechanisms. Reseeding of filter strips may be required on a frequent basis.

Cost: The annual cost of operation and maintenance is estimated to range from zero to ten percent of the investment cost (U.S. Department of Agriculture, Soil Conservation Service-Michigan, 1988).

8. Planning Considerations

Site specific resource information should be obtained from the SCS Field Office Technical Guide. Before deciding on the management practices for building a management measure system, there are several planning issues that should be considered. System adaptation to the site conditions, acceptability of the practice(s) in the system to the land user, and the reduction in erosion that will be realized by installation of the practices are key aspects that must be considered.

Local or state laws and regulations may dictate a specific level of erosion reduction or specific conservation practices that must be included. Practices that are chosen for the management measure must also meet objectives of the land user.

There are many conservation practices that can be used in developing a management measure. Standards for these practices can be found in the local Soil Conservation Service Field Office Technical Guide. Other site specific resource information necessary for good system planning can be found in these SCS guides.

Generally, more than one conservation practice will be needed to meet the sediment delivery required of the management measure. Several combinations of practices are likely to exist for meeting the established sediment delivery rate.
Management measure system options should be prepared based on water quality objectives and the land users' objectives. Each alternative should contain erosion and sediment reduction evaluations. The land user can then choose the system that best addresses personal objectives while also meeting the erosion and sediment control guidelines as well as water quality goals.

Other conservation practices, such as wildlife upland habitat management, tree planting, farmstead and feedlot windbreak, pastureland and hayland planting, or other land use conversion practices should be considered when developing a management measure. Adding one or more of these practices may provide additional erosion and sediment control, improve the environment, and add aesthetic values previously not realized.

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B. Confined Animal Facility Management

1. Management Measure Applicability

Confined animal facilities are: areas used to grow or house the animals; equipment and supplies for production, processing and storage of product; the land near the buildings that the animals have access to that does not support vegetative cover; manure and runoff storage areas; and silage storage areas. These areas are subject to runoff control. The land upon which the manure, runoff and other wastes are utilized is considered agricultural crop, hay and pasture land and also subject to management measures for: erosion and sediment control, pesticides, nutrients irrigation water and grazing, where applicable.

This management measure is to be applied to all existing confined animal facilities, except those facilities that are required to apply for and receive discharge permits under 40 CFR, Section 122.23 ("Concentrated Animal Feeding Operations"). All new facilities are expected to be built and operated in accordance with this measure.

2. Pollutants Produced by Confined Animal Facilities

The following pollutants may be contained in manure and associated bedding materials and may be transported by runoff water from confined animal facilities and process wastewater:

- Nitrogen, phosphorus and many other major and minor nutrients or other deleterious materials;
- Salts;
- Bacteria, virus and other microorganisms;
- Organic solids;
- Oxygen demanding substances; and
- Sediments.

3. Management Measure to Control Confined Animal Facilities

The management measure for confined animal facilities control is a combination of practices that reduce discharge of pollutants from a confined animal facility by storing the runoff from storms up to and including a 24 hour, 25 year frequency storm and preventing pollutant movement to ground water. Manure and runoff water that is utilized on agricultural land will be applied in accordance with the nutrient management measure. Disposal of dead animals will be accomplished in a manner that will prevent any pollution to surface and ground waters. The management measure for confined animal facilities consists of:

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(1) Storing the runoff from an confined animal facility from storms up to and including of 24 hour, 25 year frequency storm, and preventing contamination of ground water.This will require diversion of clean water around the facility and from roofs; control of runoff from lot surfaces and from storage areas for runoff and manure; and control of process wastewater.

(2) Utilizing manure and runoff water on agricultural lands in accordance with the nutrient management measure; utilizing manure for bedding; or processing of manure for commercial marketing.

(3) Disposing of dead animals from the facility by composting, incineration, utilization of an approved burial site or, removal via commercial service.

4. Confined Animal Facilities Management Practices

Following is a list of management practices for confined animal facilities that are available as tools to achieve the management measure as set forth in section B.3. Under each management practice, the U.S. Soil Conservation Service (SCS) practice number and a definition are provided. The list of practices included in this section is not exhaustive and does not preclude States or local agencies from developing special management practices in cooperation with the appropriate technical agency within the State for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as that provided by the management measure specified in this guidance. There may also be State or local standards that would require additional practices.

a. For runoff control at the production facility

Dikes (356)
An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

The purpose is to permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

Diversions (362)
A channel constructed across the slope with a supporting ridge on the lower side.

The purpose is to divert excess water from one area for use or safe disposal in other areas.

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Grassed waterway (412)
A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

The purpose is to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding and to improve water quality.

Heavy use area protection (561)
Protecting heavily used areas by establishing vegetative cover, by surfacing with suitable materials, or by installing needed structures.

The purpose is to stabilize urban, recreation, or facility areas frequently and intensely used by people, animals, or vehicles.

Lined waterway or outlet (468)
A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

The purpose is to provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

Roof runoff management (558)
A facility for controlling, and disposing of runoff water from roofs.

The purpose is to prevent roof runoff water from flowing across concentrated waste areas, barnyards, roads and alleys, and to reduce pollution and erosion, improve water quality, prevent flooding, improve drainage, and protect the environment.

Terrace (600)
An earthen embankment, a channel, or combination ridge and channel constructed across the slope.

The purpose is to: (1) reduce slope length, (2) reduce erosion, (3) reduce sediment content in the runoff water, (4) improve water quality, (5) intercept and conduct surface runoff at a non-erosive velocity to a stable outlet, (6) retain runoff for moisture
conservation, (7) prevent gully development, (8) re-form the land surface, (9) improve farmability, or reduce flooding.

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b. Manure and runoff storage

Waste storage pond (425)
An impoundment made by excavation or earthfill for temporary storage of animal or other agricultural wastes.

The purpose is to store liquid and solid wastes, waste water, and polluted runoff to reduce pollution and to protect the environment.

Waste storage structure (313)
A fabricated structure for temporary storage of animal wastes or other organic agricultural wastes.

The purpose is to temporarily store liquid or solid wastes as part of a pollution-control or energy-utilization system to conserve nutrients and energy and to protect the environment.

Waste treatment lagoon (359)
An impoundment made by excavation or earthfill for biological treatment of animal or other agricultural wastes.

The purpose is to biologically treat organic wastes, reduce pollution, and protect the environment.

c. Utilization of manure and runoff water

1. Application of manure and/or runoff water to agricultural land
Manure and/or runoff water will be applied to agricultural lands and incorporated into the soil in accordance with the management measures for nutrients.

Waste Utilization (633)
Using agricultural wastes or other wastes on land in an environmentally acceptable manner while maintaining or improving soil and plant resources.

The purpose is to safely use wastes to provide fertility for crop, forage, or fiber production; to improve or maintain soil structure; to prevent erosion; and to safeguard water resources.

2. Commercial marketing of manure

Composting facility (317)
A facility for the biological stabilization of waste organic material.

The purpose is to treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise utilized in compliance with all laws, rules, and regulations.

d. Disposal of dead animals

"Dead Bird" composting

Composting facility (317)
A facility for the biological stabilization of waste organic material.

The purpose is to treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise utilized in compliance with all laws, rules, and regulations.

Commercial Disposal Services

Incineration

Approved Burial Sites

5. Effectiveness Information

Pollution reductions that can be expected from installation of the management practices outlined above are as follows:

When runoff from storms up to and including the 24 hour, 25 year storm is stored, there will be no release of pollutants from a confined animal facility via the surface runoff route. Rare storms of a greater magnitude may produce runoff, but the "first flush" from them would be contained by the 24 hour, 25 year storage volume. Table 2-7 reflects the occurrence of such storms by indicating less than 100 percent control for runoff control systems.

Table 2-7. Runoff Control Efficiency

Management Practice	Removal efficiency Solids	Removal efficiency Phosphorus
Runoff Control System	80 to 90	70 to 95

SOURCE: Development Planning and Research Associates, Inc., 1986.

The information contained herein is primarily practice-oriented, yet EPA seeks data regarding the overall effectiveness of management measures, or systems of practices. To this end, EPA is continuing to collect and analyze more information regarding pollutant reductions, and solicits comments regarding information sources to utilize.

6. Cost Information

Cost factors for control of runoff and manure from confined animal facilities.

Table 2-8. Estimated Cost for Runoff Control Systems, by Size Range
Runoff Control Systems Only

Feedlot Capacity (head)	Investment	Cost Ranges Annual Dollars	Annualized
100	5000-12000	300-600	770-1730
500	9000-16000	400-800	1250-2310
1000	11000-20000	500-1000	1540-2900

SOURCE: Development Planning and Research Associates, Inc., 1986.

7. Operation and Maintenance of this Measure

a. Runoff control system

Operation: The holding ponds or lagoons should be drawn down to design storm capacity within 14 days of a runoff event. Solids should be removed from the solids separation system after a runoff event to ensure that solids will not enter the runoff holding facility.

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Maintenance: Diversions will need to be reshaped periodically and should be free of trees and brush growth. Gutters and downspouts should be inspected annually and repaired when needed. Established grades for lot surfaces and conveyance channels must be maintained at all times.

Channels must be free of trees and brush growth. Debris basins, holding ponds and lagoons will need to be cleaned to assure that design volumes are maintained. Irrigation equipment, if used to apply runoff water, should be flushed with fresh water after use. This is usually done twice per year. In warm climates this may be done four times per year, while in other colder climates, only once per year. Clean water should be excluded from the storage structure unless it is needed for further dilution in a liquid system.

Table 2-9. Estimated Cost Implications for Selected Management Practices

Practice	Unit	Capital (approximate)	Operating and Maintenance (Approximate)
Terrace systems	$14-39 per ha	$120-330 per ha	est. 5% of capital annually
Sod waterways	$7/ha drained	$100/ha drained	$500/ha/yr
Diversions	$90/ha	$600/ha	est. 5% of capital annually
Manure storage and use of nutrients	$10-20 per ha	$250-500 per ha	pumping, spreading of manure
Feedlot runoff control	$4/ha	$50/ha	5% of capital annually
Exclusion or limited access to water courses	$12/ha	$100/ha	5% of capital annually

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.
NOTE: All costs are 1982 dollars and amortized at a zero discount rate.

b. Manure storage system

Operation: The storage structure should be emptied when manure can be applied to cropland.Maintenance: Storage structures should be inspected for cracks and leaks after each use cycle. Manure transfer equipment must be inspected and repaired after each use cycle.

c. Cost

The annual cost of maintenance is estimated to be five percent of the investment cost.

C. Nutrient Management Measure

The basic concept of nutrient management is pollution prevention, by using only the nutrients necessary to produce a crop. This measure may result in some reduction in the amount of nutrients being applied to the land, thereby reducing the cost of production as well as protecting water quality.

1. Management Measure Applicability

This management measure is to be utilized on all agricultural lands that have nutrients applied to them. When the source of the nutrients is other than commercial fertilizer, the material must be tested to determine the nutrient value and the rate of availability of the nutrients. Also, for municipal and/or industrial treatment plant sludge and effluent, the concentration of metals and organic toxics must be known before these wastes are considered for application to agricultural lands as nutrient sources.

Those agricultural lands that also meet the applicability definitions of the pesticide management measure, erosion and sediment control management measure, grazing management measure, irrigation water management, or other management measures, are also subject to those management measures.

2. Pollutants Produced by Application of Nutrients Sources

Surface water runoff from agricultural lands that have had nutrients applied to them, may transport the following pollutants:

- Particulate bound nutrients, chemicals and metals, such as phosphorus, organic nitrogen, metals applied with some organic wastes and found naturally within the soil;
- Soluble nutrients and chemicals, such as nitrogen, phosphorus, metals and many other major and minor nutrients;
- Sediment, particulate organic solids, oxygen demanding material;

- Salts; and
- Bacteria, viruses and other microorganisms.

Ground-water infiltration from agricultural lands that have had nutrients applied to them, may transport the following pollutants:

- Soluble nutrients and chemicals, such as nitrogen, phosphorus, metals and many other major and minor nutrients, and salts.

3. <u>Sources of Nutrients That Are Applied to Agricultural Lands</u>

Nutrients are applied to agricultural land in several different forms and come from various sources, including;

- Commercial fertilizer in a dry or fluid form, containing N,P,K, secondary nutrients and micro-nutrients;
- Manure from animal production facilities including bedding and other wastes added to the manure, containing N,P,K, secondary nutrients, micro-nutrients, salts, some metals and organics;
- Municipal and/or industrial treatment plant sludge, containing N,P,K, secondary nutrients, micro-nutrients, salts, metals and organic solids;
- Municipal and/or industrial treatment plant effluent, containing N,P,K, secondary nutrients, micro-nutrients, salts, metals and organics;
- Irrigation water; and
- Atmospheric deposition of nutrients such as nitrogen and sulphur.

4. <u>Management Measure to Control Nutrients</u>

Following are the management measures for controlling excess nutrient use in agriculture. To eliminate application of excess nutrients, to improve timing of application, and to increase the use efficiency of nutrients, a nutrient management plan should be developed and implemented:

(1) Prepare a farm and field map containing soils information, a history of previous crops and current crop rotation.

(2) Assess soil productivity by field to determine expected yields for the target crop.

(3) Calculate the nutrient resources available to the producer for the target crop.

(4) Utilizing the limiting nutrient/element concept, establish nutrient/element requirement for the soil or the target crop and the nutrient sources available.

(5) Identify timing and application methods for nutrients that maximize plant utilization of nutrients and minimize the loss to the environment.

(6) Evaluate using cover crops to scavenge nutrients that might remain in the soil after harvest and water level control to keep nitrogen laden water within the root zone for plant use and to promote denitrification in drainage system.

(7) Evaluate field limitations based on environmental hazards or concerns.

(8) Control phosphorus loss from a field by controlling sediment loss. The primary management measure for control of phosphorus will be the erosion and sediment management measure, Section A., which is hereby included within the measure.

5. Nutrient Management Practices

Following is a list of management practices for nutrient management that are available as tools to achieve the management measure as set forth in section C.4. This list of practices is not exhaustive and does not preclude States and local agencies from developing special management practices, in cooperation with appropriate technical agencies for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as that provided by the management measures specified in the guidance. There may also be State and local standards that would require additional nutrient management practices.

Following are the necessary components of a nutrient management plan:

(1) Soils information, a history of previous crops and current crop rotation for each field.

(2) An assessment by field to determine expected yields for the target crop. The expected yield is determined by using the following:

- University fertility recommendations (based on soil series where available),
- SCS Soils 5 information for the soil series, and
- Average yield history for the field.

(3) A summary of the nutrient resources available to the producer for the target crop. This would include the following steps:

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- Testing of the soil in the field for phosphorus, potassium and nitrates;*

- Plant tissue testing for nutrient needs during the growing season (where tissue tests are calibrated with crop nutrient needs);

- Estimate of the nitrogen contribution form soil organic matter mineralization, where important;

- Nutrient analysis of manure and sludge; and

- Calculation of the nitrogen contribution to the soil from legumes grown in rotation.

(4) Use of proper timing and application methods for nutrients that maximize plant utilization of nutrients and minimize the loss to the environment, including split application and banding of the nutrients and incorporation of fertilizers, manures and other organic sources.

(5) Use of cover crops (see practice 340 below) to scavenger nutrients and water level control to keep nitrogen-laden water within the root zone for plant use and to promote denitrification in drainage system.

Cover and Green Manure Crop (340))
A crop of close-growing grasses, legumes or small grain grown primarily for seasonal protection and soil improvement. It usually is grown for 1 year or less, except where there is permanent cover as in orchards.

The purpose is to control erosion during periods when the major corps do not furnish adequate cover; add organic material to the soil and improve infiltration, aeration and tilth.

(6) Evaluate field limitations based on environmental hazards or concerns such as:

- Sinkholes, wells and other routes of direct access to ground water such as karst topography;
- Proximity to surface water;
- Highly erodible soils;
- Highly permeable soils; and
- Shallow aquifers.

* Soil testing for nitrates in humid regions has produced inconsistent results and should be used with caution. Consideration should be given to the alternative approach of plant tissue testing early in the growing season to determine the nitrogen needs of the crop.

(7) Provide a narrative explaining the plan and its use.

Nutrient Management (590)
Manage the amount, form, placement, and timing of applications of plant nutrients.

The purpose is to supply plant nutrients for optimum forage and crop yields, minimize entry of nutrients to surface and ground water, and to maintain or improve chemical and biological condition of the soil.

6. Effectiveness Information

Following is a summary of some of the available information regarding pollution reductions that can be expected from installation of nutrient management practices.

The State of Maryland estimates that average reductions of 34 pounds of nitrogen and 41 pounds of phosphorus per acre can be achieved through the implementation of nutrient management plans (Maryland Department of Agriculture, 1990). These average reductions may be high because they are mostly for farms that utilize animal wastes, average reductions for farms that only use commercial fertilizer may be much lower. However, they do represents a significant amount of nutrients that will not be applied to the fields and will not be available for transport from the field in surface water or for movement into the ground-water system. The actual percent reduction in the amount of these nutrients reaching coastal waters is difficult to measure or predict at this time. However, field scale and watershed models can be use to predict the reduction in nutrients moving to the edge of the field and to the ground water.

As of July 1990, the Chesapeake Bay drainage basin States of Pennsylvania, Maryland, and Virginia reported that approximately 114,300 acres (1.4 percent of eligible cropland in the basin) had nutrient management plans for in place (USEPA, Chesapeake Bay Program, 1991). The average nutrient reduction of total nitrogen and total phosphorus was 31.5 and 37.5 pounds per acre, respectively. The States initially prioritized nutrient management efforts toward animal waste utilization. Because initial planning was focused on animal wastes (which have a relatively high total nitrogen and phosphorus loading factor), estimates of nutrient reduction (see Table 2-10) attributed to nutrient management may decrease as more cropland using only commercial fertilizer is enrolled in the program.

Table 2-10. Estimated Nutrient Reductions for Selected Management Practices

Management Practice	Total P Load Reduction (%) (approximate)
Proper Rate of Fertilizer Application	3
Optimum Timing of Fertilization	20
Optimum Method of Fertilization	up to 90

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.

7. Cost Information

Following is available information on the costs of implementing nutrient management practices.

In general, most of the costs are associated with providing additional technical assistance to landowners to develop nutrient management plans. In many instances landowners can actually save money by implementing nutrient management plans. For example, Maryland estimates from the over 750 nutrient management plans that were completed prior to September 30, 1990, that if plan recommendations are followed, the landowners will save an average of $23 per acre per year (Maryland Department of Agriculture, 1990). The average saving may be high because most plans were for farm utilizing animal waste, future saving may be reduced as more farms using commercial fertilizer are included in the program.

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Table 2-11. Estimated Cost Implications for Selected Management Practices

Practice	Unit	Capital (approximate)	Operating and Maintenance (approximate)
Proper Rate of Fertilizer Application	0	0	0
Optimum Timing of Fertilization	minimal	0	minimal
Optimum Method of Fertilization	minimal	NA	minimal

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.

8. Planning Considerations for a Nutrient Management Measure

When developing a nutrient management plan the following items should be given careful consideration.

- A farm and field map

  The land that will be included in the nutrient plans should be located on a map of the farm and detailed on field maps showing the location of crop to be grown. A soils map for each field should be included in this initial information package. The map should be accompanied by the exact acres within the field, a five year average of crop yield for the field and an indication of the soil productivity of the field.

- Nutrient requirements of the target crop

  The most critical element of the plan is the yield goal established for the crop. This is to be based on the yield history and productivity of the soil in the field. The goal must be realistic for the soil, the growing season rainfall and management ability of the producer. Once the yield goal for a target crop is established, the nutrient requirements for the target crop can be calculated.

- Nutrient sources available by field and rotation system used for the field

  A list of all sources of nutrients must be developed for each field. This would include results from soil testing, analysis of animal wastes that will be applied to

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the field, analysis of any other organic wastes that will be applied to the field, credit for crop residues from previous crops, credit for cover crop if grown prior to the target crop, credit for nitrogen in irrigation water and atmospheric deposition on nitrogen on the field during the growing season.

- Indication of any environmental hazards or concerns

  A list of environmental hazards for each field should be developed at this time. The list should indicate areas of excessive leaching within the field, depth to ground water, distance to surface water, location of sink holes, indication of karst subsurface formations, location of water supply wells and areas of the field that are included in a wellhead protection zone.

- The narrative explaining the plan and its use

  The plan will specify the nutrients needed to reach the yield goal and the sources of these nutrients. It will recommend times of application for the sources and the methods of application. This may include split applications of commercial fertilizer, incorporation of manure and the use of slow release nutrient sources. The plan may require either soil testing or tissue testing after the crop reaches a specified stage as a guide for the application of additional nutrients to complete the requirements for the yield goal. Winter cover crops may also be specified to hold nutrients during this time period.

9. <u>Operation and Maintenance for Nutrient Management</u>

<u>Operation</u>:

The utilization of a nutrient management plan requires periodic soil testing for each field, soil and/or tissue testing during the early growth stages of the crop and testing of manure, sludge and irrigation water if they are used. The plan may call for multiple applications of nutrients requiring more that one field operation to apply the total nutrients required for the crop.

<u>Maintenance:</u>

A nutrient management plan should be updated whenever the crop rotation is changed or the nutrient source is changed. Application equipment must be calibrated and inspected for wear and damage periodically and repaired when necessary. Records of nutrient use and source should be maintained along with other production records for each field. These will be used to update or modify the management plan when necessary. The management plan should be reviewed at least every three years.

D. Pesticide Management

The basic concept of pesticide management is pollution prevention. The most effective approach to reducing pesticide pollution of waters is, first, to release fewer pesticides into the environment and, second, to use practices which minimize the movement of pesticides to surface and ground water. In addition, pesticides should only be applied when an economic benefit to the grower will be achieved. Such an approach emphasizes using pesticides only when, and to the extent, necessary to control the target pest. This usually results in some reduction in the amount of pesticides being applied to the land, thereby enhancing the protection of water quality as well as reducing the cost of production.

1. Management Measure Applicability

The management measures set forth in this section are to be utilized on all agricultural lands that have or are intended to have pesticides applied to them.

Those agricultural lands that also meet the applicability definitions of the erosion and sediment management measure, nutrient management measure, grazing management measure, or other management measures are also subject to those management measures.

2. Pollutants Associated with Agricultural Pesticide Use

Pesticides include any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest or intended use as a plant regulator, defoliant, or desiccant. The principal pesticidal pollutants that may be detected in surface water and in ground water are the active and inert ingredients and any persistent degradation products. Pesticides may enter ground and surface water in dissolved form or bound to eroded soil particles.

3. Sources of Pesticides

A major source of contamination from pesticide use is the result of application of pesticides. Other sources of pesticide contamination are atmospheric deposition, spray drift during the application process, misuse, and spills, leaks, and discharges that may be associated with pesticide storage, handling and waste disposal.

4. Management Measures to Manage Pesticide Use

Following are the management measures for managing agricultural pesticide use. They will reduce surface and ground-water contamination, eliminate application of excess pesticides, improve timing and efficiency of application, increase the use efficiency of pesticides, and reduce the generation of pesticide wastes. Specific pesticide management measures are as follows:

(1) Evaluate the pest problems, previous pest control measures, and cropping history.

(2) Evaluate the physical characteristics of the site for the leaching of soluble pesticides or runoff of soluble or soil-borne pesticides.

(3) Utilize integrated pest management (IPM) systems to reduce the amount of pesticides applied to the maximum extent that is technically and economically achievable. IPM is defined as a pest control strategy based on the determination of an economic threshold that indicates when a pest population is approaching the level at which control measures are necessary to prevent a decline in net returns. In principle, IPM is an ecologically based strategy that relies on natural mortality factors, such as natural enemies, weather, and crop management, and seeks control tactics that disrupt these factors as little as possible (National Research Council, 1989).

(5) If pesticide applications are necessary and a choice of materials exists, consider the persistence and leachability of products along with other factors in making a selection. Users must apply pesticides in accordance with the instructions on the label of each pesticide product, and when required, be trained and certified in the proper use of the pesticide.

(6) Ensure that pesticides are handled safely, and stored and disposed of properly.

5. <u>Pesticide Management Practices</u>

Following is a list of management practices for pesticide management that are available as tools to achieve the management measure as set forth in section D.4. This list of practices is not exhaustive and does not preclude States and local agencies from developing special management practices, in cooperation with the appropriate technical agency within the State for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as the provided by the management measures specified in the guidance. There may also be State and local standards that would require additional pesticide management practices:

(1) Inventory of current and historical pest problems, cropping patterns and use of pesticides for the field.

(2) Consider soil and physical characteristics of the site, including the potential for the leaching or runoff of pesticides. In situations where the potential for loss is high, emphasis should be given to practices and/or management measures that will minimize these potential losses. The physical characteristics to be considered should include limitations based on environmental hazards or concerns such as:

- Sinkholes, wells and other areas of direct access to ground water such as karst topography;

- Proximity to surface water;
- Highly erodible soils;
- Soils with poor adsorptive capacity;
- Highly permeable soils; and
- Shallow aquifers;

(3) Following is a list of the primary practices available to implement IPM systems:

- More efficient application methods e.g. spot spraying;
- Pesticide application based on economic thresholds;
- Use of resistant crop strains;
- Use less environmentally persistent pesticides;
- Use pesticides with reduced mobility in water;
- Use timing of field operations (planning, cultivating, and harvesting) to minimize application of pesticides;
- Conduct scouting (use periodic scouting to determine when pest problems reach the economic threshold on the farm);
- Use of biological controls:
  - (a) introduction and fostering of natural enemies;
  - (b) preservation of predator habitats; and
  - (c) release of sterilized male insects;
- Use of pheromones:
  - (a) for monitoring populations;
  - (b) for mass trapping;
  - (c) for disrupting mating or other behaviors of pests; and
  - (d) to attract predators/parasites;
- Crop rotations
- Use cover crops in the system, as needed, to promote water use and reduce deep percolation of water that contributes to leaching of pesticides into ground water;
- Destruction of pest breeding, refuge and overwintering sites;
- Use of "trap" crops;
- Habitat diversification; and
- Use of botanicals.

(4) Maintain a history of pesticide use for each field. This could include the types of pesticides used, amount, and the method of application.

(5) A strong State role and linkage with other evolving ground and surface water protection programs is critical to protect water resources from contamination from pesticide chemicals. Therefore, States should integrate this aspect of their Coastal program with State and Federal strategies designed to reduce ground and surface water contamination associated with pesticide use. Particular attention should be paid to practices which provide flexibility for decisions to be made on a geographic basis--taking into account use, value and vulnerability of ground-water resources.

6. Implementation of Management Measure

The management measures specified in section D.4 identify the changes in behavior and thought processes that are needed to manage pesticides to reduce excess pesticide use. FIFRA can be used to enforce requirements to follow pesticide label instructions and for applicator training and certification, when necessary. States are using a variety of approaches to encourage change in behavior and thought processes regarding pesticide use, such as State wide and regional strategies and farm-specific plans. EPA believes that farm-specific pesticide management plans may be necessary to document the changes in behavior and the thought processes necessary to implement the management measure.

EPA solicits comment on whether the pesticide management measure should include development of a pesticide management plan so that the behavior and thought process associated with the management measures is documented.

7. Effectiveness Information

Following is a summary of available information regarding pollution reductions that can be expected from using pesticide management practices.

Table 2-12 summarizes estimates of potential pesticide loss reductions from various management practices and systems of practices at a field level as compared with a hypothetical field utilizing cropping practices which were typical until the late 1970's. The uncertainty of the estimates is a function of the rapid transitions in production methods coupled with the variance among regions and seasons. Traditional sediment and erosion control practices are not as effective on cotton as with corn and soybeans because much cotton is grown on relatively flat land with little or no water erosion problem (Heimlich and Bills, 1984).

Table 2-13 summarizes the estimates of pesticide loss reductions from various management practices and combinations of practices for corn (North Carolina State University, 1984). These estimates are made at the field level as compared with a hypothetical field utilizing conventional, traditional or typical cropping practices realizing that these practices may vary considerably between geographic regions.

The Non-Point Source Task Force of the International Joint Commission (1983) for the Great Lakes Basin also estimated pesticide reductions associated with selected management practices and the data are summarized in Table 2-14. The Task Force found that the most effective, although not necessarily the most acceptable method of pesticide Great Lakes loading control, is regulation of the use of volatile and persistent pesticides (see practice no. 2 below). They noted that this has been effective in the Great Lakes Basin.

The Great Lakes Pollution from Land Use Activities Reference Group (PLUARG) agricultural watershed studies found that 66 percent of simazine loadings and 22 percent of atrazine loadings were due to spills in 1976-77 (Frank et al., 1978). Thus, safe handling, storage and disposal practices (see practice no.6 below) alone, can significantly reduce pesticide losses.

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Table 2-12. Estimates of Potential Reductions in Field Losses of Pesticides for Cotton Compared to a Conventionally and/or Traditionally Cropped Field[1]

	Transport Route(s)	Range of Pesticide Loss Reduction (Percent)[2]
Terracing	SR and SL #	0-(20*)
Contouring	SR and SL	0-(20*)
Reduced Tillage	SR and SL	-40 - +20 AB
Grassed Waterways	SR and SL	0-10 AB
Sediment Basins	SR	0-10 AB
Filter Strips	SR	0-10 A
Cover Crops	SR and SL	-20 - +10 B
Optimal Application Techniques[3]	All Routes ($)	40-80 A
Nonchemical Methods	All Routes	
Scouting Economic Thresholds	All Routes	40-65 A 0-30 B
Crop Rotations	All Routes	0-20 A 10-30 B
Pest Resistant Varieties	All Routes	0-60 A 0-30 B
Alternative Pesticides	All Routes	60-95 A 0-20 B

SOURCE: North Carolina State University, 1984.

* Refers to estimated increases in movement through soil profile.
\# SR = Surface Runoff
SL = Soil Leaching
$ Particularly drift and volatilization

[1]The hypothetical traditionally cropped comparison field utilizes the following management system:
a) conventional tillage without other SWCPs,
b) aerial application of all pesticides with timing based only on field operation convenience,
c) ten insecticide treatments annually with a total application of 12 kg/ha based on a prescribed schedule,
d) cotton grown in 3 out of 4 years,
e) long season cotton varieties.

[2]Assumes field loss reductions are proportional to application rate reductions.
A = insecticide (toxaphene, methylparathion, synthetic pyrethroids).
B = herbicides (trifluralin, fluometron).
Ranges allow for variation in production region, climate, slope and soils.
[3]Defined for cotton as ground application using optimal droplet or granular size ranges with spraying restricted to calm periods in late afternoon or at night when precipitation is not imminent.

Table 2-13. Estimates of Potential Reductions in Field Losses of Pesticides for Corn Compared to a Conventionally and/or Traditionally Cropped Field[1]

Management Practice	Transport Route(s) Affected	Range of Pesticide Loss Reduction (Percent)[2]
SWCPs	SR and/or SL(#)	
Terracing	SR and/or SL	40-75AB (25*)
Contouring	SR and/or SL	15-55AB (20*)
No-till	SR and/or SL	-10 - +40B 60 - +10A (10*)
Other Reduced Tillage	SR and/or SL	-10 - +60B -40 - +20A (15*)
Grassed Waterways	SR	-10-20AB
Sediment Basins	SR	0-10AB
Filter Strips	SR	0-10AB
Cover Crops	SR and/or SL	0-20B[3]
Optimal Application Techniques[4]	All Routes $	10-20 20-40B
Nonchemical Methods	All Routes	
Adequate Monitoring	All Routes	40-65A
Crop Rotations	All Routes	40-70A 10-30B

SOURCE: North Carolina State University, 1984
* Refers to estimated increases in movement through soil profile.
# SR = Surface Runoff
SL = Soil Leaching
$ Particularly drift and volatilization

[1]The hypothetical field used as the basis for comparison utilizes the following management system:
a) conventional tillage without other SWCPs,
b) ground application with timing based only on field operation convenience,
c) little or no pest monitoring; spraying on prescribed schedule,
d) corn grown in 3 out of 4 years.
[2]Assumes field loss reductions are proportional to application rate reductions. A = insecticides (carbofuran and O.P.s) B = herbicides (Triazine, Alachlor, Butylate, Parquat) Ranges allow for variation in climate, slope, soils and types of pesticides used. Ranges for no-till and reduced-till are derived from a combination of increased application rates and decreased runoff losses.
[3]Cover crops only will affect runoff and leaching losses for pesticides persistent enough to be available over the non-growing season. In the case of pesticides used on corn only the triazine and anilide herbicides will generally meet this criteria.
[4]Defined here for corn as ground application using optimal droplet or granular size ranges, with spraying restricted to calm periods in late afternoon or evening.

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Table 2-14. Estimated Pesticide Reductions for Selected Management Practices

Management Practice	Percent Reduction (Approximate)
1. Proper rate of pesticide application	50 - 75% (in conjunction with No. 3)
2. Use of pesticides with minimum persistence and volatility	100%
3. Optimum method of pesticide application	50 - 75% (in conjunction with No. 1)
4. Optimum timing of pesticide application	50% (if application prior to spring runoff can be avoided)
5. Integrated pest management	Undocumented (but up to 100% is possible)
6. Safe handling, storage and disposal of pesticides	up to 50%

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.

8. Cost Information

In general, most of the costs of implementing a pesticide management plan are program costs associated with providing additional technical assistance to landowners to develop pesticide management plans and for field scouting during the growing season. Producers can actually save money by implementing pesticide management plans.

The Non-Point Source Task Force of the International Joint Commission for the Great Lakes Basin (1983) estimated the cost implications for selected pesticide management practices and the data are summarized in Table 2-15.

Costs for erosion and sediment control and for irrigation management are in Sections A and F, respectively.

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Table 2-15. Estimated Cost Implications for Selected Pesticide Management Practices

Management Practice	Unit	Capital Approximate	Operating
1. Proper rate of pesticide application	minimal	0	minimal
2. Use of pesticides with minimum persistence and volatility	0	0	
3. Optimum method of pesticide application	minimal	minimal	0
4. Optimum timing of pesticide application	minimal	0	minimal
5. Integrated pest management	minimal	0	major inconvenience

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.

9. <u>Planning Considerations for Implementing Pesticide Management</u>

Following is a more detailed discussion regarding effective pesticide management:

- A farm and field map.

  The land where pesticides will be used should be located on a map of the farm. In addition, the following information should be compiled for each field:

  - Crops to be grown and a history of crop production;
  - Information on soils types;
  - The exact acres within each field; and
  - Record on past pesticide use on each field.

- Pesticide requirements for the target pest(s).

  The most critical element is establishment of the economic yield reductions thresholds for each crop. The reduction thresholds must be <u>realistic</u> for the producer.

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- Pesticide sources available by field and rotation system used for the field.
- Indication of any environmental hazards or concerns.

  A list of environmental hazards for each field should be developed at this time. The list should indicate
  areas of excessive leaching within the field, depth to ground water, distance to surface water, location of sink holes, indication of karst subsurface formations, location of water supply wells and areas of the field that are included in a wellhead protection zone.

10. <u>Operation and Maintenance for Pesticide Management</u>

<u>Operation</u>:

Effective pesticide management may require periodic scouting of each field for pests. Also, multiple applications of pesticides may require more that one field operation to apply the pesticides required for the crop.

<u>Maintenance</u>:

Pesticide management measures should be updated whenever the crop rotation is changed or the pesticide source is changed. Application equipment must be calibrated and inspected for wear and damage periodically and repaired when necessary. Records of pesticide application should be maintained along with other production records for each field. These will be used to update or modify the management measure when necessary. The management measure for each field should be reviewed every year.

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E. Grazing Management

This management measure is designed to improve water quality from, and protect riparian zones within, range or pasture land. The key elements are grazing management for the proper utilization of the forage component of the vegetation, controlling access to or excluding livestock from sensitive areas such as streambanks and riparian zones, and improving of vegetative cover to reduce erosion.

1. Management Measure Applicability

The management measure is to be utilized on all irrigated and non-irrigated agricultural pasture lands and range lands.

Those range and pasture lands that also meet the applicability definitions of the erosion and sediment control management measure, pesticide management measure, nutrient management measure, irrigation water management, or other management measures are also subject to those management measures.

2. Pollutants Produced by Utilization of Agricultural Range and Pasture Lands

Runoff water from agricultural pasture lands and range lands may transport the following types of pollutants:

- Sediment and particulate organic solids;
- Particulate bound nutrients, chemicals and metals, such as phosphorus, organic nitrogen, a portion of applied pesticides, and a portion of the metals applied with some organic wastes and found naturally within the soil;
- Soluble nutrients, such as nitrogen, a portion of the phosphorus, a portion of the applied pesticides, a portion of the soluble metals and many other major and minor nutrients;
- Salts; and
- Bacteria, viruses and other microorganisms.

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3. Management Measure to Control Range and Pasture Land Grazing

The range and pasture land grazing control management measure is a combination of practices to reduce the discharge of sediment, nutrients and chemicals from agricultural pasture land and range lands to receiving waters; to prevent streambank erosion caused by livestock; and to enhance or maintain riparian zones at the good to excellent conditional status. At a minimum, for range land this measure will maintain the range condition at the good condition status* or above; for pasture this measure will maintain a vegetation cover that will reduce erosion to, or maintain soil stability within, the soil loss tolerance value or below. For both range and pastures, areas will be provided for livestock watering, salting and shade that are located away from streambanks and riparian zones. This will be accomplished by managing livestock grazing and providing facilities for water, salt and shade, as needed.

4. **Range and Pasture Land Management Practices**

Following is a list of management practices for range and pasture grazing control that are available as tools to achieve the range and pasture land management measure as set forth in Section E.3. Under each management practice the U.S. Soil Conservation (SCS) practice number and a definition is provided. The list of practices included in this section is by no means exclusive and does not preclude States or local agencies from developing special management practices in cooperation with the appropriate technical agency within the State for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as that provided by the management measure specified in this guidance. There may also be state or local standards that would require additional practices.

(1) Implementation of a grazing management scheme that assures proper grazing use by grazing at an intensity that balances the number of livestock with the available forage and feed and describes the animal movement through the operating unit of range or pasture lands. Proper grazing use will maintain enough live vegetation and litter cover to protect the soil from erosion, and will maintain or improve the quality and quantity of desirable vegetation. Practices that accomplish this are:

<u>Deferred Grazing (352)</u>
Postponing grazing or resting grazing land for prescribed period.

The purpose is to: (1) promote natural re-vegetation by increasing the vigor of the forage stand and permitting desirable plants to produce seed, (2) provide a feed reserve for fall and winter grazing or emergency use, (3) improve the appearance of range having inadequate cover, and (4) reduce soil loss and improve water quality.

<u>Planned Grazing System (556)</u>
A practice in which two or more grazing units are alternately rested and grazed in a planned sequence for a period of years, and rest periods may be throughout the year or during the growing season of key plants.

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* Range land condition rating (percent climax vegetation): Excellent = 76-100%, Good = 51-75%, Fair = 26-50%, and Poor = 0-25%.

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The purpose is to: (1) maintain existing plant cover or hasten its improvement while properly using the forage of all grazing units, (2) reduce erosion and improve water quality, (3) increase efficiency of grazing by uniformly using all parts of each grazing unit, (4) insure a supply of forage throughout the grazing season, (5) increase production and improve quality of forage, (6) enhance wildlife habitat, (7) promote flexibility in the grazing program and buffer the adverse effects of drought, and (8) promote energy conservation through reduced use of fossil fuel.

Proper Grazing Use (528)
Grazing at an intensity that will maintain enough cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation.

The purpose is to: (1) increase the vigor and reproduction of key plants; (2) accumulate litter and mulch necessary to reduce erosion and sedimentation and improve water quality; (3) improve or maintain the condition of the vegetation; (4) increase forage production; (5) maintain natural beauty; and (6) reduce the hazard of wildfire.

(2) Providing water and salt supplement facilities away from streams will help keep livestock away from streambanks and riparian zones. The establishment of alternate water supplies for livestock is an essential component of this measure when distribution problems of livestock occurs in a grazing unit. In some locations, artificial shade may be constructed to encourage use of upland sites for shading and loafing. This will be accomplished through the following:

Pipeline (516)
Pipeline installed for conveying water for livestock or for recreation.

The purpose is to convey water from a source of supply to a point of use.

Pond (378)
A water impoundment made by constructing a dam or an embankment or by excavation a pit or dugout.

The purpose is to provide water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality.

Trough or Tank (614)
A trough or tank, with needed devices for water control and waste water disposal, installed to provide drinking water for livestock.

The purpose is to provide watering facilities for livestock at selected locations that will protect vegetative cover through proper distribution of grazing or through better grassland management for erosion control. Another purpose on some sites

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is to reduce or eliminate the need for livestock to be in streams, which reduces livestock waste there.

Well (642)
A well constructed or improved to provide water for irrigation, livestock, wildlife, or recreation.

The purpose is to facilitate proper use of vegetation on rangeland, pastures, and wildlife areas; and to supply the water requirements of livestock and wildlife.

(3) Minimizing access to or excluding livestock from streambanks and riparian zones is essential to the implementation of this management measure. This could be accomplished by fencing of areas where animals tend to congregate, including stream corridors and riparian zones.

Fencing (516)
Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people (does not include temporary fences).

The purpose is to: (1) exclude livestock or big game from areas that should be protected from grazing, (2) confine livestock or big game on an area, (3) control domestic livestock while permitting wildlife movement, (4) subdivide grazing land to permit use of grazing systems, (5) protect new seedings and plantings from grazing, and (6) regulate access to areas by people or prevent trespassing.

Livestock exclusion (472)
Excluding livestock from an area not intended for grazing.
The purpose is to protect, maintain, or improve the quantity and quality of the plant and animal resources; to maintain enough cover to protect the soil; to maintain moisture resources; and to increase natural beauty.

(4) Where existing conditions result in excessive erosion, it will be necessary to improve or re-establish the vegetative cover on range and pasture lands. When re-establishment of vegetation is required, it may be accomplished using the following practices:

Pasture and Hayland Planting (512)
Establishing and reestablishing long-term stands of adapted species of perennial, biannual, or reseeding forage plants. (Includes pasture and hayland renovation. Does not include grassed waterways or outlets or cropland.)

The purpose is to reduce erosion,or maintain soil stability and to produce high quality forage.

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Range Seeding (550)
Establishing adapted plants by seeding on native grazing land (does not include pasture and hayland planting).

The purpose is to: (1) prevent excessive soil and water loss and improve water quality; (2) produce more forage for grazing of browsing animals on rangeland or land converted to range from other uses; and (3) improve the visual quality of grazing land.

Critical area planting (342)
Planting vegetation, such as trees,shrubs, vines grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).

The purpose is to stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources.

5. **Effectiveness Information**

Table 2-16 presents information on pollution reductions that can be expected from installation of the management practices outlined within this management measure.

Table 2-16. Estimated Pollutant Reductions for Selected Management Practices

Practice	Sediment Load Reduction	Total P Load Reduction
Permanent Veg. Cover	less than 1 T/Ac/Yr delivered	very high
Reforestation of Erodible Crop and Pastureland	less then 1 T/Ac/Yr delivered	very high

SOURCE: Non-Point Source Task Force, International Joint Commission, 1983.
NOTE: All reductions are relative to conventional (moldboard plow) tillage.

The information contained herein is primarily practice-oriented, yet EPA seeks data regarding the overall effectiveness of management measures, or systems of practices. To this end, EPA is continuing to collect and analyze more information regarding pollutant reductions, and solicits comments regarding information sources to utilize.

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The Soil Conservation Service has developed a set of water quality statements for each practice that provide some insight into the use of the practice for water quality improvement. They also include warnings of negative water quality impacts that might occur by using the practice. Water quality statements for the practices listed in this management measure are contained in Table 2-17.

6. Cost Information

Cost factors for control of erosion and sediment transport from agricultural lands.

The cost to install the Grazing Land Protection system (SL6) for the 42 states which used the practice, was $5.68 per acre in 1990 (USDA, ASCS, 1991).

The system reduced erosion by an average of 2.2 tons per acre at an amortized cost of $0.50 per ton (USDA, ASCS, 1991).

The SL6 Grazing Land Protection contain many of the practices recommended in this management measure (see Appendix 2-A).

7. Planning Considerations

The selection of management practices for this measure will be based on an evaluation of current conditions, problems identified, quality criteria, and management goals.

Successful resource management on range and pasture land is the correct application of a combination of practices that will meet the needs of the range and pasture land ecosystem - the soil, water, air, plant and animal resources and the objectives of the land user.

For a sound grazing land management system to function properly and to provide for a sustained level of productivity, the following should be considered.

(1) Know the key management plant species and their response to different seasons and degrees of use by various kinds and classes of livestock.

(2) Know the demand for, and seasons of use, of forage and browse by wildlife species.

Table 2-17. Water Quality Statement for Selected Management Practices

Practice	Water Quality Statement
Deferred Grazing (352)	In areas with bare ground or low percent ground cover, deferred grazing will reduce sediment yield because of increased ground cover, less ground surface disturbance, improved soil bulk density characteristics, and greater infiltration rates. Areas mechanically treated will have less sediment yield when deferred to encourage re-vegetation. Animal waste would not be available to the area during the time of deferred grazing and there would be less opportunity for adverse runoff effects on surface or aquifer water quality. As vegetative cover increases, the filtering processes are enhanced, thus trapping more silt and nutrients as well as snow if climatic conditions for snow exist. Increased plant cover results in a greater uptake and utilization of plant nutrients.
Fencing (382)	Fencing is a practice that can be on the contour or up and down slope. Often a fence line has grass and some shrubs in it. When a fence is built across the slope it will slow down runoff, and cause deposition of coarser grained materials reducing the amount of sediment delivered downslope. Fencing may protect riparian areas which act as sediment traps and filters along water channels and impoundments. Livestock have a tendency to walk along fences. The paths become bare channels which concentrate and accelerate runoff causing a greater amount of erosion within the path and where the path/channel outlets into another channel. This can deliver more sediment and associated pollutants to surface waters. Fencing can have the effect of concentrating livestock in small areas, causing a concentration of manure which may wash off into the stream, thus causing surface water pollution.

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Table 2-17. (Continued)

Practice	Water Quality Statement
Pasture and Hayland Planting (556)	The long-term effect will be an increase in the quality of the surface water due to reduced erosion and sediment delivery. Increased infiltration and subsequent percolation may cause more soluble substances to be carried to ground water.
Planned grazing system (556)	Planned grazing systems normally reduce the system time livestock spend in each pasture. This increases quality and quantity of vegetation. As vegetation quality increases, fiber content in manure decreases which speeds manure decomposition and reduces pollution potential. Compacted layers of the soil tend to diminish because of the opportunity for freeze-thaw, shrink-swell, and other natural soil mechanisms to occur that reduce compacted layers during the absence of the grazing animals. This increases infiltration, increases vegetative growth, slows runoff, and improves the nutrient and moisture filtering and trapping ability of the area. Decreased runoff will reduce the rate of erosion and movement of sediment and dissolved and sediment-attached substances to downstream water courses. No increase in ground water pollution hazard would be anticipated from the use of this practice.
Range seeding (550)	Increased erosion and sediment yield may occur during the establishment of this practice. This is a temporary situation and sediment yields decrease when reseeded area becomes established. If chemicals are used in reestablishment process, chances of chemical runoff into downstream water courses are reduced if application is applied according to label instructions. After establishment of the grass cover, grass sod slows runoff, acts as a filter to trap sediment, sediment attached substances,

Table 2-17. (Continued)

Practice	Water Quality Statement
	increase infiltration, and decreases sediment yields.
Pipeline (516)	Pipelines may decrease sediment, nutrient, organic, and bacteria pollution from livestock. Pipelines may afford the opportunity for alternative water sources other than streams and lakes, possibly keeping the animals away from the stream or impoundment. This will prevent bank destruction with resulting sedimentation, and will reduce animal waste deposition directly in the water. The reduction of concentrated livestock areas will reduce manure solids, nutrients, and bacteria that accompany surface runoff.
Trough or tank (614)	By the installation of a trough or tank, livestock may be better distributed over the pasture, grazing can be better controlled, and surface runoff reduced, thus reducing erosion. By itself this practice will have only a minor effect on water quality; however when coupled with other conservation practices, the beneficial effects of the combined practices may be large. Each site and application should be evaluated on their own merits.
Pond (378)	Ponds may trap nutrients and sediment which wash into the basin. This removes these substances from downstream. Chemical concentrations in the pond may be higher during the summer months. By reducing the amount of water that flows in the channel downstream, the frequency of flushing of the stream is reduced and there is a temporary collection of substances held temporarily within the channel. A pond may cause more leachable substance to be carried into the ground water.

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Table 2-17. (Continued)

Well (642)	When water is obtained it has poor quality because of dissolved substances, its use in the surface environment or its discharge to downstream water courses the surface water will be degraded. The location of the well must consider the natural water quality and the hazards of its use in the potential contamination of the environment. Hazard exists during well development and its operation and maintenance to prevent aquifer quality damage from the pollutants through the well itself by back flushing, or accident, or flow down the annual spacing between the well casing and the bore hole.

SOURCE: USDA, Soil Conservation Service, 1988.

(3) Know the amount of plant residue or grazing height that should be left to protect grazing land soils from wind and water erosion and to provide for plant regrowth.

(4) Know the range site production capabilities and the pasture land suitability group capabilities so an initial stocking rate can be established.

(5) Know how to use livestock as a tool in the management of the range ecosystems and pasture lands to insure the health and vigor of the plants, soil tilth, proper nutrient cycling, erosion control, and riparian area management, while at the same time meeting livestock nutritional requirements.

(6) Establish grazing unit sizes, watering, shade and salt locations, etc. to secure optimum livestock distribution and utilization.

(7) Provide for livestock herding, as needed, to protect sensitive areas from excessive use at critical times.

(8) Encourage proper wildlife harvesting to ensure proper population densities and forage balances.

(9) Know the livestock diet requirements in terms of quantity and quality to ensure that there are enough grazing units to provide adequate livestock nutrition for the season, kind and classes of animals on the farm/ranch.

(10) Maintain a flexible grazing system to adjust for unexpected environmentally and economically generated problems.

F. Irrigation Water Management

1. Management Measure Applicability

This management measure is to be utilized on all irrigated agricultural lands, including but not limited to the following: cropland, pastureland, orchards, specialty crop production, and nursery crop production.

Those irrigated agricultural lands that also meet the applicability definitions of the erosion and sediment management measure, nutrient management measure, pesticide management measure, grazing management measure, or other management measures are also subject to those management measures.

2. Pollutants Produced by Irrigation

Runoff water and leachate from irrigated land may transport the following types of pollutants:

- Sediment and particulate organic solids;
- Particulate bound nutrients, chemicals and metals, such as phosphorus, organic nitrogen, a portion of applied pesticides, and a portion of the metals applied with some organic wastes and also found naturally within the soil;
- Soluble nutrients, such as nitrogen, soluble phosphorus, a portion of the applied pesticides, soluble metals, salts and many other major and minor nutrients; and
- Bacteria, viruses and other microorganisms.

3. Management Measure to Control Irrigation Water

The management measure for irrigation water on agricultural lands is a combination of practices that maximizes the water use efficiency of the irrigation system, minimizes the amount of water that is wasted or discharged from the system, and improves the water quality of both surface and subsurface return flows from the system by: (1) scheduling and managing the application of irrigation water; (2) minimizing to the extent possible irrigation water runoff from all irrigation systems except for surface irrigation, which will be recovered and reused with a tailwater recovery system*; and (3) eliminating unnecessary deep percolation, thereby reducing the amount of pollutants entering nearby surface waters and groundwater. When chemigation is used, the management measure includes backflow preventers.

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* In some locations, tailwater or runoff of applied irrigation water are subject to other water rights or are required to be released to maintain stream flow. In these special cases, reuse on-site may not be allowed and would not be considered part of the management measure for such locations.

(1) Proper irrigation scheduling is a key element in irrigation water management. Irrigation scheduling should be based on knowing the daily water use of the crop, the water holding capacity of the soil, the lower limit of soil moisture for each crop and soil and measuring the amount of water applied to the field. Also natural precipitation should be considered and proper adjustment made in the scheduled irrigations.

(2) Irrigation water should be applied properly in a manner that assures efficient use and uniform distribution of irrigation water and minimizes runoff or deep percolation.

(3) Irrigation water transportation systems that move water from the source of supply to the irrigation system should be designed and managed in a manner that minimizes evaporation, seepage flow-through water losses from canals and ditches.

(4) The utilization of runoff water for additional irrigation or to reduce the amount of water diverted increases the efficiency of use of irrigation water. For surface irrigation systems that require runoff or tailwater as part of the design and operation, a tailwater management practice be installed and used.

(5) Drainage water from an irrigation system should be managed to reduce deep percolation, move tailwater to the reuse system, reduce erosion at the end of the irrigated field and help control adverse impacts on surface and ground water. A total drainage system should be an integral part of the planning and design of an efficient irrigation system.

4. Irrigation Water Management Practices

Following is a list of management practices for irrigation water management that are available as tools to achieve the irrigation water management measure as set forth in Section F.3. Under each management practice the U.S. Soil Conservation Service (SCS) practice number and a definition are provided. The list of practices included in this section is not exhaustive and does not preclude States or local agencies from developing special management practices in cooperation with the appropriate technical agency within the State for unique conditions and problems that may be encountered in particular areas, provided that the management measures (the system of individual practices adopted) achieve a level of performance that is as effective as that provided by the management measures specified in this guidance. There may also be state or local standards that would require additional practices.

(1) Proper irrigation scheduling

Practices that may be used to accomplish proper irrigation scheduling are:

Irrigation water management (449)
Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner.

The purpose is to effectively use available irrigation water supply in managing and controlling the moisture environment of crops to promote the desired crop response, to minimize soil erosion and loss of plant nutrients, to control undesirable water loss, and to protect water quality.

To achieve this purpose the irrigator must have knowledge of: (1) how to determine when irrigation water should be applied, based on the rate of water used by crops and on the stages of plant growth, (2) how to measure or estimate the amount of water required for each irrigation, including the leaching needs, (3) the normal time needed for the soil to absorb the required amount of water and how to detect changes in intake rate, (4) how to adjust water stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or the amount of irrigation runoff from an area, (5) how to recognize erosion caused by irrigation, (6) how to estimate the amount of irrigation runoff from an area, and (7) how to evaluate the uniformity of water application.

Water measuring device
An irrigation water meter, flume or other water measuring device installed in a pipeline or ditch. The measuring device must be installed between the point of diversion and water distribution system used on the field. The device should be a recording meter that will indicate both the rate of flow and the total water used.

The purpose is to provide the irrigator the rate of flow and/or application of water, and the total amount of water applied to the field with each irrigation.

Soil and crop water use data
From soils information the water holding capacity of the soil can be determined along with the amount of water that the plant can extract from the soil before additional irrigation is needed. Water use information for various crops can be obtained from various USDA publications.

The purpose is to allow the irrigator to estimate the amount of available water remaining in the root zone at any time, thereby indicating when the next irrigation should be scheduled and the amount of water needed. There are methods to measure the soil moisture and these should be employed for high value crops or where the water holding capacity of the soil is very low.

(2) Proper application of irrigation water

The type of irrigation system employed will vary with the type of crop grown, the topography, and soils. There are several systems that, when properly designed and operated, can be used as follows:

Irrigation system, drip or trickle (441)
A planned irrigation system in which all necessary facilities are installed for efficiently applying water directly to the root zone of plants by means of applicators (orifices, emitters, porous tubing, or perforated pipe) operated under low pressure. The applicators can be placed on or below the surface of the ground.

The purpose is to efficiently apply irrigation water directly to the plant root zone to minimize water loss, erosion, impacts to water quality, and salt accumulation while maintaining soil moisture within the range for good plant growth.

Irrigation system, sprinkler (442)
A planned irrigation system in which all necessary facilities are installed for efficiently applying water by means of perforated pipes or nozzles operated under pressure.

The purpose is to efficiently and uniformly apply irrigation water to minimize water loss, erosion, and impacts to water quality while maintaining soil moisture for optimum plant growth.

Irrigation system, surface and subsurface (443)
A planned irrigation system in which all necessary water control structures have been installed for efficient distribution of irrigation water by surface means, such as furrows, borders, contour levees, or contour ditches, or by subsurface means.

The purpose is to efficiently convey and distribute irrigation water to the point of application to minimize water loss, erosion, and impacts to water quality while maintaining soil moisture for optimum plant growth.

Irrigation field ditch (388)
A permanent irrigation ditch constructed to convey water from the source of supply to a field or fields in a farm distribution system.

The standard for this practice applies to open channels and elevated ditches of 25 ft^3/second or less capacity formed in and with earth materials.

The purpose is to prevent erosion or loss of water quality or damage to the land, to make possible proper irrigation water use, and to efficiently convey water to minimize conveyance losses.

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Irrigation land leveling (464)
Reshaping the surface of land to be irrigated to planned grades.

The purpose is to permit uniform and efficient application of irrigation water without causing erosion, loss of water quality, or damage to land by waterlogging and at the same time to provide for adequate surface drainage.

(3) Irrigation water transportation systems

Transporting irrigation water from the source of supply to the irrigation system can be a significant source of water loss and cause of degradation of both surface water and ground water. Losses during transmission include seepage from canals and ditches, evaporation from canals and ditches, and flow-through water (water that is never applied to the land but is needed to maintain hydraulic head in the ditch). The primary water quality concern is the development of saline seeps below the canals and ditches and the discharge of saline waters. Another water quality concern is the potential for erosion caused by the discharge of flow-through water. Practices that are used to assure proper transportation of irrigation water from the source of supply to the irrigation system are:

Irrigation water conveyance, ditch and canal lining (428)
A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch or irrigation canal or lateral.

The purpose is to prevent waterlogging of land, to maintain water quality, to prevent erosion, and to reduce water loss.

Irrigation water conveyance, pipeline (430)

A pipeline and appurtenances installed in an irrigation system.

The purpose is to prevent erosion or loss of water quality and damage to land, to make possible proper water use, and to reduce water conveyance losses.

Structure for water control (587)
A structure in an irrigation, drainage, or other water management systems that conveys water, controls the direction or rate of flow, or maintains a desired water surface elevation.

The purpose is to control the stage, discharge, distribution, delivery, or direction of flow of water in open channels or water use areas. Also used for water quality control, such as sediment reduction or temperature regulation. These structures are also used to protect fish and wildlife and other natural resources.

(4) Utilization of runoff water for additional irrigation or to reduce the amount of water diverted. The practice is described as follows:

<u>Irrigation system, tailwater recovery (447)</u>
A facility to collect, store, and transport irrigation tailwater for reuse in the farm irrigation distribution system.

The purpose is to conserve farm irrigation water supplies and water quality by collecting the water that runs off the field surface for reuse on the farm.

(5) Management of drainage water

There are several practices to accomplish this:

<u>Filter strip (393)</u>
A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and waste water.

The primary purpose is to remove sediment and other pollutants from runoff or waste water by filtration, deposition, infiltration, absorption, decomposition, and volatilization, thereby reducing pollution and protecting the environment. An additional purpose is to prevent erosion at the upland edge of fields by dissipating the energy of irrigation water applied as concentrated flow.

<u>Surface drainage field ditch (607)</u>
A graded ditch for collecting excess water in a field.

The purpose is to drain surface depressions for recovery and reuse of excess water or for the controlled delivery of excess water to a filter strip for treatment; collect or intercept excess surface water, such as sheet flow, from natural and graded land surfaces or channel flow from furrows and carry it to an outlet for recovery and reuse or for the controlled delivery of excess water to a filter strip for treatment; and collect or intercept excess subsurface water and carry it to an outlet for recovery and reuse or for the controlled delivery of excess water to a filter strip for treatment.

5. <u>Effectiveness Information</u>

Following is information on pollution reductions that can be expected from installation of the management practices outlined within this management measure.

The Rock Creek Rural Clean Water Program (RCWP) project in Idaho is the source of much information regarding the benefits of irrigation water management (Idaho Department of Health and Welfare, 1990). All crops in the Rock Creek watershed are irrigated with water diverted from the Snake River and delivered through a network of canals and laterals. The combined implementation of irrigation management practices, sediment control practices, and conservation tillage has resulted in high reductions (from 61 percent to 95 percent reduction for all six stations) in suspended sediment loadings in Rock Creek from 1981 to 1988. Similarly, eight of ten sub-basins showed reductions in suspended sediment loadings over the same time period.

The Soil Conservation Service has developed a set of water quality statements for each practice that provide some insight into the use of particular irrigation water management practices for water quality improvement (USDA, SCS, 1988). They also include warnings of negative water quality impacts that might occur by using the practices. Water quality statements for the practices listed in this management measure are contained in Table 2-18.

6. Cost Information

Cost estimates for practices to control irrigation water on agricultural lands are taken from the U.S. Department of Agriculture (USDA ASCS, 1991). Cost estimates reported in this document are given by primary purpose, type of agreement (long-term agreement or regular ACP), and as overall estimates. The costs reported here lump long term agreements and regular ACP agreements. The components of each practice are given in Appendix 2-A.

The cost to install the irrigation water conservation system (practice WC4) for the primary purpose of water conservation in the 28 states which used the practice, was about $77.00 per acre served in 1990. Practice WC4 increased the average irrigation system efficiency from 47 percent to 63 percent at an amortized cost of $9.74 per acre foot of water conserved.

The cost to install water management systems for pollution control (practice SP35) with the primary purpose being water quality was about $103 per acre served. Overall, the cost of practice SP35 was about $50 per acre served.

Table 2-19 shows the cost (per ton of soil saved) of implementing practices WC4 and SP35 for the primary purpose of erosion control.

Table 2-18. Water Quality Statement for Selected Management Practices

Practice	Water Quality Statement
Irrigation water management (449)	Management of the irrigation system should management provide the control needed to minimize losses of water, and yields of sediment and sediment attached and dissolved substances, such as plant nutrients and herbicides, from the system. Poor management may allow the loss of dissolved substances from the irrigation system to surface or ground water. Good management may reduce saline percolation from geologic origins. Returns to the surface water system would increase downstream water temperature.
Irrigation system, drip or trickle (441)	Surface water quality may not be significantly affected by transported substances because runoff is largely controlled by the practice. Chemical applications may be applied through the system. Reduction of runoff will result in less sediment and chemical losses from the field during irrigation. If excessive, local, deep percolation should occur, a chemical hazard may exist to shallow ground water or to areas where geologic materials provide easy access to the aquifer.
Irrigation system, sprinkler (442)	Proper irrigation management controls runoff and prevents downstream surface water deterioration from sediment and sediment attached substances. Over irrigation through poor management can produce impaired water quality in runoff as well as ground water through increased percolation. Chemigation with this system allows the operator the opportunity to mange nutrients, waste water and pesticides. For example, nutrients applied in several incremental applications based on the plant needs may reduce ground water

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Table 2-18 (Continued)

Practice	Water Quality Statement
	contamination considerably, compared to one application during planting. Poor management may cause pollution of surface and ground water. Pesticide drift from chemigation may also be hazardous to vegetation, animals, and surface water resources. Appropriate safety equipment, operation and maintenance of the system is needed with chemigation to prevent accidental environmental pollution or backflows to water sources.
Irrigation system, surface and subsurface (443)	Operation and management of the irrigation system in a manner which allows little or no runoff may allow small yields of sediment or sediment-attached substances to downstream waters. Pollutants may increase if irrigation water management is not adequate. Ground water quality from mobil dissolved chemicals may also be a hazard if irrigation water management does not prevent deep percolation. Subsurface irrigation that requires the drainage and removal of excess water from the field may discharge increased amounts of dissolved substances such as nutrients or other salts to surface water. Temperatures of downstream water courses that receive runoff waters may be increased. Temperatures of downstream waters might be decreased with subsurface systems when excess water is being pumped from the field to lower the water table. Downstream temperatures should not be affected by subsurface irrigation during summer months if lowering the water table is not required. Improved aquatic habitat may occur if runoff or seepage occurs from surface systems of from pumping to lower the water table in subsurface systems.

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Table 2-18 (Continued)

Practice	Water Quality Statement
Irrigation field ditch (388)	Salinity changes may occur in the soil and water. This will depend on the irrigation water quality, the level of water management, and the geologic materials of the area. The quality of ground and surface water may be altered depending on environmental conditions. Water lost from the irrigation system to downstream runoff may contain dissolved substances, sediment, and sediment-attached substances that may degrade water quality and increase water temperature. This practice may make water available for wildlife, but may not significantly increase habitat.
Irrigation land leveling (464)	The effects of this practice depend on the level of irrigation water management. If root zone water is properly managed, then quality decreases of surface and ground water may be avoided. Under poor management, ground and surface water quality may deteriorate. Deep percolation and recharge with poor quality water may lower aquifer quality. Land leveling may minimize erosion and when runoff occurs concurrent sediment yield reduction. Poor management may cause an increase in salinity of soil, ground and surface waters.
Irrigation water conveyance, ditch and canal lining (428)	Potentials for ground water effects from infiltration of poor quality water with and canal lining dissolved substances would be reduced. Potential for ground water effects from infiltration of high quality water would be reduced. Increased stability of the conveyance will also reduce bank or bed erosion which would provide sediment yield reduction within the system and to downstream waters.

Table 2-18 (Continued)

Practice	Water Quality Statement
Irrigation water conveyance, pipeline (430)	Potentials for ground water effects from infiltration of poor quality water would be eliminated by this practice. No streambank or bed erosion would occur which may provide sediment or sediment attached substances to downstream water courses. Deep percolation of saline water may be avoided. Temperature increases that occur from flow in an open conveyance may be eliminated by the pipeline. Wildlife or aquatic habitat that had depended on seepage from the irrigation water conveyance will be decreased.
Structure for water control (587)	Use of the practice to conduct water one elevation to a lower elevation within, to or from a ditch, channel, or canal may not have any effect on the quality of surface or ground water. Use of the practice to control the elevation of water in drainage or irrigation ditches may reduce bank erosion and scouring in the channel; this results in the reduction of sediment and related pollutants delivered to the surface water. When used to control, the division or measurement of irrigation water may have an insignificant effect on the quality of surface and ground water. Use of the practice to keep trash, debris, or weed seeds from entering pipelines has little effect on the quality of surface and ground water. Use of the practice to control the direction of channel flow resulting from tides and high water or backflow from flooding has little effect on the quality of surface and ground water.

Table 2-18 (Continued)

Practice	Water Quality Statement
	Use of the practice to control the level of water table or to remove surface subsurface water from adjoining land, to flood land for frost protection, or to manage water levels for wildlife or recreation may increase infiltration and percolation of water by supplying a surplus of water to the surface when used for flooding. This will enable soluble pollutants to be carried into the ground water. When used to remove drainage water from the surface or subsurface, substances may be "straight-lined" into the surface waters. When the function is to impound water, the pH of the surface water may be lowered with a consecutive increase in tannic acid and iron content. Water temperature may be increased in the summer months. Use of the practice to convey water over, under, or along a ditch, canal, road, railroad, or other barriers will have little effect on the quality of surface or ground water. Use of the practice to modify water flow to provide habitat for fish, wildlife, and other aquatic animals may increase the dissolved oxygen content of the stream, and may lower the water temperature.
Irrigation system, trailwater recovery (447)	The reservoir will trap sediment and sediment attached substances from runoff waters. Sediment and chemical will accumulate in the collection facility entrapping would decrease downstream yields of these substances. Salts, soluble nutrients, and soluble pesticides will be collected with the runoff and will not be released to surface waters. Recovered irrigation water with high salt and/or metal content will ultimately

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Table 2-18 (Continued)

Practice	Water Quality Statement
	have to be disposed in an environmentally safe manner and location. Disposal of these waters should be part of the overall management plan. Although some ground water recharge may occur, little if any pollution hazard is expected.
Filter strip (393)	Filter strips for sediment and related pollutants meeting minimum requirements may trap the coarser grained sediment. They may not filter out soluble or suspended fine-grained materials. When a storm caused runoff in excess of the design runoff, the filter may be flooded and may cause large loads of pollutants to be released to the surface water. This type of filter requires high maintenance and has a relative short service life and is effective only as long as the flow through the filter is shallow sheet flow. Filter strip for runoff form concentrated livestock areas may trap organic material, solids, materials which become adsorbed to the vegetation or the soil within the filter. Often they will not filter out soluble materials. This type of filter is often wet and is difficult to maintain. Filter strips for controlled overland flow treatment of liquid wastes may effectively filter out pollutants. The filter must be properly managed and maintained, including the proper resting time. Filter strips on forest land may trap coarse sediment, timbering debris, and other deleterious material being transported by runoff. This may improve the quality of surface water and has little effect on soluble material in runoff or on the quality of ground water. All types of filters may reduce erosion on the area on which they are constructed.

Table 2-18 (Continued)

Practice	Water Quality Statement
	Filter strips trap solids from the runoff flowing in sheet flow through the filter. Coarse-grained and fibrous materials are filtered more efficiently than fine-grained and soluble substances. Filter strips work for design conditions, but when flooded or overloaded they may release a slug load of pollutants into the surface water.
Well (642)	When water is obtained it has poor quality because of dissolved substances, its use in the surface environment or its discharge to downstream water courses the surface water will be degraded. The location of the well must consider the natural water quality and the hazards of its use in the potential contamination of the environment. Hazard exists during well development and its operation and maintenance to prevent aquifer quality damage from the pollutants through the well itself by back flushing, or accident, or flow down the annual spacing between the well casing and the bore hole.

SOURCE: USDA, SCS, 1988.

Table 2-19. Summary of Costs for Selected Irrigation Management Practices

System Number and Name (Systems are combinations of SCS practices - see Appendix 2-A)	Total Cost Per Ton of Soil Saved (1990, amortized $)
WC4 Irrigation Water Conservation	3.65
SP35 Water Management systems for Pollution Control	0.46

SOURCE: USDA, Agricultural Stabilization and Conservation Service, 1991.

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7. **Planning Considerations for Irrigation Water Management**

During the development and implementation of this management measure for irrigation, the following water quality effects and impacts should be considered.

(1) Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

(2) Effects on the movement of dissolved substances below the root zone or to ground water.

(3) Short-term and construction related effects on the quality of downstream water courses.

(4) Potential of uncovering or redistributing toxic materials such as saline soil.

(5) Effects of water management on the salinity of soils, soil water, or aquifers.

(6) Potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers.

(7) Effects of soil water levels on such nutrient processes as nitrification and denitrification.

(8) Effects on the temperatures of downstream waters that could prevent undesirable effects on aquatic and wildlife communities.

(9) Effects of installing the lining on the erosion of the earth conveyance and the movement of sediment and soluble and sediment-attached substances carried by water.

(10) Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.

(11) Effects on the nutrient budget within the filter strip as related to removal, residence, or accumulation of nutrients. Nutrient budgets should account for effects of growing and decaying vegetation.

(12) Filtering effects of vegetation on movement of sediment, pathogens, organic loads, and dissolved and sediment-attached substances.

(13) Effects of the filter strip vegetation's uptake of nutrients on surface and ground water.

(14) Effects of the timing of the vegetation's management, including clipping, harvesting, removal and re-establishment on the nutrient balance within the filter strip.

(15) Effects on the visual quality of on-site and downstream water resources.

(16) Effects on wetlands or water-related wildlife habitats.

VI. MANAGEMENT PRACTICE TRACKING

Tracking of the installation of agricultural management measures and systems of management measures is critical to knowing how well a program is working. It is also important to know where and by whom a management measure is installed, when it was certified, and how long it should stay in place. This will allow program managers to go back to a farm or field and re-certify that the management measure or practice is still there and operating according to design.

Such tracking systems may be used and/or developed to track initial installation of management measures and to provide a system to check on them at specific time intervals in the future. The funding agency for a particular management practice should know when and where a management measure or practice is installed and should certify it for payment, as appropriate. This should be the first check needed. For later re-certification, field evaluations will be needed to re-certify a practice. The funding agency may decide that it is most practical for county conservation districts to fulfill the role of checking and re-certifying management measures and practices.

VII. SOURCES OF ASSISTANCE TO IMPLEMENT MANAGEMENT MEASURES

This section is to be developed in a later draft. Following is a preliminary draft outline for this section:

A. Federal

1. USDA

- SCS, ES, ASCS, etc.
- Agricultural Conservation Program
- Hydrologic Unit Projects
- Demonstration Projects
- PL 566 Projects
- Conservation Reserve Program
- New Farm Bill programs (Water Quality Incentive Program, etc.)

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2. **EPA**

- Section 319, Nonpoint Source Program
- Section 320, National Estuary Program
  Section 117, Chesapeake Bay Program
- Section 314, Clean Lakes Program
- Wellhead Protection Program
- Nitrogen Action Plan

B. **State/Local**

- State/Local NPS Programs
- State Revolving Funds
- State/Local Land Use Control Programs
- Conservation Districts

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APPENDIX 2-A
Practice Names and Codes Used by USDA-ASCS
(USDA, Agricultural Stabilization and Conservation Service, 1989)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
SL 1	Permanent vegetative cover establishment	
	Conservation tillage	329
	Pasture and hayland Planting	512
	Range seeding	550
	Cover and green manure crop (orchard and vineyards only)	340
	Field borders	386
	Filter strips	393
SL 2	Permanent vegetative cover improvement	
	Conservation tillage	329
	Pasture and hayland management	510
	Pasture and hayland Planting	512
	Fencing	382
	Range seeding	550
	Deferred grazing	352
	Firebreak	394
	Brush management	314
SL 3	Stripcropping System	
	Divided slopes	363
	Obstruction removal	500
	Stripcropping, contour.	585
	Stripcropping, field	586
	Stripcropping, wind	589
	Subsurface drain	606
SL 4	Terrace system	
	Critical area planting	342
	Grade stabilization structure	410

Appendix 2-A (Continued)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
	Grassed waterway	412
	Lined waterway outlet	468
	Obstruction removal	500
	Terrace	600
	Subsurface drain	606
	Underground outlet	620
	Vertical drain	630
	Water and sediment crt. basin	638
SL 5	Diversions	
	Critical area planting	342
	Dike	356
	Diversion	362
	Grassed waterway	412
	Lined waterway outlet	468
	Obstruction removal	500
	Pipeline	516
	Subsurface drain	606
	Underground outlet	620
	Vertical drain	630
SL 7	Windbreak restoration or establishment	
	Fencing	382
	Field windbreak	392
	Well	642
	Windbreak renovation	650
	Irrigation system	
	Trickle (drip)	441
	Sprinkler	442
	Surface or subsurface	443
SL 8	Cropland protection cover	
	Cover and green manure crop	340

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Appendix 2-A (Continued)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
SL 11	Permanent vegetative cover on critical areas	
	Cover and green manure crop	340
	Critical area planting	342
	Fencing	382
	Field borders	386
	Filter strip	393
	Forest land erosion control system	408
	Mulching	484
	Streambank and shoreline protection	580
	Tree planting	612
SL 13	Contour farming	
	Contour farming	330
	Obstruction removal	500
	Subsurface drain	606
SL 14	Reduced tillage system	
	Conservation tillage	329
	Stubble mulching	588
SL 15	No-till system	
	Conservation tillage	329
	Stubble mulching	588
SP 35	Water management system for pollution control	

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Appendix 2-A (Continued)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
	Grass and legumes in rotation	411
	Underground outlets	620
	Land smoothing	466
	Structure for water control	587
	Subsurface drain	606
	Surface drainage-field ditch	607
	Surface drainage-main or lateral	608
	Toxic salt reduction	610
WC 4	Irrigation water conservation	
	Critical area planting	342
	Irrigation canal or lateral	320
	Structure for water control	587
	Irrigation field ditch	388
	Sediment basin	350
	Grassed waterway or outlet	412
	Irrigation land leveling	464
	Irrigation water conveyance ditch and canal lining	428
	Irrigation water conveyance pipeline	430
	Irrigation system, trickle (drip)	441
	Irrigation system, sprinkler	442
	Irrigation system, surface or subsurface	443
	Irrigation system, tailwater recovery	447
	Land smoothing	466
	Irrigation pit or regulation reservoir	552
	Subsurface drainage (for salinity only)	607
	Toxic salt reduction	610

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Appendix 2-A (Continued)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
WL 1	Permanent wildlife habitat	
	Fencing	382
	Wildlife upland habitat management	645
WP 1	Sediment retention, erosion or water control structures	
	Critical area planting	342
	Dam, diversion	348
	Dam, multiple purpose	349
	Sediment basin	350
	Diversion	362
	Fencing	382
	Dam, floodwater retention	402
	Grade stabilization structure	410
	Grassed waterway	412
	Lined waterway outlet	468
	Mulching	484
	Pond sealing or lining	521
	Structure for water control	587
	Subsurface drain	606
	Underground outlet	620
	Vertical drain	630
	Water and sediment control basin	638
WP 2	Stream protection	
	Filter strip	393
	Channel vegetation	322
	Fencing	382
	Pipeline	516
	Streambank and shoreline protection	580

Appendix 2-A (Continued)

ASCS PRACTICE CODE	DESCRIPTION TITLE	TECHNICAL PRACTICE CODE
	Field border	386
	Tree planting	612
	Trough or tank	614
	Stock trails or walkways	575
WP 3	Sod waterways	
	Critical area planting	342
	Grassed waterway	412
	Lined waterway outlet	468
	Mulching	484
	Structure for water control	587
	Subsurface drain	606
	Underground outlet	620
	Vertical drain	630

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CHAPTER 3. FORESTRY MANAGEMENT MEASURES

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CHAPTER 3

FORESTRY MANAGEMENT MEASURES

I. TYPES OF NPS PROBLEMS FROM FORESTRY ACTIVITIES

The potential for forestry related activities to cause water pollution has long been recognized. Water quality concerns for forestry were addressed in the 1972 Clean Water Act and later more comprehensively under Sections 208 and 319 as nonpoint sources. The types of problems related to Forestry activities include generation of sediment from roads and landslides, loss of shade from stream canopy removal, woody debris jams from poorly managed logging slash, increased channel erosion and increased stream bedload sediments. In some areas this has resulted in:

- Suspended and bedload sediments
- Turbidity
- Woody material accumulations on bottoms
- Temperature increases, including potential temperature induced effects to the development of salmonid smolts and changes in aquatic communities
- Loss of important stream structural habitat provided by large woody debris from fallen trees, especially conifers. In smaller streams these obstructions perform many important functions including: pool formation, cover, habitat complexity, nutrient and energy retention, stream bank and bed stability, and bed sediment storage.
- Concentration and channelization of flows entering wetlands from road drainage systems and drainage of wetlands due to mechanical site preparation.
- Loss of chum, humpback, pink, chinook, atlantic, and coho salmon, steelhead and sea-run cutthroat trout (salmonids), smelt, and other anadromous fish species.
- Nutrient accumulations from forest fertilizer mis-applications or spills.
- Toxic pollutant accumulations from mis-applications of pesticides or spills.

II. APPROACHES TO THE USE OF MANAGEMENT MEASURES

If management measures are needed to prevent or correct the problems listed, then they should be comprehensively designed to prevent or address the causes of the problems. Often this means a site specific design to best achieve effectiveness. In some cases it may mean a prohibition of

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activity in certain especially sensitive areas to ensure prevention of impairment. For example, some harvesting practices may need to be avoided on steep slopes or the amounts of pesticide or herbicide applied may be reduced in order to prevent pollution. It should focus on the pathways and causes of the NPS pollution to be an effective control.

There may be a number of Management Measures approaches to a certain problem. States should remain flexible to work with operators and other agencies to find feasible solutions to water quality and habitat problems which achieve equivalent NPS control levels specified in this guidance.

III. PRESENT STATE FORESTRY NPS PROGRAMS

All states with important forestry activities have identified Best Management Practices (BMP's) to control silviculturally (forestry activities) related nonpoint source (NPS) water quality problems. Often the water quality problems which are presently occurring are not due to the ineffectiveness of the practices themselves, but of the failure to implement them appropriately.

There are two basic types of state forestry NPS programs. One is a voluntary program relying upon a set of Best Management Practices as guidelines to operators. Sometimes BMP's can be applied in the normal course of forest harvest operations with few significant added costs. Operator education and technology transfer is a primary activity of the state departments of forestry. Workshops, brochures, field tours are continually held to educate and demonstrate to operators the latest water quality management techniques. Landowners hiring operators are often encouraged to require operators who have attended state sponsored workshops or to stipulate in contracts that the state forestry BMP's must be applied.

The other type of state forestry program is a set of Forest Practice Rules and Regulations based on a State Forest Practices Act or local government regulations. These Rules and Regulations may closely resemble the sets of BMP guidelines described previously, but have requirements which are enforceable. Often streams are classified based upon importance for municipal water supply or propagation of aquatic life as the most sensitive designated use. Protective requirements of various kinds for shade, large woody debris recruitment, bank stability, and others are often stipulated for streamside zones, riparian areas, filter, or buffer strips. Harvest plans of operations or applications to perform a timber harvest are frequently required for review by the State Department of Forestry and other state agencies.

Present state Coastal Zone Management (CZM) programs may already include specific regulations or BMP guidelines for forestry activities. In some states, CZM programs have adopted by reference, or as part of a networked program, the state forestry regulations or BMPs.

IV. FEDERAL LAND MANAGEMENT AGENCIES

Federal land management agencies engaged in forestry activities such as the USDA Forest Service and the USDI Bureau of Land Management are to meet all federal, state, interstate, and local requirements to the same extent as any nongovernmental entity. Similarly, the revised CZMA Act requires federal agencies to comply with state Coastal Zone NPS Management Plans to protect coastal water quality and habitat.

The USFS and BLM in nearly all of the states where agency lands are situated have developed Memoranda of Understanding (MOU) with the water quality agencies to develop and use BMP's which meet or exceed the state BMP'S and Forest Practice Rules. Many of these MOU's have been recently updated to become a part of states' 319 NPS Management Programs. In most cases these agencies have become a Designated Management Agency (DMA) under authority in Section 208 of the Clean Water Act. The DMA authority requires the agency to develop its own Water Quality Program which must be approved by the State. The agency then is delegated responsibility to manage the waters under its jurisdictions according to state law meeting water quality standards and other state requirements. Often there is an action plan required by the state, and agency progress is evaluated on an annual basis. State enforcement of the MOU and DMA programs varies among states. A few states require the agencies to provide annual monitoring reports and annual monitoring plans.

V. LOCAL GOVERNMENTS

Counties, municipalities, and local soil and water conservation management districts may also impose additional requirements on landowners and operators conducting forestry activities. In urban settings this often relates to the conversion of forested lands to urban uses, primarily for residential and business developments. Developers are not always familiar with forestry activity BMP'S or state forest practice rules and regulations. In some cases, the potential for speculative investing leads to major land development which may overwhelm a small government agencies ability to monitor and manage these types of forestry activities.

In rural areas additional requirements for forestry activities may be made by soil and water conservation districts. These requirements primarily apply to small non-industrial forest owners who manage small woodlots. Collectively, non-industrial forest owners control a majority of the productive timber lands in the eastern U.S. and sizeable acreages in some western states. The major industrial privately owned timber lands are located in the Southeast and Northwest parts of the U.S.

VI. MANAGEMENT MEASURES

A. MM No. 1 Identification and Designation of Streamside Special Management Areas

1. Components and Specifications

The objective of this MM is to protect water quality and aquatic habitat and prevent the occurrence of adverse impacts from logging, roadbuilding, and other land disturbing management activities. Streamside Special Management Areas are the areas immediately neighboring streams or waterbodies, which greatly influence water quality and aquatic habitats. These areas function in the following ways:

(1) Filters sediments from waters flowing across the surface toward waterbodies,

(2) Provides a renewable source of large woody debris for cover for fishes and other aquatic organisms, hydraulic control features to dissipate flow energy and develop pools, and bed and bank structure to improve stream channel stability. This large woody debris also provides hydraulic control features to dissipate flow energy and develop pools, and bed and bank structure to improve stream channel stability,

(3) Provide important water surface shading to moderate stream temperature during extreme weather conditions in the summer and winter,

(4) Provide hydraulic roughness on banks and within stream channels to attenuate flood flows, thereby reducing the extreme nature of high flow events

(5) Provide a source of energy and nutrients (litter and leaves) for small tributary streams supporting efficiently functioning aquatic communities.

The identification and designation of streamside areas is needed to determine the extent and distribution of highly valued and sensitive riparian resources. The boundaries of these areas are determined by the minimum distance needed to provide protection to the water quality and habitat functions. Distances needed may vary depending on soil type, slope and riparian cover. Some States and forest management agencies and companies have set minimum distances to protect water quality and ecosystem function. Additional distance is required if there is reasonable risk of pollution or loss of the functions described above.

Use of existing resource inventories, water quality data, stream classifications, state water quality designations, topographic maps, aerial photos, and best professional judgment of the harvest sale planner and resource specialists are needed to define the boundaries of the streamside special management area. Any activities planned within the area must not degrade water quality or habitat value. Most states have identified streamside management zone widths in BMP guidelines or State regulations.

Boundaries of this area must be clearly identified to avoid any misunderstanding by the forestry operator. This will prevent the inadvertent continuation of forestry activities which are occurring outside of the streamside special management area which would impair the water quality and habitat values if conducted in the SSMA. The designation of this area must accomplish the following:

(1) Reduce delivery of forestry activity created sediments from upland or adjacent areas to the waterbody being protected except during storm events with

recurrence intervals greater than 10 years estimated using standard procedures and appropriate storm durations for the local climatic conditions.

(2) Provide a source of large woody debris within the Streamside Special Management Area to the stream at a rate that is equivalent to natural rates of supply over a time period that is the average lifespan of the tree species in the stand.

(3) Provides shading to the stream water surface which is equivalent to natural levels for the potential natural vegetation present. If the existing shading condition prior to activity is less than the natural levels for the potential natural vegetation present, then there should be no reductions of shading caused by proposed activities.

(4) Provide sufficient width to withstand wind damage or blowdown.

2. <u>Effectiveness</u>

The effectiveness of SSMA identification to prevent impacts to streamside areas is 75-85%. This rate of effectiveness is limited by runoff from roads which drains directly to the stream network. Errors in marking and identification of the appropriate boundary occur. Temporary boundary markers occasionally are removed or become lost permitting accidental incursions into the special management with higher disturbance levels. In the west landslides may deliver large quantities of sediments from upslope roads or harvest units across the SSMA.

3. <u>Costs</u>

The net cost for the establishment of streamside management zones may include the costs of layout and marking of the zone. It may also include any additional costs from special harvesting techniques which are used to extract merchantable timber from the streamside management zone. However, these extra harvesting costs are generally offset by the value of the harvested stumpage. It is possible that merchantable timber which is not harvested from the streamside zone due to percent removal restrictions or other management considerations, may be considered an indirect cost of the SMZ. If there is existing vegetation on the site direct cost of implementing this management measure will be limited.

For situations where existing vegetation is not present, cost estimates for control of erosion and sediment transport from forestry activities in streamside areas have been summarized by the USDA Agricultural Stabilization and Conservation Service (ASCS). For streamside management zones the ASCS Stream Protection Practice (WP2) the average cost to install was about $130.00 per mile.

In the State of Virginia Best Management Practices Handbook for forestry, forest filter strips were estimated to have no direct costs if preserving existing vegetation. If the management

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measure requires the planting of a filter strip on a disturbed area the costs estimated to be the same as for revegetation.

The following example costs for activities related to the establishment of streamside special management zones are USDA Forest Service estimates from the Pacific Northwest:

Activities	Costs
Streamside prescription	$250/mile
Boundary marking	$200/mile
Indirect or Foregone Opportunity Cost of Merchantable stumpage not harvested	

10 MBF/ac @ $100/MBF = $1000/acre
20 MBF/ac @ $150/MBF = $3000/acre
50 MBF/ac @ $200/MBF = $10000/acre

B. MM No. 2 Identification and Designation of Wetland Special Management Areas

1. Components and Specifications

The objective in designating boundaries for Wetland Special Management Areas (WSMA) is to maintain wetland functions and values and to prevent adverse impacts to water quality and habitat in wetland areas from logging.

Wetlands are important in providing moderating influences for water quality and habitats in coastal areas. Wetland ecosystems are commonly key components to a healthy coastal environment. The CWA protects the chemical, physical and biological integrity of wetlands as waters of the United States. Management activities in these areas must not degrade or adversely affect the functions and values of these ecosystems. Effects to the hydrologic conditions in wetlands are commonly the most permanently destructive to the ecosystems. Vegetation communities may also be adversely affected by the introduction of exotic plants or selective removal of key component species.

The boundaries of these WSMAs are determined by the minimum distance needed to provide protection to the water quality and habitat. Additional distance is required if there is reasonable risk of impairment or loss of the functions described above.

Information from resource inventories, topographic maps, aerial photos, and soil surveys and the Federal Manual for Identifying and Delineating Jurisdictional Wetlands will be useful to identify areas needing protection as WSMAs. Planning must identify the areas where operation of heavy equipment may not be appropriate. Flowing wetlands connected to riverine systems should be distinguished from isolated wetlands, because these ecosystems function differently.

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Forestry access must be designed to avoid wetland areas and minimize road construction across wetlands. Where roads must be constructed across wetlands flow passages should be planned to prevent disturbances and hydrologic differences between the two sides of the road. Driest seasons should be used to access and harvest these areas.

Boundaries of Wetland Special Management Areas must be clearly identified to prevent misunderstanding by the forestry operator about the location and extent of the WSMA. In many cases this will require on site boundary marking with flagging, paint, or signs where the WSMA adjoins an area with planned forestry activities. The designation and planning of activities in the WSMA'S must provide a level of protection that:

(1) Prevents ground disturbing activities which would cause wetland areas to drain during wet periods or clearly cause a disruption of the hydrologic conditions of the wetland.

(2) Prevents delivery of human activity created sediments from the areas outside of the area to the wetland being protected except during storm events with recurrence intervals estimated using standard procedures to be greater than 10 years.

(3) Prevents loss of sensitive aquatic habitat conditions which otherwise would occur without the designation of the Wetland Special Management Area.

2. <u>Effectiveness</u>

The effectiveness of wetland boundary identification to prevent impacts to wetlands is 75-85%. This rate of effectiveness is limited by runoff from roads which drains directly to wetlands or to the stream network upstream. Errors in marking and identification of the appropriate boundary occur. Boundary markers occasionally are removed or become lost permitting accidental incursions into the special management area with higher disturbance levels.

3. <u>Costs</u>

The net cost for the establishment of wetland special management zones may include the costs of layout and marking of the zone. The following example costs for activities related to the establishment of streamside special management zones are USDA Forest Service estimates from the Pacific Northwest:

Activities	Costs
Wetland prescription	$250/mile
Boundary marking	$200/mile

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C. MM No. 3 Transportation System Planning and Design

1. Components and Specifications

The objective of this MM is to locate and design roads with minimal sediment delivery potential to streams and coastal areas. Roads have been shown consistently to be the largest cause of sedimentation resulting from forestry activities. Good location and design of roads can greatly reduce sources and transport of sediment materials.

Important sediment sources are associated with stream crossings, fills on slopes greater than 60 percent, poorly designed road drainage structures, and road locations close to streams. In the west the largest sources of sediment are often associated with landslides. Certain rock types and geomorphic conditions are conducive to the risk of landslides. Such areas can be identified and avoided. In other areas inadequate cross drainage and poor location are the greatest sources of sediment to waterbodies.

a. Location

Location of roads on ridges versus natural drainages is an important way to distance, and thereby prevent, the effects of surface erosion of road surfaces, cut, and fills from streams. Roads must not be located along stream channels where the road fill extends within 25 horizontal feet of the average annual high water level, except for crossings. Existing roads in poor locations must be relocated when the road is to be reconstructed. Roads on gentle slopes drain more freely than roads on flat areas. Roads on steep terrain should avoid use of switchbacks through more favorable locations. "Stacking" of roads above one another should be avoided by the use of longer span cable harvest techniques.

b. Drainage crossings

Sizing of bridges and large culverts for major drainage crossings must be designed based upon reliably tested regionalized methods for permanent well trafficked roads. Appropriate equipment and materials must be planned for installation of the drainage crossing structures. Crossings should be designed to cross drainages at 90° to the flow to minimize effects to the channel and flow capacity through the structure. Designs must provide suitable measures to facilitate fish passage when fish-bearing streams are crossed. This is especially important in the west for streams with anadromous fish.

Structures for permanent road crossings should be adequately designed to avoid failure as follows:

(1) Small culverts should be designed to pass the 25 year recurrence interval discharge without entrance head above the top of the structure

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(2) Major culverts and small bridges should pass the 50 year recurrence interval discharge without head above the top of the structure and

(3) Major bridges should pass the 100 year recurrence interval discharge without head above the structure.

(4) Additional capacity must be provided when debris loading above the structure would potentially become lodged in the structure opening and reduce its capacity.

Use of fords should be limited to extreme situations where use of bridges and culverts is not feasible. Fords should be located where streambeds are stable having bedrock or a concrete apron carefully installed. Springs flowing continuously for more than 1 month must have drainage structures, rather than allowing use of road ditches to carry the flow to a drainage culvert.

c. Road prism

Design of the road prism must be appropriate to the terrain where the road is located. Alignments that roll with the terrain cause less slope disturbance than strongly controlled sections with sustained grades and alignments. Balanced construction of the road cross-section must be limited to reasonable sideslopes. Sideslopes greater than 60 percent requires full-bench construction and removal of the excavated road cut material to a suitable disposal area. Surface design as crowned, insloped, or outsloped must be consistent with the road drainage structures.

d. Road drainage

Careful design of the surface drainage to match natural sideslope drainage swales and appropriate spacings must occur. Inlet and outlet structures for culverts must be planned to avoid sedimentation where erosion of ditches and fills occurs. Road dips must be designed to drain freely without eroding the road surface. Roads in flat areas should have elevated roadbeds to avoid development of mudholes (this practice may not be appropriate in flat areas with periodic surface flows.

e. Surfacing

Roads planned for all-weather use must be surfaced with suitable materials unless native surfaces support truck traffic without becoming rutted or eroding. Planning for rock quarry locations must include a quarry development and rehabilitation plan.

f. Landslides

Use of available geologic information, soil maps, topographic maps, aerial photos, local experience, and technical consultation with a geologist, a geotechnical engineer or a qualified specialist must be made when landslide prone areas are known to exist in the planned area to be accessed. Landslide prone areas should be avoided even if alternative routes are longer or more costly to construct. If there are no alternative routes and landslide prone areas must be crossed, specialized construction techniques will be planned to prevent landsliding. Sufficient testing of the bearing materials, piezometric surface of shallow groundwater during storm events, and other site specific investigative techniques must be used to appropriately design slope drains, locations of bin walls, use of geotextile materials, riprap, and other specialized techniques to prevent landslides.

g. Water sources

Locations of water sources used to wet and compact road beds and surfacing must be preplanned. The water source development and water tank-truck access must be planned to minimize sedimentation and protect the natural water source. Road fills at drainage crossings must not be used as water impoundments unless they have been suitably designed as an earthfill dam. Such earthfill embankments must have outlet controls to allow draining prior to runoff periods.

h. Muskegs

Roads crossing muskegs (high water table areas in northern climates typified by humus and acid waters) must use overlay construction techniques with suitable non-hazardous materials. Cross drains must be provided to allow free drainage especially in sloping areas.

The following are specifications for this MM:

(1) Location: The locations of new roads must not encroach on streams, fills must not be located within 25 horizontal feet of the annual high water level. Construction of new switchback roads must not occur near streams. There must not be planned construction of a streamside road when there is an existing road on the opposite side of the drainage, unless the existing road is being replaced and will be obliterated.

(2) Drainage crossings: Must meet the design levels described above. Must be designed to allow fish passage in fish-bearing streams. Fish passage specifications should be designed for the fish species present.

(3) Road prism: Sideslopes greater than 60 percent for new construction require full bench construction and removal of fill material to a suitable location. Planning of the road surface prism must match the road surface drainage system.

(4) Road drainage: Spacing of drainage structures must match terrain and be appropriate to endure the 25 year precipitation recurrence interval for a storm duration appropriate to the area without rilling, gullying or loss of drainage structures.

(5) Surfacing: Appropriate sized aggregate, percent fines, and suitable particle hardness must protect the surface from rutting and eroding under heavy truck traffic during wet periods of operation. Ditch runoff should not be visibly turbid during these conditions. Aggregate must not contain high sulfide ores that would produce acid drainage or be contaminated with hazardous materials.

(6) Landslides: Designs must prevent the occurrence of landslides for storms with a precipitation recurrence interval of 100 years or less for an appropriate design storm duration typically causing flooding in the area being considered.

(7) Water sources: Planned water source developments to be used to wet and compact roadbeds and surfaces should not impact channel banks and streambeds of the watercourses being used for this purpose. Access roads to water sources should not provide sediment to the water source.

(8) Muskeg roads: Roads must not pond water on the upslope side of the road. Overlay materials cannot include hazardous materials.

2. Effectiveness

The effectiveness of this MM to prevent sedimentation is 85-90 percent. Careful planning is the most effective aspect of road management. The variation in effectiveness is due to the differing complexity of terrain. Landslide prone areas present a difficult challenge for road planners. Vertical relief, slope steepness are other factors influencing design effectiveness. Available funding to allow certain expensive structural designs may be lacking. Design tools and techniques are continually improving. Models for predicting unstable slope conditions are presently available, if data can be collected.

3. Costs

Activities	Costs
Planning	Add 25%

D. MM No. 4 Transportation System Construction/Re-construction

1. Components and Specifications

The objective of this MM is to minimize erosion and sedimentation during road construction/reconstruction projects. The disturbance of soil and rock during road construction/reconstruction creates a significant potential for erosion and sedimentation of nearby streams and coastal waters. Road construction includes: (1) the clearing phase to remove trees and woody vegetation from the road right-of-way, (2) the pioneering phase, where the slope is excavated and filled to establish the road centerline and approximate grade, (3) the construction

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phase, where final grade and road prism design specifications are made, bridges, culverts and road drainage structures are installed, and (4) the surfacing phase when the road bed is placed, compacted; road fills are compacted, and the lifts of gravel surfacing and pavement (if planned) is placed and compacted.

Slash materials from right-of-way clearing should not be left in streams. This material is often useful if placed as windrows along the base of the fill slope. This operation is efficiently handled by an excavator or "big hoe". This same piece of equipment is often used in the pioneering and road construction phases. Right of way material that is merchantable is often utilized by the operator.

Pioneering earthwork activities should not be allowed to proceed more than .5 miles from the finished road surface. During rainy seasons this distance should be reduced due to the necessity for shutdown if wet conditions develop. Crossing of flowing streams during the pioneering operation should be minimized. Operation within streams during seasons when spawning and where salmonid eggs are incubating must not occur. Careful planning of equipment operation is necessary to minimize the movement of excavated material downslope as unintentional sidecast. Disposal sites identified in the planning phase must be used.

Construction of bridges and culverts must be conducted carefully. The construction should occur during low flow conditions. Equipment operation within the streambed must be minimized. Construction of piers, footing, abutments, wingwalls, and other structures within the normally wetted portion of the stream will require measures to redirect flows within the channel area and contain turbid waters in settling basins. Care must be taken to minimize sedimentation.

Construction of cuts, fills, and the roadway must be done according to planning and design specifications. Care must be used to contain materials and minimize loss of excavated material downslope. Culverts and ditches must be properly bedded, and placed according to appropriate procedures. Inlet and outlet structures must be installed properly.

Compaction of the road base at the proper moisture content, surfacing, and grading is accomplished to give the designed rcad surface drainage shaping. Surface drainage waterbars, open-top culverts, or slit-troughs are installed to prevent rilling and intercept rut drainage which may develop.

Use of straw bales, straw mulch, grass-seeding, hydromulch, and other erosion control and re-vegetation techniques complete the construction project. Freshly disturbed soils will need protection until vegetation is established. Construction and Reconstruction activities must be managed to minimize impacts to streams and coastal areas as follows:

(1) Slash material must not be left in watercourses. It must be removed before the appropriate equipment to retrieve it leaves the area.

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(2) Excess fill material must be carefully managed and not permitted to slough downslope beyond reach of construction equipment.

(3) Bridges, culverts, and other stream crossing structure installations must be conducted to minimize production of sediment. Turbid waters must be contained and diverted to settling basins or flat areas before discharge to the stream. Equipment should not operate within the streambed, but should be limited to making the minimum number of crossings for access to the site.

(4) Installation of road drainage culverts and structures must be made according to planned and designed specifications. Road surfacing and shaping must follow designs.

(5) Mulching and revegetation must be done as quickly as possible to protect disturbed soils from excessive erosion such as rilling and gullying.

2. Effectiveness

This MM has an effectiveness range of 65-80 percent to prevent entry of sediment into area waterbodies. The reason that complete prevention of sedimentation does not occur is the fine particles that are eroded from freshly exposed soils. Studies show that 80 percent of erosion on studied roads occurred during the first 3 years following construction. A certain amount of fillslope material sloughs downslope and finally, the road drainage systems acts as a new stream network on the landscape which must establish an equilibrium with its bed. The variation in effectiveness is due to slope steepness, rock type and soils, climate, landslide sensitivity, runoff events during the first 3-year period, execution error, and unanticipated springs, supplying additional runoff and erosion.

3. Costs

The cost of implementing erosion control practices for forest land management access roads has been estimated to be $11.00 per mile based on national summaries provided by the USDA Agricultural Stabilization and Conservation Service (ASCS). In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for the construction of woodland access roads and skid trails:

Activities	Costs
Construction of Access Roads:	$160.00/100 feet
Land clearing and earthwork	
Culverts	
Bridges	
Drainage Dips	
Water Bars	$4.75 each

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Surface Materials	
Seed	$4.75/100 feet
Mulching	$160.00/acre
Construction of Skid Trails (Water Bars) (Drainage Dips)	$40.00/100 feet

The following example percentages for activities related to the construction of forest roads are based on USDA Forest Service estimates from the Pacific Northwest:

Activities	Costs
Clearing phase	Add 5%
Pioneering phase	Add 30%
Construction phase	Add 30%
Surfacing phase	Add 50%

E. MM No. 5 Road Management

1. Components and Specifications

Landowners with roads must manage those roads to prevent sedimentation and pollution from transported materials. Roads that are actively eroding and providing sediment to waterbodies, whether in use or not, must be treated to prevent erosion. Major sources such as landslides must be prevented by maintenance or removal of drainage crossings such as bridges, culverts, and fords as well as road surface drainage structures such as ditches, culverts, dips, waterbars, etc. Large deposits of sediment due to sloughing or road related landsliding must be stabilized to the greatest degree practicable to reduce sedimentation.

If roads are no longer needed, an effective treatment is to remove drainage crossings and culverts if there is a risk of plugging or failure from lack of maintenance. In other cases it is economically more viable to periodically maintain the crossing and drainage structures. Roads subject to rutting must either be maintained to properly drain without excess sediment or be blocked from traffic. While road maintenance is an expensive proposition, it is far cheaper than repair after failure or decades of fish population losses. For some unstable sections, the only effective treatment is excavation and haul of the road section or expensive geotechnical solutions such as groundwater drainage, grouting, or support by pilings.

2. Effectiveness

The effectiveness of this MM is 75-90% due to the periodic nature of road maintenance activities, especially for older roads not in use. The effectiveness varies with the landslide sensitivity, slope steepness, rock type and soils, runoff events, and overall condition of the road system.

3. Costs

In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for the management and maintenance of forest roads and skid trails:

Activities	Costs
Road Maintenance	
Cleaning Culverts	$3.25/100 feet
Filling Ruts and Grading	$3.25/100 feet
Retirement of Roads	$8.00/100 feet
Filling Ruts and Grading	$3.25/100 feet
Bedding with Brush	$2.00/100 feet
Water Bars	$4.75/each
Seeding	$4.75/100 feet
Retirement of Skid Trails	$ .80/100 feet
Bedding with Brush	$2.00/100 feet
Water Bars	$4.75/each
Seeding	$4.75/100 feet
Mulching	$160.00/acre

The following example costs for activities related to the construction of forest roads are based on USDA Forest Service estimates from the Pacific Northwest:

Activities	Costs
Routine maintenance of drainage	$200-600/mile structures
Routine maintenance of the road surface	
native surface	$200-$1200/mile
gravel	$200-$600/mile
Road barriers	$300-5,000 each
Replacement of drainage culverts	$30-50,000/mile
Replacement of drainage crossings	
culverts	$5-500,000 each
bridges	$.1-5.0 million
Excavation of unstable road section	$.1-1.0 million
Underground drainage, piles	$.2-1.0 million

F. MM No. 6 Timber Harvest Planning

1. Components and Specifications

Timber harvest is usually selected for areas with merchantible stands of timber that economically are viable. Selection of stands for harvest also is made based on silvicultural considerations for the regeneration or future condition of the stand. Such planning must also include provisions to identify unsuitable areas which may have merchantible trees, but pose risks for landslides. These concerns are greatest for steeply sloping areas in areas of high rainfall or snowpack in sensitive rock types. Decomposed granite, highly weathered sedimentary, fault zones in metamorphic rocks are potential rock-types of concern. Deep soils derived from these rocks, colluvial hollows, and fine textured clay soils often referred to as "blue goo" are soil conditions causing potential problems. Such areas usually have a history of landslides either naturally or related to earlier land disturbing activities. When risks of landslides are present, a technical specialist such as a geologist, soil scientist, hydrologist or geotechnical engineer should be consulted.

Studies have identified cumulative sedimentation effects from the incremental additions of small sediment volumes added together within a drainage basin. In some climatic zones often related to elevation and orientation to the prevailing winds, streamflow peaks may be increased from timber harvest at certain points in the drainage network. These peaks may cause adjustments in channel beds and banks with net sediment increases. In areas where the cumulative effects of timber harvest activities are affecting water quality and habitats, adjustments in planned harvest are necessary. This includes selection of harvest units with low risks of sedimentation, such as flat ridges or broad valleys, postponement of harvesting until erosion sources are stablilized, and selection of limited areas of harvest using existing roads.

Planning of the silvicultural system of harvest as even-aged (eg. clearcut, seedtree, shelterwood,) or un-evenaged (eg. group selection, or individual tree selection) and the type of yarding system must consider potential water quality and habitat impacts. At first, it may appear more beneficial to water quality to use un-even aged silvicultural stand management, because less ground disturbance and loss of canopy cover occurs. This may be misleading, because more acres must be treated to yield equivalent timber volumes which require more miles of road construction and/or re-construction. Roads have been shown repeatedly to produce the greatest volumes of sediment in forestry activities.

Additionally for moderately sloping areas, yarding of uneven-aged silvicultural systems is most often accomplished by ground-skidding equipment which disturbs soils several times more in total area than cable yarding systems. Cable yarding systems may be used in sloping areas for even-aged silvicultural systems. Whichever silvicultural system is selected will require planning to minimize erosion and sediment delivery to waterbodies. Harvested areas should be immediately replanted or regenerated to prevent further erosion and potential impact to waterbodies. The following are specifications for this MM:

(1) Planned harvest units will not add to problems of cumulative sedimentation effects.

(2) Selection of the silvicultural system will include consideration of potential water quality impacts from needed roads and skidding operations.

(3) Areas with identified risks of landslides by a qualified specialist, eg. geologist, soil scientist, geotechnical engineer, or hydrologist will not be harvested.

2. Effectiveness

This MM will provide a 85-100% effectiveness in preventing the entry of sediments into waterbodies. This variation is due to uncertainties in identifying landslide prone areas, the slope steepness, the uncertainty of assessing cumulative effects, and the runoff events.

3. Costs

Provide an additional 15 percent of planning time for water quality considerations in timber harvest planning.

G. MM No. 7 Landings and Groundskidding of Logs

1. Components and Specifications

Landings and skidtrails will be pre-planned to control erosion and delivery of sediments to watercourses. Locations are primarily determined in the field based upon the distribution of timber volumes designated for harvest. Generally, this pre-planning will take place when the harvesting unit is layed out as described in MM No. 6. The most economically efficient locations for landings and skidtrails will be adjusted to protect waterbodies from the delivery of sediments. Landings must be located outside of the Streamside or Wetland Special Management Areas.

Landings will be no larger than necessary to safely and efficiently store and load trucks. Drainage structures such as waterbars, culverts, and ditches will be constructed. Slope of the landing surface should be less than 5 percent and will be shaped to promote efficient drainage of runoff. Landing fills must not exceed 40 percent slope and must not have incorporated woody or organic materials. If landings are to be used during wet periods a suitable depth of gravel surfacing will be necessary to prevent rutting.

Groundskidding of logs will be limited to slopes less than 40 percent. For sensitive soils further limitation of activities on slopes is needed. During wet periods, groundskidding should be stopped when rutting and churning of the soil begins and when runoff from skidtrails is turbid and no longer infiltrates within a short distance from the skidtrail. Groundskidding on frozen soils or frozen snowpack should be conducted as a method to avoid disturbance of sensitive soils during winter logging. Winter logging may still lead to sedimentation if provisions for drainage during the spring thaw or break up are not made.

Skidtrails should also be pre-planned (again, this should be done prior to harvest - MM No. 6) to minimize disturbance and compaction of soils. In SSMAs felling of trees should be carried out with the large ends toward the skidtrails (felling to the lead) to minimize disturbance and yarding costs. Skidtrails will not be located within Streamside or Wetland Special Management Areas. Yarding of trees within these areas must be accomplished by endlining, use of winch and cable to each log turn. Unimproved skidtrails should not be located across flowing drainages. Improved crossings may be constructed as long as earth material does not enter waters and woody materials are removed immediately following skidding operations in the area. Skidtrails must not exceed 1200 feet in length. The pattern of skidtrails will disperse rather than concentrate runoff. Drainage waterbars will be constructed with appropriate spacing and locations to prevent rilling and gullying of the skidtrail and for areas receiving the drainage.

2. Effectiveness

Depending upon the sensitivity of the area considering factors such as percent slope, amount of area in skidtrails, volume of timber yarded, soils, climate, runoff events, proximity to streams, proper location and pre-planning of landings and skidtrails should provide 85-100 percent effectiveness in preventing sediment entry to watercourses immediately after harvest.

3. Costs

	Cost
Landings	
Pre-planning and drainage design	$80-100/landing
Construction drainage structures	$30-50/landing
Skidtrails	
Pre-planning	$20/mile
Construction, drainage structures	$40/mile

H. MM No. 8 Landings and Cable Yarding

1. Components and Specifications

Landings for cable yarding equipment will be carefully located and designed. Locations with risk of landslides identified by a qualified specialist (geologist, geotechnical engineer, soil scientist, or hydrologist) will not be used. Landings will not be located within Streamside or Wetland Special Management Areas or located over drainages.

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Landings will be no larger than necessary to operate yarding and loading equipment safely and efficiently. Drainage structures such as waterbars, culverts, and ditches will be constructed to efficiently control runoff. Slope of the landing surface will be less than 5 percent and will be carefully shaped for efficient drainage. Landing fills must not exceed 40 percent slope and must not incorporate woody and organic materials. Landing fills will not slough or fail into watercourses. If landings are to be used during wet periods, a suitable depth of gravel surfacing will be necessary to prevent rutting.

Landings will be located where slope profile data indicate favorable deflection conditions for the yarding equipment planned for use. Profiles must allow only minimal area of yarding corridor gouge or soil plowing. Such disturbed areas will be hand water-barred and covered with straw mulch if the continuous disturbance area is greater than 450 square feet.

High lead cable systems should be used on an average profile slope of less than 15 percent to avoid soil disturbance from side wash. Skyline cable systems are suitable for average profile slopes greater than 15 percent. Yarding corridors for Special Streamside Management Areas will meet Components and Specifications for these areas. Yarded logs will not make surface contact within the major channel banks of the watercourse of the SSMA. Yarding generated slash materials will be removed from watercourses by the end of the workday.

2. Effectiveness

Preplanning of landings and yarding corridors for cable yarding should provide a range of effectiveness of 70-100 percent effectiveness depending upon the sensitivity of the site to landsliding, based on such factors as percent slope, proximity to streams, rock type, soils, climate, runoff events, and the volume of timber harvested.

3. Costs

Landings	Cost
Pre-planning and drainage design	$80-100/landing
Construction drainage structures	$30-50/landing
Cable Corridors	
Pre-planning	0
Hand water-barring	$5-30/corridor
Straw mulching	$30-50/corridor

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I. MM No. 9 Mechanical Site Preparation

1. Components and Specifications

Mechanical site preparation will not be applied to slopes greater than 30 percent. On sloping terrain greater than 10 percent, ground disturbing activities will be conducted on the contour leaving slash windrows also on the contour. The objective is to provide a seedbed or remove competing vegetation species from seedlings while minimizing the potential for erosion. Mechanical site preparation will not be conducted within Streamside Special Management Areas. Filter strips of suitable width will protect all drainages to prevent sedimentation by the 10 year precipitation event for storms of common duration for the climate of the area. All slash material must be removed from drainages by the end of the workday. Operation is prohibited during wet periods when equipment begins to cause rutting or churning of the soil. Windrows will be located a safe distance from drainages to prevent movement of the material during high runoff conditions. Breaks in the windrows will occur at regular intervals to equalize water levels on both sides of the windrow.

Bedding operations in high water table areas will be conducted during dry periods of the year. Bedding areas will be located on the contour or at right angles to the direction of flow when flooded. Openings in the beds will occur at sufficient intervals to avoid ponding and allow water levels to equalize on both sides of the bed. Disturbed soil area between beds will be minimized. Special care will be used to prevent changes in the natural hydrologic conditions of these forested wetlands.

2. Effectiveness

The use of this MM should provide 80-100% effectiveness in preventing sedimentation to streams and in protecting the hydrologic conditions in wetlands.

3. Costs

The cost to conduct erosion control practices during site preparation for forest regeneration averaged about $62.00 per acre treated in 1990 based on national summaries provided by the ASCS. In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for the site preparation:

Activities	Costs
Prescribed Burning	$16.00/acre
Bulldozing or Shear Blading	$105.00/acre
Chemical	
Ground	$41.00/acre
Aerial	$38.00/acre
Chopping	$70.00/acre

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Discing	$40.00/acre
Bedding	$24.00/acre

The following example costs for activities related to site preparation are USDA Forest Service estimates from the Pacific Northwest:

Add 5 percent to the cost of mechanical site preparation for achieving these MM's.

J. MM No. 10 Prescribed Fire

1. Components and Specifications

No prescribed fire for site preparation or forestry slash removal purposes will be conducted in SSMAs. Prescribed fire in wetland areas should be carefully designed to protect wetland values and prevent erosion. Intense prescibed fire will not occur in streamside vegetation for small drainages where there is risk of sedimentation due to the loss of canopy and the soil binding ability of vegetation roots. Firelines will be constructed outside of the streamside zones protected from prescribed fire. Intense prescribed fire on steeply sloping areas must not increase the risk of sedimentation to nearby drainages. Prescriptions for prescribed fire will avoid conditions requiring extensive blading of fire lines by heavy equipment. Where possible, prescriptions should rely on hand lines, firebreaks, and hose lays to minimize soil disturbance, especially on sloping areas where firelines must be parallel to the slope. All firelines must be water-barred at appropriate intervals to prevent rills and gullies on the fireline and in the area receiving the runoff. Waterbars should be constructed to drain runoff outside of the burned area.

2. Effectiveness

Use of this MM to reduce erosion related to prescribed fire should provide 90-100% effectiveness in preventing sedimentation to waterbodies in the area. Variation in effectiveness is due to slope, soils, intensity of the burn, runoff events, and climate.

3. Cost

In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for the use of prescribed fire for site preparation:

Activities	Costs
Prescribed Burning	$16.00/acre

The following example cost percentages for prescribed fire are USDA Forest Service estimates from the Pacific Northwest:

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Firelines	Cost
Additional to protect drainages, fall	Add 30-50%
Reductions due to wetter conditions	Minus 30-50%

K. MM No. 11 Mechanical Tree Planting

1. Components and Specifications

Equipment will be operated on the contour to prevent erosion. Mechanical planting will not be conducted within Streamside Special Management Areas. When crossing small ephemeral drainages (drainages which only flow during storms or snowmelt), the plow will be raised until the equipment passes well beyond the zone of flow. Slits should be turned upslope before crossing the drainage to prevent entry of slit runoff.

2. Costs

The cost to install forest tree plantations for the primary purpose of erosion control was about $137.00 per acre in 1990 based on national summaries provided by the ASCS. In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for tree planting:

Activities	Costs
Tree Planting	
Hand	
Loblolly Pine	$47.00/acre
White Pine	$70.00/acre
Hardwoods	$141.00/acre
Machine	
Loblolly Pine	$50.00/acre
White Pine	$71.00/acre

The following are example cost percentage for mechanical tree planting based on USDA Forest Service contracts from the Pacific Northwest:

Add 5 percent to the cost of mechanical site preparation for achieving these MM's.

L. MM No. 12 Revegetation of Disturbed Areas

1. Components and Specifications

The objective of this MM is to reduce erosion by the fastest revegetation possible. Revegetation efforts will be conducted in the most efficient and effective manner economically feasible appropriate to the area. In humid areas during the growing season, grass and legume seeding will be done immediately following the completion of the earth disturbing activity, preferably within days after the activity has ended. Use of straw as mulch, hydromulch, lime and fertilizer, wetting agents, jute netting, woven fabrics, etc. will depend on the most successful mixes of species and treatments for the area.

In dry areas during the growing season, it is most often successful to postpone seeding and related treatments to just prior to the normal beginning of the wet period, often fall and spring. Seeding done earlier would commonly fail due to the lack of sufficient moisture. Late fall or winter seeding often fails due to cold soil temperatures inhibiting germination, and being conducive to seed-killing mold and fungi.

Revegetation efforts should be concentrated on the largest areas of disturbance near waterbodies. On steep slopes use of native woody plants planted in rows, cordones, or wattles may be more effective than grass in becoming established and binding the soil with roots. Seed mixtures will contain plants with soil binding properties. Cattle grazing must be prevented on newly re-established vegetation plantings. Seed selection should include natives where possible, and should consist primarily of annuals to allow natural revegetation of native understory plants in time. Exotic species which may spread to other areas must not be used.

2. Effectiveness

The effectiveness of revegetation to prevent sedimentation of area waterbodies varies from 40% to 60% This variation and limited effectiveness is due to the period of time that soils are exposed to rain and snowmelt before vegetation is established. The period of exposure is strongly related to the weather, climate, antecedant soil moisture, soils, slope steepness, runoff events, and grazing by animals.

3. Costs

The cost to establish permanent vegetative cover on critical areas for the primary purpose of erosion control was about $140.00 per acre in 1990 based on national summaries provided by the ASCS. In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for the use of prescribed fire for site preparation:

Activities	Costs
Seedbed Preparation	
Lime	$19.00/ton
Fertilizer	Variable- depending on sowing rate
Seed	$4.75/100 feet
Mulching	$158.00/acre

The following example costs for revegetation methods are based on USDA Forest Service contracts from the Pacific Northwest:

Method	Cost
Grass-seeding (hand)	$50/acre
Grass-seeding (helicopter)	$100/acre
Hydromulching seed and fertilizer	$150/acre
Straw mulch	$500/acre
Jute netting	$1,000/acre
Woven fabric	$5,000/acre
Woody plant rows, cordon, wattles	$1/foot

M. MM No. 13 Stream Protection for Pesticide and Fertilizer Projects

1. Components and Specifications

Pesticides: Pesticides are used for many different purposes. Since they are toxic materials, they must be mixed, transported, loaded, applied, and their containers disposed of with great care. Their use must be prescribed for the appropriate pest after consideration of integrated pest management (IPM) approaches. Application must be conducted according to label instructions for the certified use. Applicators must be licensed by the appropriate state agency.

Spray programs must meet state requirements. For aerial applications this commonly involves inspection of the mixing and loading process, nozzle calibration, and approval of appropriate weather conditions, and spray area and buffer area monitoring. Buffer areas for identifiable flowing waters must be established and made identifiable for applicators. Accidental spills of toxic materials into waterbodies must be immediately reported to the state water quality agency. Spill contingency plans must be in place and include effective means to control spills to the maximum extent practicable.

Streams must be sampled adjacent to or below application areas at time intervals to measure the expected peak concentration based upon time of application, travel time, and nature of the material. Sampling results must be reported to the state water quality agency and licensing agency.

Fertilizers: Fertilizers may also be toxic materials depending upon the concentration. Similar planning, care in use, sampling, and reporting are necessary. Serious consideration of the costs and benefits of fertilizer use in forest applications will be made. Spill contingencies apply as well. Appropriate buffers for flowing waters and aerial weather conditions will be properly managed to prevent the entry of fertilizers into waterbodies.

2. Effectiveness

This MM varies between 95-100% effective in preventing entry of pesticides and fertilizers in waterbodies. While the consequences of entry of pesticides and fertilizers is high, the risk of entry is low when this MM is applied.

3. Costs

In the State of Virginia Best Management Practices Handbook for forestry, the following costs were estimated[1] for control of the use of pesticides to protect water quality:

Activities	Costs
Chemical application for Pine Release	
Ground	$32.00/acre
Aerial	$32.00/acre

The following cost estimate is based on USDA Forest Service information from the Pacific Northwest:

Activities	Costs
Planning and coordination	Equal to Application Costs

N. MM No. 14 Petroleum Products Pollution Prevention

1. Components and Specifications

Planning to designate appropriate areas for petroleum storage, procedures and equipment for dispensing, and procedures for spill containment and contingencies will be done. Sites for storage and transfer must meet state and federal regulations. Spills of fuels must be contained and treated. Fuel trucks and pickup mounted fuel tanks must not have leaks. Fuel storage and transfer sites must be located sufficiently distant from waterbodies to prevent entry of petroleum products should the storage tank lose its entire capacity of storage.

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A specified area must be designated for draining lubicants from equipment during routine maintenance. The area should allow all waste lubricants to be collected and stored until transported off-site for recycling, re-use, or disposal at an approved site. Waste oil, filters, grease cartridges, and other petroleum contaminated materials will not be left as refuse in the forest, but must be transported to an approved disposal site.

2. Effectiveness

This MM is 95% effective in preventing the entry of petroleum products into streams. The small percentage of failure occurs as fuel spills from leaking tanks or traffic accidents. Leaking of petroleum from moving vehicles cannot be completely eliminated nor can traffic accidents.

3. Costs

Activities	Costs
Preventive measures	$0 These measures are already required by state and federal rules and regulations

NOTE: Comments are solicited on all aspects of this section, and particularly on the amount and the level of detail in this discussion. In addition, comments on the cost and effectiveness information which is provided or additional information which may be available elsewhere are requested. Additional or alternative management measures required to address a given practice or pollutant source, or which are more applicable to a specific region of the United States, are also requested. EPA will be collecting additional information on management measures, and their costs and effectiveness, during the revision of this draft guidance. The contributions and suggestions of commenters on these subjects will be welcome.

FOOTNOTES

[1]Costs are in converted from 1979 to 1990 dollars using an aggregate cost index from the Engineering News Report, March 25, 1991.

REFERENCES

Commonwealth of Virginia. 1979. Best Management Practices Handbook - Forestry. Virginia State Water Control Board, Planning Bulletin 317.

USDA. 1991. Agricultural Conservation Program - 1990 Fiscal Year Statistical Summary. ASCS, Washington, DC.

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CHAPTER 4. MANAGEMENT MEASURES FOR URBAN SOURCES OF NONPOINT POLLUTION

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CHAPTER 4

MANAGEMENT MEASURES FOR URBAN SOURCES OF NONPOINT POLLUTION

I. INTRODUCTION

This chapter specifies management measures to abate and control water quality problems in coastal areas resulting from urban runoff. Urbanizing and urbanized areas, construction, onsite sewage disposal systems (septic systems), highways, and bridges will be covered under this heading.

It has been well documented that urban sources of pollution contribute significantly to the degradation of coastal and estuarine water resources. The National Urban Runoff Program (NURP), State 305(b) reports, and the Section 319 Assessment reports all indicate that urban loadings of sediments, nutrients and toxic substances to surface waters are significant and may cause impairment or denial of beneficial uses.

Curtailment of recreational and commercial uses of coastal waters due to contamination from urban runoff has been well publicized. Land conversion associated with the urbanization of undeveloped lands has resulted in the loss of vegetation and sensitive wetlands, alteration of natural drainage patterns and the creation of expanded areas of imperviousness. This loss of infiltrative capacity has been correlated with increases in the velocity, volume and frequency of stormwater runoff. Mitigation and prevention of this process is inherently difficult in that sources are diverse, changes in water quality may be gradual and cumulative, existing institutional frameworks often fail to address NPS pollution in a comprehensive manner, and political constraints tend to limit the number of viable options for meaningful change.

Management measures appropriate to control urban runoff must address an array of pollutants. As urbanization occurs, strategies must comprehensively address pollutants generated during all phases of this process. Management practices or systems need to be developed for urban sources of NPS which anticipate and adjust to these ongoing changes. In such an environment, a phased approach is often necessary to prevent and control each type of pollutant generated. Planning and site design can be effective means to prevent and control nonpoint source pollution. Both watershed and site planning can be used to (1) locate development away from sensitive land forms which may be highly erodible or serve as natural filters for stormwater runoff and (2) design developments to allow more effective or efficient control of nonpoint source runoff. This subject will be addressed in more detail within the body of this section. To further illustrate this point, where development or construction are planned, site suitability evaluations are appropriate prior to the planning and design phase. As planning and design occur, best management strategies should assess the environmental effects of the project and identify practices or controls needed to prevent or mitigate runoff during and after construction. During construction, management practices should schedule activities to minimize site disturbance and include the use of sediment control measures and practices. Finally, post construction measures should ensure that proper operation and maintenance of control devices such as buffer strips and detention basins occur on a long term basis.

The management measures presented in the following sections represent the EPA's preliminary effort to specify the best practices or management systems to control urban sources of nonpoint pollution. Where possible, data on effectiveness, cost of implementation and operation and maintenance has been provided. In the absence of readily available data, the guidance contains examples or cites existing State practices which are under consideration as best management practices. The Agency is soliciting information both on additional management measures that apply to urban problems and any cost or effectiveness data which is applicable to these or previously identified measures. The Agency will consider these and additional information regarding costs and pollution reduction effects prior to publishing the final guidance.

Listed below are some of the major sources of urban nonpoint pollution:

(1) Construction on sites less than five acres in size
(2) Onsite Sewage Disposal Systems - septic tanks
(3) Households
(4) Roads, Highways and Bridges
(5) Golf Courses/Parks
(6) Service stations

As pointed out in the introduction, some of these activities may be required to apply for and receive point source permits. In such cases, they are not subject to this guidance. (See the National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges published in 55 Fed. Reg. 47990 (November 16, 1990) for more information concerning point source discharges.)

A. Urban Nonpoint Pollutants and Water Quality Effects

Most pollutants enter coastal waters either as soluble forms or bound to sediments. Additional pollutants result from atmospheric deposition. Data from both the National Urban Runoff Program (NURP) and the §319 Report documents that sediments, nutrients and pathogens are the most likely pollutants to impair water quality and designated uses. Heavy metals, oils and grease, toxic organic chemicals and oxygen-demanding materials may also contribute to water quality problems.

Volume and pollutant concentration in urban runoff affect the extent receiving coastal waters are impaired. Daniel (1978) found high concentrations of pollutants are generally associated with the following conditions: (1) densely populated and/or industrial areas; (2) intensive storms; (3) beginning stages of storms; (4) prolonged dry periods prior to a runoff event; and (5) drainage areas with significant construction activity.

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Some generic water quality impacts associated with urban runoff include: (1) rapid short-term changes in water quality during and shortly after storm events which result from the discharge of pollutants at relatively high concentrations; (2) longer-term water quality impacts on biological communities and health associated with the discharge of toxic pollutants at lower concentrations; (3) long-term effects associated with the discharge of nutrients and other pollutants into estuaries and wetlands; (4) physical changes related to the erosion of stream banks and/or the creation of sediment deposits in near coastal areas; and (5) water quality changes associated with the scouring and resuspension of in place pollutants.

B. Urban Nonpoint Source Pollutants

Listed below are the principal types of NPS pollutants found in urban runoff with brief descriptions of their potential to adversely affect surface and coastal waters (Schueler, 1987). Table 4-1 further illustrates types and sources of hazardous urban pollutants (EPA, Urban Targeting and BMP Selection, 1990)

Sediment: Suspended sediments comprise the bulk of urban nonpoint source pollutants. Sediment has both short and long term impacts on receiving waters. Some immediate detrimental impacts of high sediment loadings include: increased turbidity, impaired respiration of fish and aquatic invertebrates, reduced fecundity and impairment of commercial and recreational fishing. High sediment concentrations may also cause long term effects. Heavy sediment deposition in low velocity receiving waters may result in smothered benthic communities, increased sedimentation of watercourses, changes in bottom substrate composition and alteration of the water's aesthetic value. Additional chronic effects may occur where sediments rich in organic matter or clay are present. Such sediments tend to bind and transport nutrients, toxic substances and trace metals. These enriched depositional sediments may present a continued risk to aquatic and benthic life especially where the sediments are disturbed and resuspended.

Oxygen Demanding Substances: Dissolved oxygen levels are critical to healthy waters. Decomposition of organic matter by microorganisms depletes dissolved oxygen (DO) levels in receiving waters, especially estuaries. Data has shown that urban runoff with high concentrations of decaying organic matter can severely depress DO levels after storms (EPA, 1983). The NURP study found that oxygen demanding substances are present in urban runoff at concentrations approximately equal to those in secondary treatment discharges. The Chesapeake Bay Office is currently recommending that DO levels not fall below specified thresholds for selected habitats (see Table 4-2: Note, however, that Table 4-2 only applies to the Chesapeake Bay and should not be applied elsewhere without adjustment).

Nutrients: The problems created by excess phosphorus and nitrogen loading to water bodies are well known and discussed in detail in Chapter 2 (agriculture). Accelerated eutrophication, decreases of submerged aquatic vegetation (SAV) and toxicity to humans or wildlife may occur when the concentration of certain forms of nutrients exceed a critical level. Surface algal scum,

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Table 4-1. Potential Sources of Toxic and Hazardous Substances in Urban Runoff

	Automobile Use	Pesticide Use	Industrial/Other Use
Heavy Metals			
Copper	metal corrosion	algicide	paint, wood preservative electroplating
Lead	gasoline, batteries		paint
Zinc	metal corrosion tires, road salt	wood preservative	paint, metal corrosion
Chromium	metal corrosion		paint, metal corrosion, electroplating
Halogenated Aliphatics			
Methylene chloride		fumigant	plastics, paint remover solvent
Methyl chloride	gasoline	fumigant	refrigerant, solvent
Phthalate Esters			
Bis (2-ethylhexyl) phthalate			plasticizer
Butylbenzyl phthalate			plasticizer
Di-N-butyl phthalate		insecticide	plasticizer, printing inks, paper, stain, adhesive
Polycyclic Aromatic Hydrocarbons			
Chrysene	gasoline, oil, grease		
Phenanthrene	gasoline		wood/coal combustion
Pyrene	gasoline, oil, asphalt	wood preservative	wood/coal combustion
Other Volatiles			
Benzene	gasoline		solvent
Chloroform	formed from salt, gasoline & asphalt	insecticide	solvent, formed from chlorination
Toluene	gasoline, asphalt		solvent
Pesticides and Phenols			
Lindane (gamma-BHC)		mosquito control seed pretreatment	
Chlordane		termite control	
Dieldrin		insecticide	wood processing
Pentachlorophenol		wood preservative	paint
PCBs			electrical, insulation

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Table 4-2. Recommended DO Habitat Requirements

Category	DO Value (mg/L)	Specific Requirements
Spawning Reaches: Instantaneous DO	5.0	DO should not fall below 5.0 mg/L at any time within anadromous fish spawning reaches and nursery areas during late winter through late spring (February 1 - June 15).
All Tidal Waters of the Chesapeake Bay for All Seasons Except the Spawning Areas and Times Defined Above:		
Category I - Instantaneous DO	0.5	DO should not be below 0.5 mg/L at any location, at any season, or for any duration.
Category II - One-hour DO	1.0	DO should not fall below 1.0 mg/L for more than one hour at any location or at any time. Excursions below 1.0 mg/L should not occur more frequently than every 12 hours.
Category III - Twelve-hour DO	3.0	DO should not fall below 3.0 mg/L for more than 12 hours at any location or time. Twelve-hour excursions below 3.0 mg/L should not occur more frequently than every 48 hours.
Category IV - Monthly Average DO	5.0	Monthly mean DO should not be below 5.0 mg/L at any location or season.

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water discoloration, strong odors, depressed oxygen levels, and release of toxins are also common problems.

Heavy Metals: Heavy levels of copper, lead and zinc are the most prevalent priority pollutant constituents found in urban runoff. The presence and concentrations of these metal is in some cases high enough to impact beneficial uses and cause detrimental effects to aquatic life. Groundwater sources of drinking water supplies may also be degraded or endangered by the presence of heavy metals and nitrates.

Oil and Grease: Oil and grease contain a wide variety of hydrocarbon compounds. Some polynuclear aromatic hydrocarbons (PAH's) are known to be toxic to aquatic life at low concentrations. The precise impacts of hydrocarbons on the aquatic environment are not well understood.

Pathogens: The presence of pathogens in surface water may cause public health standards for water contact to be exceeded and restrict shell fish harvesting. Although high fecal coliform counts have documented in urban runoff, the health implications are unclear where contamination is not from improper sanitary connections or septic systems.

Other Pollutants: Other toxic chemicals are rarely found in urban runoff from residential and commercial land use areas in concentrations that exceed current water quality criteria. Pesticide concentrations in urban runoff generally are near detection limits. PAHs commonly detected organic compounds found in urban runoff have not been correlated with known problems. There is currently a lack of data on industrial runoff to draw conclusions about the fate and effects of related pollutants.

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II. CONSTRUCTION MANAGEMENT MEASURE

A. Management Measure Applicability

This management measure is applicable to all construction activities which result in land development or disturbance and are not subject to a requirement to apply for and receive an NPDES permit [Note: All construction activities, including clearing, grading and excavation which result in the disturbance of areas greater or equal to 5 acres or are part of a larger development plan are covered by the NPDES regulations]. Activities subject to this management measure include, but are not limited to, commercial or residential development, road, highway, airport and bridge construction, landscaping and installation of underground storage tanks or sewer/stormwater conveyances.

B. Pollutants Generated by Construction Activities

Construction related pollutants transported in urban runoff, listed in decreasing order of importance include:

- Sediment and particulate organic solids;
- Toxic metals and hydrocarbons (deposited from onsite equipment);
- Nutrients (applied to promote revegetation and site stabilization).

The major pollutant generated from construction activities is sediment. Sediment loadings from construction sites may be as much as 100 times greater per acre than those from agricultural lands and perhaps 2,000 times per acre greater than from undisturbed forestland (IEN p. 64, Bergquist, 1986). Exposed, disturbed and stockpiled soils are extremely susceptible to erosion and transport off site. In general, downstream suspended sediment levels are greatest during the advanced stages of construction when sediment delivery conditions are optimal (Schueler, 1990).

C. Construction Management Measures

Management measures for construction consist of the following sets of measures.

(1) Reduce site disturbance and the detachment and transport of soil on construction sites by disturbing the smallest area for activities, stabilizing disturbed areas within a reasonable time, reducing runoff velocities, and protecting disturbed areas from stormwater runoff.

(2) Control eroded sediment on site such that off-site sediment and particulate organic solids delivery is reduced to or below the lower of either pre-development sediment loadings (to the extent practicable) or the acceptable soil loss tolerance for agricultural lands.

(3) Reduce toxic and nutrient loadings to pre-development levels (to the extent practicable) by reducing the generation and migration of toxic substances and avoiding excess applications of nutrients.

D. Available Management Practices to Achieve Management Measures

Listed below is a selection of state-of-the-art erosion and sediment control practices ideal for coastal regions. These practices are available as tools to achieve the construction management measure specified in section II.C.

1. Practices Available to Achieve Management Measures 1 and 2

Practices for general use:

- Plan development to fit the topography, soils, drainage patterns and natural vegetation of the site.
- Avoid mass clearing and grading of the entire site (e.g., use phased construction sequencing to limit the amount of disturbed area at any given time).
- Establish vegetative cover on all disturbed sites where construction activity has been interrupted for an unreasonable time.
- Configure site plans to retain the maximum area of open vegetated space.
- Divert and convey off-site runoff around disturbed soils and steep slopes to stable areas in order to retain sediment onsite and prevent transport of pollutants offsite.
- Utilize grading methods which impede vertical runoff and provide maximum runoff infiltration capacity.
- Implement a maintenance and follow-up program for control practices including post storm event inspections of all control practices.
- Restrict the clearing and grading of all areas that will later function as post development buffer zones.
- Locate large graded areas on the most level portion of the site and avoid the development of steep vegetated slopes.
- Reestablish vegetative areas that have been filled or damaged by construction equipment or activities.
- Conduct temporary construction and fill activities outside of floodplains.

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- Prepare an erosion and sediment control plan which specifies location, installation, and maintenance of practices to prevent and control erosion and sediment loss at the site. The efficacy of this practice can be further enhanced by communicating the provisions of the control plan to all employees associated with the project and by designating responsibility for implemention of the plan to an individual certified in erosion and sediment control practices by the local authority.

- Use surface roughening (horizontal depressions) to control erosion and aid the establishment of vegetative cover.

- Avoid the placement of entrances on steep grades or curves.

- Protect inlets to storm sewers by suitable filtering devices during construction.

- Construct access roads with grades less than 10%.

- Stockpile topsoil and reapply it to revegetate the site.

- Use practices such as benching, terracing, or diversional structures where development occurs on steep vegetated slopes.

- Physically mark off limits of land disturbance on the site with tape, signs or barriers to ensure preservation of offsite areas.

- Evaluate the need for extraordinary controls and, if necessary, implement such controls.

Vegetative Stabilization Practices - Rapid establishment of a grass or mulch cover on a cleared or graded area at construction sites is the single most important factor in reducing downstream sediment and can reduce suspended sediment levels to receiving waters by up to six fold (Schueler, 1990).

- Temporary seeding - Temporary seeding may be the single most important factor in reducing construction related erosion ("New York Guidelines for Urban Erosion and Sediment Control:, USDA - Soil Conservation Service, March 1988). Temporary seeding practices have been found to be up to 95% effective in reducing erosion ("Guides for Erosion and Sediment Control in California"- Soil Conservation Service, Davis, CA, Revised 1985). For critical areas, vegetation should cover 90% of each square yard of disturbed area to adequately stabilize soils. Moderately sloped areas with fertile soils require at least 75% of each square yard of exposed area to be vegetated. (Pennsylvania Soil and Erosion Control Manual, 1983)

- Permanent Seeding
- Mulching - wood Fiber hydroseeder slurries are well suited to establish vegetation on steep slopes, in critical areas, and areas with severe climates
- Sod stabilization - good sod cover may be up to 98% effective in controlling erosion (PA S & E,1983)
- Vegetative buffer strips
- Tree and shrub protection: fencing, tree armoring, retaining walls or tree wells

(See Chapter 7 for additional data on vegetative stabilization/filtration practices.)

Perimeter Control practices - Perimeter controls are devices placed at the edge or boundary of construction site disturbance to: (1) prevent sediments from washing off site and; (2) direct surface runoff into a sediment trap or basin.

- Temporary and permanent diversions - "among the most effective and least costly practices for controlling erosion and sediment" (North Carolina Erosion and Sediment Control Planning and Design Manual, 1988).
- Grass covered earthen berms
- Silt fences or curtains
- Infiltration trenches
- Straw bales - When installed properly straw bales can remove up to 67% of the sediment provided rotten or broken bales are replaced (VA Erosion and Sediment Control Handbook, 1980).

Trap & Basin Practices - Sediment traps and basins are used at construction sites to capture surface runoff of sediment during storm events. The sediment-laden water is retained for a period or time to allow sediment particulates to settle to the bottom of the trap. Current designs of sediment traps and basins have been found to be only moderately effective. Sattherwaithe, found that for 2/3 of storms in the Northeast, sediment controls were less than 50% effective. In Maryland, current recommendations have been proposed to require traps and basins with 1800 cubic feet/acre of permanent pool and 1800 cf/acre of "dry de-watering storage". This design with a total volume of 3600 cf/acre will effectively treat 90% of the storms each year assuming (1) a runoff coefficient of .5 during the most active stage of construction and (2) 90% of annual runoff results from storms of 1.5 inches or less (Performance of Current Sediment Control Measures at Maryland Construction Sites, Schueler and Lugbill, 1990).

Super Basin Practices - Super basins have wet and dry storage equivalent to one-inch of sediment per acre of upland watershed area. Properly designed and maintained super basins can provide reliable high rates of sediment removal for most annual storm events.

Extraordinary and Redundant Control Practices - Extraordinary controls apply to both stormwater management and sediment and erosion control.

- Oversized devices such as sediment basins or traps
- Immediate stabilization of disturbed areas
- Inspections of erosion and sediment control practices following every storm event

(Note: For additional extraordinary practices, refer to section E.)

2. Additional Practices Available to Achieve Management Measures 1 and 2

Listed below are other practices which have varying degrees of effectiveness and can be utilized in combination with the preceding practices to achieve the level of reduction specified in management measures 1 and 2. This list is not all inclusive.

- Riprap - use on or for:
  - Steep cut and fill slopes subject to severe weathering or seepage;
  - Channel liners;
  - Inlet and outlet protection at culverts;
  - Streambank protection;
  - Shorelines subject to wave action.
- Temporary construction entrance/exit - gravel buffer to collect mud and sediment and prevent tracking of soils offsite
- Vehicle washing in area with drainage and sediment trap
- Dune stabilization - vegetative planting
- Diversion dikes (Perimeter protection) - require immediate vegetation after construction and stabilization of the channelized area according to flow conditions
- Grass-lined channels
- Riprap lined and paved channels
- Temporary slope drains
- Level spreaders
- Temporary stream crossings (fords, culverts, bridges)
- Streambank stabilization practices - vegetative and structural including gabions, deflectors, log cribbing, reinforced concrete and grid pavers. (Stream channel velocities for 10 year storm must be less than 6 ft/sec for vegetative stabilization to be effective)
- Subsurface drains
- Check dams
- Paved flumes
- Nets and mats
- Dust control measures - vegetative, sprinkling, wind barriers

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3. Practices Available as Tools to Achieve Management Measure 3

Toxic substances and nutrients tend to bind to fines. In most cases where proper erosion and sediment controls have been utilized, heavy metals, hydrocarbons and nutrients will be immobilized. There is, however, an additional set of practices which can be utilized to reduce the volume and concentration of floatable and soluble pollutants such as oil and grease and nitrates.

- Provide sanitary facilities for construction workers.
- Maintain highway equipment and machinery only in confined areas specifically designed to control runoff (BMP Handbook, VA State Water Control Board Planning Bulletin 321, 1979).
- Use absorbent materials such as hay bales, cat litter and absorbent pads to collect and prevent migration of pollutants.
- Store, cover and isolate construction materials, including topsoil and chemicals to prevent runoff of pollutants and contamination of groundwater.
- Spill Prevention and Control Plan - Spill prevention and control is an important element of a runoff control strategy. Agencies, contractors and other commercial entities that store, handle, or transport fuel, oil or hazardous materials should develop a spill response counter measures plan.
- Maintain and wash highway equipment and machinery in confined areas specifically designed to control runoff (BMP Handbook, VA State Water Control Board Planning Bulletin 321, 1979).

E. Erosion and Sediment Practices for Particularly Sensitive Watersheds

Sensitive watersheds may need additional protection above the level required for most construction activities. Consistent with other measures in this guidance, the watershed affected and the type of resources needing protection will dictate the combination of practices which are necessary. Comments are solicited on the following set of practices and their suitability for inclusion in the final guidance as a management measure for particularly sensitive watersheds. (Note: The Maryland Chesapeake Bay Critical Area Program regulations define sensitive areas as having the following features: hydric soils or soils with hydric properties, highly erodible soils with high K values, steep slopes greater than 15%)

(1) 72-hour stabilization requirement;
(2) Installation of double rows of silt fencing;
(3) Oversizing of sediment traps and basins;

(4) Immediate installation of infiltration practices with provisions to maintain these devices until vegetation is established;
(5) Innovative scheduling for paving vs. vegetative stabilization and implementation of infiltration practices to reduce thermal impacts;
(6) Minimization of cleared forest lands;
(7) Establishment or protection of forested buffers along streams;
(8) Phased clearing operations;
(9) Installation of traps and basins prior to grading;
(10) Installation of turbidity curtains;
(11) Maintenance of controls following every storm-event; and
(12) Increased inspection intervals (once a week minimum; the 1983 Maryland Standards and Specifications for Erosion and Sediment Control suggest daily inspections).

(Maryland State Highway Administration Chesapeake Bay Initiatives Action Plan, August 15, 1990)

F. Effectiveness and Cost

Table 4-3 provides information on effectiveness, cost and applicability of some of the erosion and sediment control practices discussed above.

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Table 4-3. Erosion and Sediment Control Practices

EROSION & SEDIMENT CONTROL	Key	Extraordinary Controls	Super Basins	Traps & Basins	Perimeter Controls	Vegetative Stabilization	Time/Area Disturbance
General	• Performance of BMP Affected by High Sediment Inputs	•	•	•	•	•	•
Nutrient Control	● 0-40% High Level of Control; ◐ 30-40% Moderate Level of Control; ○ 0-30% Low Level of Control; ⊗ Ineffective	●	●	◐	○	◐	◐
Shellfish	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ⊗ Ineffective	◐	●	◐	○	○	○
Estuarine Habitat Protection	● Directly Protects; ◐ Indirectly Protects; ○ No Protection; ⊗ Not Related	●	●	◐	◐	◐	●
Sedimentation	● 80%+ High; ◐ 30-80% Mod; ○ 0-30% Low; ⊗ Ineffective	●	●	◐	◐	●	◐
Sediment Toxics	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ⊗ Ineffective	◐	◐	◐	⊗	⊗	⊗
Stormwater Control	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ⊗ Ineffective	◐	●	◐	⊗	○	○
Feasibility in Coastal Areas	● Widely Applicable; ◐ Applicable Depending on Site; ○ Seldom Applicable; ⊗ Not Applicable	◐	◐	●	●	●	●
Maintenance Burdens	● Low Burden; ◐ Moderate Burden; ○ High Burden; ⊗ Not Applicable	○	●	◐	○	◐	●
Longevity	● Long Lived; ◐ Long Lived w/Maintenance; ○ Shortlived; ⊗ Not Applicable	●	●	◐	◐	○	●
Community Acceptance	● Positive; ◐ Neutral; ○ Negative; ⊗ Mixed	◐	◐	●	●	●	●
Secondary Environmental Impacts	● None or Positive; ◐ Slight Negative Impacts; ○ Strong Negative Impacts at Some Sites; ⊗ Prohibited	◐	◐	◐	●	●	●
Cost to Developers	● Low; ◐ Moderate; ○ High; ⊗ Very High	○	○	◐	●	●	●
Cost to Local Governments	● Low; ◐ Moderate; ○ High; ⊗ Very High	○	◐	◐	◐	◐	◐
Difficulty in Local Implementation	● Easy; ◐ Moderate; ○ tough; ⊗ Very Tough	○	◐	◐	●	●	●
Site Data Required	● Simple; ◐ Moderate; ○ Complex; ⊗ None	○	◐	◐	●	●	◐
Water Dependent Use	● Can Be Used Moderately In These Areas; ◐ Sometimes Can Be Used; ○ Seldom Used; ⊗ Not Used	●	⊗	◐	●	●	●

Source: Metropolitan Washington Council of Governments, Draft, 1991

III. URBAN STORMWATER RUNOFF MANAGEMENT

A. Applicability of This Management Measure

This management measure applies to all urban areas other than those which are required to apply for and receive NPDES stormwater permits.

B. Problem Description

Urbanized areas, or those in which development has altered the natural infiltration characteristics of the land, experience increased surface runoff. Land development alters the natural balance between stormwater runoff and natural absorption areas by replacing them with greater amounts of impervious surface. This results in increased surface runoff at greater velocity.

As a result of increased quantity and velocity of runoff, greater amounts of pollutants are carried in the increased runoff flow, streambanks are eroded, greater amounts of pollutants are carried in the increased runoff flow, and the likelihood of flooding, erosion and water quality degradation increases. Moreover, streambank erosion results in degraded aquatic habitat.

Urbanized areas experience pollutant runoff loadings many times that of land in its pre-development state. The principal pollutants found in urban runoff include sediment, oxygen-demanding substances, nutrients, heavy metals, bacteria & pathogens, oil & grease, and toxics & pesticides.

C. Management Measures for Urban Stormwater Management

(1) Limit the creation of impervious surface and retain the appropriate amount of pervious surface in order to achieve optimal infiltration of runoff into soil. Protect natural vegetation and drainageways.

(2) Limit disturbance of areas such as steep slopes and unstable areas.

(3) Control the first flush of runoff to reduce loadings of sediment and toxic pollutants, taking into account cost and pollutant reduction effects.

(4) Protect against streambank erosion by reducing post-development stormwater runoff peak flows.

(5) Implement source controls where appropriate to reduce the availability of pollutants to be entrained in stormwater runoff.

(6) Control the application of nutrients and pesticides to golf courses and parks.

D. Principal Management Practices

Following is a list of management practices for urban stormwater runoff management that are available as tools to achieve the urban stormwater runoff management measure:

(1) Pond Systems (Detention/Retention)

(a) Detention devices: Runoff is temporarily stored, then subsequently discharged to a surface water. Pollution abatement results from the settling of pollutants during the detention period.

(b) Retention devices: Runoff is permanently captured so that it is never discharged directly to surface waters. Wetlands may often be constructed in such devices to promote nutrient uptake.

(2) Biofiltration

These methods accomplish pollutant removal by filtration, biological uptake, or trapping sediment. These controls comprise an infiltration system which not only allows pollutant removal but also recharges the groundwater through infiltration. These methods may also be incorporated as components of pond systems. (See Chapter 7 for further discussion of biofiltration)

(3) Infiltration Devices

Infiltration devices utilize various methods for removing the soluble and fine particulate pollutants found in stormwater runoff.

The devices or practices described above are the primary means by which to control the bulk of pollutants in urban stormwater runoff after they leave the site.

E. Effectiveness of Stormwater Runoff Controls

The best available procedures for urban stormwater management include both structural and non-structural components and involve a combination of detention, infiltration and filtering devices. Treatment systems, rather than individual practices, will tend to achieve the greatest pollutant reduction goal. Systems should include source control, stormwater management and riparian protection to achieve the highest level of effectiveness.

Stormwater treatment systems are site-specific; their effectiveness is highly variable and dependent on many factors, including the following: contributing drainage area; the infiltration characteristics of soils on site; site topography; and available space for a treatment structure on site.

In addition, practices or combinations of practices which are considered to be "best available" in some or in many situations, may nevertheless not be the most effective or economically achieveable for a particular site, and may even be entirely ineffective for the site. A system of practices should be tailored to a particular site to avoid selection of unsuitable practices, maintenance problems, or failure to achieved desired pollutant reduction.

Table 4-4 provides a matrix that shows the relative suitability, effectiveness, and costs of a variety of stormwater runoff treatment or control practices. A brief discussion of these practices follows immediately below.

1. Pond Systems (Detention/Retention)

The ponds described below (and referred to in D(1) above) range from completely dry structures to permanently wet structures with various combinations included. In addition, wetland components are discussed for their ability to enhance pollutant removal, create habitat diversity, and provide visual interest.

Wet Extended Detention Pond - A permanent pool system containing a forebay near the inlet to trap sediments and a deeper pool near the riser. This pond system provides an optimal combination of downstream channel protection and urban pollutant removal. Extended detention wet ponds are generally the most cost effective urban/coastal practices available for pollutant removal and stormwater control.

Wet Pond - A pond system with all of its storage utilized as a permanent pool. This system provides high levels of urban pollutant removal through biological uptake from aquatic wetland plant species. In addition, a wet pond can be an attractive community feature.

ED Micro-Pool - A dry ED system containing one or two small permanent pools for pollutant removal. One micro-pool located near the riser protects the ED pipe from clogging. A second micro-pool located near the inlet acts as a sediment forebay. The micro-pool system has a much lower maintenance burden than conventional dry ED pond systems and is a particularly useful design for fingerprinting a pond into a sensitive woodland or wetland area.

ED Shallow Marsh - A system utilizing emergent aquatic wetland plant species as its principal pollutant removal mechanism. The ED shallow marsh typically consists of a 0-3 foot deep irregularly shaped permanent pool, creating diverse wetland habitats in a relatively small space, while providing moderate levels of soluble pollutant removal.

Shallow Marsh - A system with much of its storage devoted to a shallow marsh, this pond design can consume a great deal of land area. However with proper grading, design and propagation techniques, this system can result in the creation of extensive, high quality emergent wetland habitat. The shallow marsh can achieve high removal rates of soluble and particulate pollutants through the biological uptake mechanism of emergent aquatic plants.

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Table 4-4. Stormwater Runoff Treatment/Control

Legend	Peat/Sand Filters	Sand Filters	Bio-Filters	Grassed Swale	Forest Filter Strip	Grass Filter Strip	Porous pavement	Dry Well	Infiltration Basin	Infiltration Trench #2	Infiltration Trench	In-filter Dry	Shallow Marsh	Wet Pond	Wet ED Pond	ED Shallow Marsh	ED Micro-Pool	Dry ED Pond	BMPs
	FILTER SYSTEMS						*INFILTRATION SYSTEMS*					*POND SYSTEMS*							
	All Can Be Used in Stormwater Projects																		**General**
● 0-40% High Level of Control ◐ 20-40% Moderate Level of Control ○ 0-20% Low Level of Control ⊗ Ineffective	●	◐	●	◐	●	◐	●	◐	●	●	◐	●	●	●	●	●	◐	◐	**Nutrient Control**
● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	●	◐	●	◐	●	◐	◐	◐	◐	◐	◐	●	●	●	●	●	●	●	**Shellfish**
● Directly Protects ◐ Indirectly Protects ○ No Protection ⊗ Not Related	◐	◐	◐	◐	●	◐	◐	○	◐	◐	◐	◐	●	◐	◐	●	◐	◐	**Estuarine Habitat Protection**
● 60%+ High ◐ 30-60% Med ○ 0-30% Low ⊗ Ineffective * Performance of BMP Affected by High Sediment Inputs	●*	●	●	◐	●*	●	●*	●*	●*	●*	●*	●*	●	●	●	●	●	●	**Sedimentation**
● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	●	◐	●	◐	●	●	●	●	●	●	●	◐	●	●	●	●	◐	◐	**Sediment Toxics**
● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	⊗	◐	◐	○	⊗	⊗	●	◐	●	◐	⊗	●	●	●	●	●	●	●	**Stormwater Control**
● Widely Applicable ◐ Applicable Depending on Site ○ Seldom Applicable ⊗ Not Applicable	◐	◐	◐	◐	●	◐	○	◐	◐	◐	◐	◐	●	●	●	●	●	●	**Feasibility in Coastal Areas**
● Low Burden ◐ Moderate Burden ○ High Burden ⊗ Not Applicable	○	◐	●	●	●	◐	○	◐	○	○	◐	○	◐	●	●	◐	◐	○	**Maintenance Burdens**
● Long Lived ◐ Long Lived w/Maintenance ○ Shortlived ⊗ Not Applicable	◐	◐	◐	●	●	●	○	◐	○	◐	◐	◐	◐	●	●	◐	◐	◐	**Longevity**
● Positive ◐ Neutral ○ Negative ⊗ Mixed	◐	◐	⊗	●	●	●	◐	◐	◐	◐	◐	◐	⊗	●	●	⊗	⊗	○	**Community Acceptance**
● None or Positive ◐ Slight Negative Impacts ○ Strong Negative Impacts at Some Sites ⊗ Prohibited	●	●	●	●	●	●	●	●	◐	◐	◐	●	◐	◐	◐	◐	●	◐	**Secondary Environmental Impacts**
● Low ◐ Moderate ○ High ⊗ Very High	⊗	○	●	●	●	●	⊗	●	◐	◐	◐	○	○	○	○	○	◐	◐	**Cost to Developers**
● Low ◐ Moderate ○ High ⊗ Very High	○	○	◐	●	●	●	⊗	◐	◐	◐	◐	○	⊗	○	○	○	○	○	**Cost to Local Governments**
● Easy ◐ Moderate ○ Tough ⊗ Very Tough	○	○	◐	●	●	●	○	●	◐	◐	◐	○	◐	◐	◐	◐	◐	◐	**Difficulty in Local Implementation**
● Simple ◐ Moderate ○ Complex ⊗ None	◐	◐	◐	●	●	●	○	●	○	◐	◐	○	⊗	◐	◐	◐	◐	◐	**Site Data Required**
● Can Be Used Moderately in These Areas ◐ Sometimes Can Be Used ○ Seldom Used ⊗ Not Used	◐	◐	●	●	●	●	○	●	⊗	◐	◐	⊗	◐	⊗	⊗	⊗	⊗	⊗	**Water Dependent Use**

Source: Metropolitan Washington Council of Governments, Draft, 1991

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In-Filter Dry Pond - An innovative dry pond system for sites having permeable soils that promote infiltration. Design includes stormwater detention, pretreatment via plunge pools and grassed swales, and a series of infiltration trenches and basins.

Dry ED Pond - A pond system typically comprised of two stages: The upper stage is graded to remain dry except for infrequent storms; whereas the lower stage is designed for regular inundation. Runoff pretreatment is difficult to achieve with this pond system, and it is equally difficult to prevent clogging of the ED control device.

Evaluation

Wet Ponds and Wet Extended Detention Ponds are extremely effective water quality practices. When properly sized and maintained, Wet Ponds and Wet Extended Detention Ponds can achieve a high removal rate for sediment, BOD, nutrients, and trace metals. Biological processes within the pond also remove the soluble nutrients (nitrate and ortho-phosphorous) that contribute to nutrient enrichment (eutrophication). Soluble nutrient removal is achieved through a process known as biological uptake where aquatic plants convert the soluble nutrients into biomass which then settles into pond sediments and is later consumed by bacteria and thus removed from the pond system.

Wet Extended Detention Ponds are most cost effective in larger, more intensely developed sites. Pond practices normally require a significant contributing watershed area (greater than 10 acres) to ensure proper operation. Positive impacts associated with wet pond systems can include: creation of local wild life habitat, increased property values, recreation, and landscape amenities.

Extended Detention Ponds are effective in controlling post-development peak stormwater discharge rates to a desired pre-development level for the design storm(s) specified. If stormwater is detained for 24 hours or more, as much as 90% removal of particulate-form or suspended solid pollutants is possible.

However, it should be noted that extended detention ponds have the disadvantage of elevating water temperatures. Thus their use may be inappropriate in some locations, such as trout habitat. In addition, care should be taken not to reduce base flows below levels necessary to sustain the aquatic habitat.

2. Infiltration Systems

The infiltration systems described below (and described in D(3) above) range in design from stone-filled trenches and basins to permeable asphalt pavement. All utilize differing methods for removing soluble and fine particulate pollutants found in stormwater runoff. To prevent infiltration systems from becoming clogged with fine sediment, it is essential to pretreat the incoming runoff. Methods of pretreatment range from filter cloth to vegetated filter strips. With pretreatment, infiltration systems can be an effective component of an urban water quality practices.

It is important to recognize that infiltration systems create a risk of transferring pollutants from surface water to ground water. Therefore, infiltration systems should not be used near wells or in wellhead protection areas or in settings in which drinking water supplies may become contaminated.

Infiltration Trench - An Infiltration Trench works by diverting stormwater runoff into a shallow (3 - 8 feet) excavated trench which has been back-filled with stone to form an underground reservoir. Runoff is then either exfiltrated into the sub-soil or collected in under-drain pipes and conveyed to an outflow facility. Infiltration Trenches are an adaptable practice that adequately remove both soluble and particulate pollutants. Infiltration Trenches are primarily an on-site control and are seldom practical or economical for drainage areas larger than 5 to 10 acres. Infiltration Trenches are one of the few practices that adequately provide pollutant removal on small sites or infill development. Infiltration Trenches preserve the natural groundwater recharge capabilities of a site and can often fit into margins, perimeters, and other unutilized areas of the site. A disadvantage is that Infiltration Trenches require careful construction, pretreatment, and regular maintenance to prevent premature clogging.

Infiltration Trench #2 - Similar to the trench system described above, this design accepts sheet flow from the lower end of a parking lot or paved surface. Runoff is diverted off the paved parking lot through slotted curbs. The slotted curbs function as a level spreader for stormwater. A grass filter strip separates the trench from the paved surface for capture of sediments. This trench includes a perforated PVC-type pipe for passage of large design storm events. At the end of the trench is a grassed berms to ensure that runoff does not escape.

Infiltration Basin - Infiltration Basins are an effective means for removal of soluble and fine particulate pollutants. Unlike other infiltration systems, basins are easily adaptable to provide full control for peak storm events. Basins can also serve large drainage areas (up to 50 acres). Basins are a feasible option where soils are permeable. Basins are advantageous in that they can preserve the natural water table of a site, serve larger developments, can be used as a construction sediment basin, and are reasonable cost effective in comparison to other practices. One disadvantage is the need for frequent maintenance. In addition, infiltration basins have sometimes failed because they were installed in unsuitable locations or soils.

Dry Well - A small infiltration system designed to accept stormwater from a roof-drain down-spout. Rather than dispersing its stormwater across a paved surface or grassed area, the down spout pipe connects directly into the dry well which filters roof top runoff into soils.

Porous Pavement - Porous Pavement is a permeable pavement having the capability to remove both soluble and fine particulate pollutants in urban runoff and provide groundwater recharge. Use is restricted to low traffic volume parking areas. Porous Pavement systems can receive runoff from adjacent roof tops. This reasonably cost-effective practice is only feasible on sites with gentle slopes, permeable soils, deep water tables and bedrock levels. Requires careful design, installation, and maintenance. Although Porous Pavement has the high capability to

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remove both soluble and fine particulate pollutants from urban runoff, it can become easily clogged and is difficult and costly to rehabilitate.

Evaluation

From a pollutant removal standpoint, Infiltration Trenches, Basins, and Porous Pavement have a moderate to high removal capability for both particulate and soluble urban pollutants, depending upon how much of the annual runoff volume is effectively exfiltrated through the soil layer. It should be noted that infiltration practices should not be entirely relied upon to achieve high levels of particulate pollutant removal (particularly sediments), since these particles can rapidly clog the device. For these systems to be effective, particulate pollutants must be removed before they enter the structure by means of a filter strip, sediment trap or other pre-treatment devices, and these devices must be regularly maintained.

In summary, infiltration systems can adequately remove soluble urban pollutants on smaller sites (10 acres or less). As a practice for controlling coastal non-point source pollution, infiltration systems should only be considered as part of an integrated system of management measures.

3. Filter Systems

The filter systems described below (and described in D(2) above) rely on various forms of erosion resistant vegetation to amplify particulate pollutant removal, improve terrestrial habitat, and enhance the appearance of a development site. In addition, filter systems can improve both the performance and amenity value of pond and infiltration practices via stormwater pretreatment, and can be used in such areas as golf courses and parks to intercept runoff and prevent its entry into surface waters and coastal shorelines.

Grass Filter Strip - Similar to a grassed swale, but can only accept overland sheet flow. Filter strips are effective when used to protect surface infiltration trenches from clogging by sediment. Effective in removal of sediment, organic material, and trace metals. Should be used as a component in an integrated stormwater management system. Filter strips are inexpensive to establish and cost almost nothing if preserved prior to site development. As with all filter systems, long-term maintenance (mowing, inspection for short circuiting, etc.), should be included in overall costs. Grass filter strips are discussed in detail in chapter 7 of this guidance.

Riparian Buffer Strip - Riparian buffer strips improve water quality by removing nutrients, sediment and suspended solids, and pesticides and other toxics from surface runoff, as well as subsurface and groundwater flows. The pollutant removal mechanism associated with riparian vegetation combines the physical process of filtering and the biological processes of nutrient uptake and denitrification. Riparian buffer strips are discussed in detail in chapter 7 of this guidance.

Grassed Swale - A grassed, low gradient conveyance channel that provides some water quality improvements for stormwater via natural filtration, settling, and nutrient uptake of the grass cover. Often used as an alternative to curb and gutter drainage conveyance. Grassed swales affect peak discharges by lengthening time of concentration. Can be fitted with low check dams to increase removal efficiency via temporary ponding.

Sand Filters - A water quality control filtration system used to remove large particulates from runoff and protect filter media from excessive sediment loading at stormwater quality control basins. Sand filters can be used independently or with a dry pond/basin element.

Peat/Sand Filters - A man-made soil filter system utilizing the natural absorptive features of peat. The system features a grass cover crop and alternating sub-layers of peat, sand, and a perforated pipe underdrain system. Systems are presently used for municipal waste effluent treatment and are being adapted for use in stormwater management.

Evaluation

Filter strips have a low to moderate capability of removing pollutants in urban runoff, and exhibit higher removal rates for particulate rather than soluble pollutants. Pollutant removal techniques include filtering through vegetation and/or soil, settling/deposition, and uptake by vegetation. Riparian buffer strips appear to have a higher pollutant removal capability than grass filter strips. However, length, slope, and soil permeability are critical factors which influence the effectiveness of any strip. Another practical design problem is prevention of stormwater from concentrating and thereby "short-circuiting" the strip.

Filter Systems are an essential component of a comprehensive nonpoint source control strategy, but should generally be used in conjunction with infiltration systems and/or pond systems, as a pre-treatment for runoff.

4. Source Control Systems

Source control systems reduce the availability of pollutants that can become entrained in stormwater runoff.

Street Maintenance - Implementation of street-cleaning programs, scheduled on a regular basis, can be effective at removing pollutants attached to fine sediment. Street-cleaning should occur on a more frequent basis during periods of more frequent storm events. Street maintenance can be effective in reducing the total amount of pollutant load which is carried off-site by runoff. Implementation of catch-basin maintenance and cleaning programs to remove sediment and debris from storm drains is an additional practice.

Leaf & Lawn Vegetation Collection - Implementation of leaf and lawn vegetation collection programs to reduce the amount of nutrient load in stormwater runoff can be an effective, yet

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inexpensive management practice. Collection frequency should be increased during autumn and spring periods of increased leaf fall.

Toxic and Hazardous Pollutants Recycling - Sources of toxic and hazardous pollutants can be identified and programs to educate and inform citizens about how to control and recycle them can be implemented. Used motor oil recycling programs are one example of this management practice.

REQUEST FOR COMMENTS

In Chapter 1 of this guidance (Introduction), EPA has generally requested submission of comments, information and data on relevant management practices, their effectiveness, and their costs. We also request specific comment on the following aspects of the urban stormwater management measures:

1. One of the stormwater management measures for control of the first flush of runoff, does not specify the amount of runoff to be treated or the length of time it should be treated. EPA requests comment and information on the costs and pollution reduction effects of specifying the treatment of the first flush of stormwater runoff by detaining at least 1/2 inch of runoff from the drainage area for 12-48 hours, depending on particle size and settling velocity. If this is not feasible or appropriate, what management measure should be established for controlling the first flush of urban stormwater runoff?

2. Another of the stormwater management measures calls for implementing source controls to reduce the availability of pollutants to be entrained in stormwater runoff, but does not specify source controls for runoff from service stations. Other, specific controls are listed in the section on recommended practices. EPA requests comment on the costs and pollutant reduction effects of specifying, in the management measure, service station runoff controls and collection systems, including the control of oil and grease through appropriate disposal methods utilized off-site.

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Florida Department of Environmental Regulation, The Florida Development Manual: Storm Water Management Practices (June 1988)

Metropolitan Washington Council of Governments, Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs (Washington, DC, 1987)

North Carolina Department of Natural Resources and Community Development, Erosion and Sediment Control Planning and Design Manual (September 1988)

USEPA, Urban Runoff and Stormwater Management Handbook (Chicago, 1990)

USEPA, Urban Targeting and BMP Selection (Chicago, 1990)

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IV. ROADS AND HIGHWAYS

A. Management Measure Applicability

This management measure applies to new and existing roads and highways located in coastal areas.

B. Pollutants of Concern

The primary pollutants associated with roads and highways are:

- Deicing chemicals
- Vehicular deposits
- Erosion and sediment
- Herbicides
- Dust, dirt, and debris

In areas where deicing agents are used, deicing chemicals and abrasives are the largest source of pollutants during winter months. The major source of pollutants are from vehicular deposits and runoff. (FHWA, US DOT, Technical Summary, Sources and Migration of Highway Runoff Pollutants, Reports No. FHWA/RD-84/057-060-XX, June 1987.)

Table 4-5 lists the pollutants found in stormwater runoff from roads and highways and their sources. The disposition and subsequent magnitude of pollutants found in highway runoff are site-specific and affected by traffic volume, highway design, surrounding land use, climate, and accidental spills. The major impacts of these pollutants can cause impairment to coastal area surface and ground waters.

C. Management Measures

The management measures for roads and highways are devised to (1) prevent direct discharge of stormwater runoff from impervious road surfaces into coastal receiving waters, and (2) to minimize the flow of runoff to coastal waters.

1. Location and Design

Locate roads and highways away from wetlands, critical habitat areas, and drainage channels in the coastal zone, and to minimize cut and fill. Design drainage systems to avoid direct discharge into surface waters. Additional management measures set forth in Section VIII of this chapter should be used where applicable.

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Table 4-5. Highway Runoff Constituents and Their Primary Sources

Constituents	Primary Sources
Particulates	Pavement wear, vehicles, atmosphere, maintenance
Nitrogen, Phosphorus	Atmosphere, roadside fertilizer application
Lead	Leaded gasoline (auto exhaust), tire wear (lead oxide filler material, lubricating oil and grease, bearing wear)
Zinc	Tire wear (filler material), motor oil (stabilizing additive), grease
Iron	Auto body rust, steel highway structures (guard rails, etc.), moving engine parts
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake lining wear, fungicides and insecticides
Cadmium	Tire wear (filler material), insecticide application
Chromium	Metal plating, moving engine parts, break lining wear
Nickel	Diesel fuel and gasoline (exhaust), lubricating oil, metal plating, bushing wear, brake lining wear, asphalt paving
Manganese	Moving engine parts
Cyanide	Anticake compound (ferric ferrocyanide, sodium ferrocyanide, yellow prussiate of soda) used to keep deicing salt granular
Sodium, Calcium, Chloride	Deicing salts
Sulphate	Roadway beds, fuel, deicing salts
Petroleum	Spills, leaks or blow-by of motor lubricants, antifreeze and hydraulic fluids, asphalt surface leachate
PCB	Spraying of highway rights-of-way, background atmospheric deposition, PCB catalyst in synthetic tires

Source: U.S. DOT, FHWA, Report No. FHWA/RD-84/057-060, June 1987.

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2. Construction

Minimize construction debris and deposits. Cut and fill areas are to be stabilized to prevent sink holes and erosion. Additional management measures set forth in Section II of this Chapter should be used where applicable.

3. Operation and Maintenance

Establish inspection and compliance programs. Stabilize slopes in accordance with Section II. Prevent herbicides from entering drainage systems. Maximize overland flow for runoff containing deicing salts and abrasives to prevent direct discharge to surface and coastal waters. Additional management measures for erosion and sediment control in Section III of this chapter also apply.

D. Management Practices

Following is a list of management practices for roads and highways that are available as tools to achieve the management measures specified above. These practices can be used separately or as combined systems and are applicable for new roads and highways, and are also suitable for retrofitting to existing roads and highways. See Sections II, III, and VIII for detailed information on extended detention ponds, wet ponds, infiltration practices, filter strips, and grassed swales.

In addition, the following practices can be effective:

(1) Washing and Cleaning- Wash construction vehicles to remove mud and other deposits prior to leaving the construction site. Construction vehicles entering or leaving the site with debris or other loose material should be covered with protective tarps. Construction materials and stockpiles on-site should be covered to prevent transport of dust, dirt, and debris. Install and maintain mud and silt traps.

Sweeping and vacuuming road surfaces is a practical means of removing accumulated dust, dirt, and debris. Road cleaning programs need to be effective at removing pollutants attached to fine sediment. Cleaning should occur on a scheduled basis with more frequent cleaning during periods of frequent storm events. This reduces the total amount of pollutant load which is carried away by runoff.

(2) Restabilize Slopes - Eroded slopes and washed-out areas should be stabilized with newly applied vegetative cover, rocks or gabions. Vegetative cover is preferred to reduce runoff and to filter/absorb pollutants. Vegetative materials that require minimal maintenance should be used.

(3) Herbicide Controls - Ensure proper handling, application, and disposal of herbicides used to control weeds and other unwanted vegetative material.

(4) Education Programs - Encourage public participation through programs such as " Adopt A Highway" to alert action to remove animal debris and wastes, and call attention to abuses affecting the disposal of toxic wastes such as waste crankcase oil into drainage systems.

(5) Water Quality Inlets - Current designs of water quality inlets appear to have low to moderate removal rates for particulate pollutants, and low to zero rates for soluble pollutants. Water quality inlets rely primarily on settling for removal, and given their small storage capacity and brief residence times, it is likely that only coarse grit, sand, and some silts will be trapped. Inlets do show some promise in removing hydrocarbons, such as oil, gas and grease, from runoff. Due to resuspension problems, however, pollutant removal can only be attained in water quality inlets if they are cleaned regularly.

E. Effectiveness and Cost

Effectiveness of each of the management practices identified, with approximate costs where available, are discussed in the appropriate sections referenced above. EPA intends to collect additional information on effectiveness and costs of these and the additional practices identified.

V. BRIDGES

A. Applicability

This management measure is applicable to new and existing bridges with solid roadways that cross coastal waters or their tributaries.

This management measure does not apply to U.S. Coast Guard-approved bridges that are covered by Nationwide Permit No. 15 issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act.

B. Problem Description

Bridge construction in coastal areas may cause significant erosion and sedimentation resulting in the loss of wetlands and riparian vegetation. Runoff from bridges may deliver considerable loadings of heavy metals, hydrocarbons and toxic substances from cars and de-icing of roads as a result of direct delivery through scupper drains into coastal waters with no overland buffering or treatment. Maintenance of structures can result in runoff and direct discharge of lead, rust, paint, particulates, solvents, and cleaners.

C. Management Measures for Bridges

The management measures for bridges are devised to control direct delivery of pollutants to coastal waters and reduce the pollutants which reach coastal waters in stormwater runoff.

(1) Site new bridges so that significant adverse impacts to wetlands and riparian vegetation are minimized.

Implement applicable measures identified in Development Section VIII.

(2) Design new bridges to reduce the amount of pollutants transported to surface water, where appropriate.

Route runoff to land for treatment in accordance with management measures for stormwater runoff identified in Section III.

(3) Control sedimentation activities during bridge construction (especially on steep slopes at crossing).

Implement applicable measures identified in Construction Section II.

(4) Control sediment from dredging.

(5) Reduce the delivery of any pollutants used or generated during maintenance

operations (paint, rust and paint removal agents) to coastal waters by capturing, containing storing and properly disposing of work or waste materials. (COMAR)

D. **Management Practices**

(1) Site bridges as far as possible from wetlands, sensitive areas such as shellfish beds, and critical habitat areas.

(2) Limit the use of scupper drains (which drain runoff directly into coastal waters) on bridges. Scupper drains allow runoff in the bridge gutters to drain directly into coastal waters (South Carolina Coastal Council Policy).

(3) Capture, contain and collect scrapings, paint, and sand blast material that could fall into coastal waters using suspended tarps, vacuums, or booms in water.

(4) Require proper disposal of wastes; prohibit the disposal of any waste material into coastal waters.

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VI. HOUSEHOLD MANAGEMENT MEASURES

A. Applicability

The following management measures apply to households and workplaces.

B. Pollutants Generated

Pollutants generated from households include:

(1) Household toxics - used oil, paint, solvents and pesticides
(2) Nutrients - nitrogen and phosphorus
(3) Pathogens - bacteria, fecal coliform and other pathogens

Municipal housekeeping and homeowner participation have been shown to have an effect on water quality especially in areas of high population density (The Jones Falls Watershed Urban Stormwater Runoff Project, 1986). Public education and outreach are crucial to the effectiveness of these measures.

The main sources of household pollution are:

- Landscaping activities - erosion (see construction section)
- Lawn/garden care - over-fertilization, unnecessary herbicide or pesticide use, improper leaf management
- Household toxics - improper disposal of oil/grease, antifreeze, paint, household cleaners and solvents
- Pets - improper disposal of fecal matter
- Car/boat care - poor maintenance, washing

C. Management Measure

Communities should establish and implement programs to educate, assist, and where appropriate, require households and workplaces to minimize the introduction of pollutants and pollutant sources into surface water or terrestrial areas in a manner that may result in runoff to surface or ground waters.

D. Management Practices Available as Tools to Achieve the Management Measure

The management practices listed below are principles and tools that local communities may use to build household management programs to achieve the management measure in section VI.C. These practices are arranged by source and implementable on an individual basis. These practices, based on the principle of source reduction, are self-implementing, reduce use of materials and in general lower operating and maintenance costs to existing pollution reduction systems:

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(1) Lawn Management and Landscaping

- Reduce herbicide application and watering by mulching to retain moisture and inhibit weeds
- Do not apply pesticides or fertilizers before rainstorms or pesticides on windy days; reduce chemical lawn additives to bare minimum or use organic methods; test soils for nitrogen and phosphorous content before fertilizing; leave grass clippings on lawn to provide nutrients; compost leaf matter and other yard waste; avoid late spring fertilization; use manual or mechanical weed control methods where possible
- Prevent soil erosion - do not mow within 5 feet of water body; plant ground cover in bare areas; reduce disturbed areas as much as possible
- contour lawns to avoid erosion, impede runoff and facilitate infiltration
- limit amount of water applied to lawns and gardens; water only when necessary preferably in the morning

(2) Household Toxics

- Dispose of used paints, pesticides, toxic household cleaners and solvents at hazardous waste collection centers
- Recycle used oil at designated service stations or collection centers
- Soak up oil spills and other automobile fluid leaks with absorbent materials; place used material in municipal trash
- Minimize use of toxic cleaners, encourage use of biodegradable cleaners.

(3) General

- Refrain from placing materials down the storm drains; keep drains clear of foreign matter
- Retain as much permeable area as possible; consider alternatives to concrete such as permeable pavement or flagstones
- Use phosphate free detergents

(4) Pet Wastes

- Manage pet waste to minimize runoff into surface waters

(5) Car/boat Care

- Dispose of antifreeze down household drain while running tap water (this practice is not applicable for septic systems)
- Minimize use of antifouling paint; dispose paint and paint scrapings at hazardous waste collection center
- Use biodegradable cleaners

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- Use absorbent materials (e.g., cat litter) to soak up household chemical spills or engine leaks

E. **Effectiveness**

Pet waste control has been shown to remove greater than 50% of nutrients and pathogens (Maryland Regional Planning Council, 1986). The Agencies solicit information on cost and effectiveness of the above practices.

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VII. ONSITE SEWAGE DISPOSAL SYSTEMS

A. Applicability

This management measure applies to any residential sewage that is not treated or planned for treatment in a centralized public sewer system. Onsite sewage disposal systems (OSDS) include conventional septic systems, large scale conventional systems, alternative and innovative designs, and private sewage treatment facilities.

B. Coastal Water Pollution Caused by Onsite Sewage Disposal Systems

Proper treatment of wastewater effluent with onsite disposal systems is an essential component of coastal water quality protection. When properly sited, designed, installed, and maintained, individual sewage disposal systems can be used to treat most pollutants found in household waste simply and effectively. Treated wastewater usually reaches coastal waters by groundwater recharge or by groundwater/surface water interfaces.

1. Nutrients Cause Eutrophication

Nitrogen is generally not removed by conventional onsite systems, and can therefore cause eutrophication in coastal areas. For example, Nixon (1982) found OSDS effluent to contribute an estimated 12 to 44 percent of the annual nitrogen load to eight south shore coastal lagoons in Rhode Island.

Under most conditions, phosphorus tends to be attenuated quickly and effectively by soil processes. Except in sensitive waterbodies (including fresh waters and some fresher inshore sectors of estuaries), phosphorus presents less hazard as a transportable nutrient than does nitrogen. In sensitive phosphorus limited waterbodies, however, extremely low phosphorus concentrations can induce eutrophication, and concern is warranted. For example, Sikora and Corey concluded that phosphorus contamination of groundwater could be anticipated primarily in sandy soils with low organic matter content, soil having high water table, and shallow soils over creviced bedrock. Systems in sandy soil near surface water bodies, therefore, are most likely to contribute phosphorus loading to receiving waters.

2. Nitrogen/Pathogens Cause Drinking, Swimming, and Shellfish Contamination

Many coastal areas depend on groundwater sources for water supplies, and are vulnerable to loss of supplies to OSDS-related contamination. EPA has established a drinking water standard of 10 mg/L nitrate nitrogen to reduce the risk of infant cyanosis or methemoglobinemia caused by elevated nitrate levels in drinking water. Improperly treated OSDS effluent can also create significant health hazards if pathogens (bacteria & viruses), which may be present in effluent, contaminate groundwaters, saturated surface soils, or coastal waters. Research indicates that bacteria and viruses are capable of traveling considerable distances, and that transport may be particularly rapid in highly permeable soils. Heufelder (1988) prepared an extensive review of many pertinent issues relating to entrainment of nonpoint source pathogens in groundwater, transport of groundwater entrained organisms in estuarine areas, and survival of viruses in marine systems. In many coastal states, closure of shellfish areas and swimming areas, and restriction of other beneficial uses, have been attributed to pollutant concentrations traceable to improperly functioning septic systems within the contributing watershed or recharge area.

3. Poorly Operating Systems Worsen Problems

The degree of the problems can increase significantly in poorly operating systems. In overt system failure, soils can no longer accept effluent and sewage may break out onto the ground surface where it is transported by drainage systems or overland runoff to surface runoff. Overland pipes and subsurface drainage pipes, designed to prevent system flooding, may intercept contaminated groundwater and discharge contaminants directly to surface waters. Hydraulic overloading(too much wastewater for the system to handle) can cause bacteria, viruses, and nutrients to enter coastal waters via groundwater. Often, both groundwater and surface waters are vulnerable to contamination, due to coastal areas' susceptibility to flooding and sea level rise, high water tables, and groundwater recharge of coastal embayments.

C. Management Measures

Five management measures apply to OSDS in coastal areas. The goals of the management measures are to: (1) minimize pollutants discharges to OSDS; (2) minimize the flow of water to OSDS through conservation, thereby prolonging OSDS life and improving operation, and (3) minimize or eliminate the discharge of nutrients, pathogens (viruses & bacteria), and other pollutants from the OSDS into ground and surface waters.

1. Phosphate Limits in Detergents

a. Management measure

Detergents should contain low amounts of phosphates. Phosphate restrictions are already in place in many coastal States, including the District of Columbia, Indiana, Maryland, Michigan, Minnesota, New York, Virginia, Wisconsin (see Table 4-6).

This measure is especially protective of systems located near where groundwater discharges to the surface or that are failing/overloaded, enabling phosphorus to reach sensitive, phosphorus limited embayments.

b. Effectiveness/Costs

The use of these detergents in place of high phosphate detergents is expected to reduce the loadings of phosphates to OSDS by 50 percent (EPA, 1980). Cost should be negligible.

Table 4-6. Phosphate Limits in Detergents

State	Phosphorus (P) Laundry Detergents	Phosphorus (P) Dishwashing Detergents	Phosphorus (P) Levels Industry
District of Columbia	≤ 0.5% by weight as elemental P		
Indiana [1,2]	≤ 0.5% by weight as elemental P		1mg/L total P effluent conc. at discharges ≥ 3,785m³/d (1MGD) within Great Lake Basin
Maryland	≤ 0.5% by weight as elemental P	≤ 8.7% by weight as elemental P	
Michigan[1]	≤ 0.5% by weight as elemental P	≤ 8.7% by weight as elemental P	1mg/L total P effluent conc. at discharges ≥ 3,785m³/d (1MGD) within Great Lake Basin
Minnesota[1]	≤ 0.5% by weight as elemental P		1 mg/L total P effluent conc. at discharges ≥ 3,785m³/d (1MGD) within Great Lake Basin
New York[1]	≤ 0.5% by weight as elemental P		1mg/L total P effluent conc. at discharges ≥ 3,785m³/d (1MGD) within Great Lake Basin
Wisconsin[1]	≤ 0.5% by weight as elemental P		1mg/L total P effluent conc. at discharges ≥ 3,785m³/d (1MGD) within Great Lake Basin

1 Sonzogni, William, and Thomas Heidtke. 1986. "Effect of Influent Phosphorus Reductions on Great Lakes Sewage Treatment Costs." Water Resources Bulletin AWRA 22:4 (623-627).

2 Indiana Administrative Code. 1991. Cumulative Supplement. Title 327 IAD 2-5-1.

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2. **High Efficiency Plumbing Fixtures**

a. **Management measure**

New or replacement plumbing fixtures should be high-efficiency. Plumbing fixtures in failing systems should be replaced as soon as possible.

b. **Effectiveness/Costs**

Water conservation will help solve hydraulic overloading problems and reduce the cost of retrofit management measures for system improvement and nitrogen removal. Modern, high efficiency fixtures include: 1.5 gallon or less per flush toilets, 2.0 gallon per minute (gpm) or less shower heads, faucets of 1.5 gpm or less, and front loading washing machines of up to 27 gallons per 10 to 12 pound load. These can result in a 30 to 70 percent reduction of total in-house water use (Consumer Reports July 1990 and Feb. 1991 and Krause, et al, 1990). When used in connection with management practices for new and replacement construction, the reduced flows save costs by reducing the size of new and retrofit treatment facilities, extending the life of OSDSs, increasing performance of existing facilities, and lowering costs of operation for holding tanks. Cost savings have also been documented due to reduced demands for potable water (Logsdon, 1987). The cost is minimal, especially for replacement when a fixture breaks.

3. **Garbage Disposals**

a. **Management measure**

Garbage disposal use should not be allowed when an on-site system is failing. Garbage disposals should generally be avoided to: (1) reduce loadings of nitrogen to OSDS, and (2) reduce solids/BOD and decrease pumping frequency for septic/holding tanks.

b. **Effectiveness/Costs**

The use of a garbage disposal contributes substantial quantities of biochemical oxygen demand (BOD), suspended solids, and nutrients to the wastewater load (Table 4-7). As a result, it has been shown that the use of a garbage disposal may increase sludge and scum, and also produce a higher failure rate for conventional OSDS under otherwise comparable situations (EPA, 1980). Also, most waste handled by a garbage disposal could be handled as solid wastes, either for compost piles or trash pick up to public landfills. The cost is minimal as other disposal options are available, such as home composting and solid waste removal to municipal disposal sites. The effectiveness would be to remove from the total household loadings to the OSDS about 28 percent of the BOD, 37 percent of suspended solids, 5 percent of total nitrogen, and 2 percent of total phosphorus from entry into OSDS's (Table 4-7).

Table 4-7. Pollutant Contributions of Major Residential Wastewater Fractions (gm/cap/day)

Parameter	Garbage Disposal	Toilet	Basins, Sinks, Appliances	Approximate Total
BOD_5	18.0 (10.9 - 30.9)	16.7 (6.9 - 23.6)	28.5 (24.5 - 38.8)	63.2
Suspended Solids	26.5 (15.8 - 43.6)	27.0 (12.5 - 36.5)	17.2 (10.8 - 22.6)	70.7
Nitrogen	0.6 (0.2 - 0.9)	8.7 (4.1 - 16.8)	1.9 (1.1 - 2.0)	11.2
Phosphorus	0.1	1.2 (0.6 - 1.6)	2.8 (2.2 - 3.4)	4.0

Means and ranges of results reported by EPA, 1980.

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4. Onsite Sewage Disposal Systems for Removal of Pathogens, Phosphorus, BOD

a. Management measure

A properly designed and maintained septic system, with appropriate set-backs from coastlines based on soil types, should be used to achieve almost complete removal of pathogens, phosphorus, and BOD within the property line of an individual residence.

b. Effectiveness/Costs

Modern conventionally designed septic systems are composed of a building sewer, a septic tank, a distribution box, and a drainfield or leachfield. Most solids entering the septic tank settle to the bottom and are partially decomposed by anaerobic bacteria. Some treatment of the wastewater occurs in the septic tank, which is primarily designed to remove 30-40% of the biochemical oxygen demand (BOD) and most solids to prevent their entering the drainfield. Periodic septic tank pumping is essential to preserve the capacity of the tank and prevent clogging of the drainfield and premature system failure. Periodic inspections should be required. The liquid effluent from the tank is discharged to a distribution box, which separates effluent flow into approximately equal flow, for discharge to a drainfield perforated pipe network, usually crushed stone surrounded by native soil. Once in the drainfield, effluent leaving the perforated pipe network percolates through the crushed stone and moves downward into the underlying soil material where treatment takes place. Nutrients and pathogens may be mechanically filtered out, microbially decomposed, or chemically attached to soil particles. The rate and efficiency of this treatment depends upon the characteristics of the soil, depth to water table, and the nature of the wastestream.

There are a number of alternative designs which apply to areas of high water tables, sandy soils, and other site specific factors. Some of these are discussed below and in the EPA Onsite Wastewater Treatment and Disposal Systems Design Manual, 1980 - which is being updated. Costs of a Septic System usually range from $4,000 to $10,000.

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5. Onsite Sewage Disposal Systems for the Removal of Nitrogen

a. Management measure for OSDS in existing development

Install Denitrifying Treatment Systems where appropriate to reduce nitrogen from existing onsite sewage disposal systems.

b. Practices available to achieve this management measure

A number of treatment systems, two of which are identified below, are known to remove nitrogen using denitrification, which is carried out under anoxic conditions by microorganisms which convert nitrate to nitrogen gasses. Most are in early stages of development and require nitrification of septic tank effluents as an intitial part of the treatment process, because between

65%-75% of the total nitrogen in septic tank effluents is in ammonia form. Operation and maintenance of denitrification systems are complex. EPA solicits cost and effectiveness information on these and other systems to remove nitrogen onsite from sewage.

(1) Intermittent Sand Filters - The intermittent sand filter consists of a pretreatment unit such as a septic tank, a dosing unit, and a sand filter with underdrains. A sand filter is an open bed of 2 to 3 feet of sand underlain by graded gravel with collector drains. Dose recycling between sand filter and septic tank can reportedly remove 50 to 70 percent of the total nitrogen. These systems can also treat BOD and suspended solids to less than 10 mg/l and pathogens to 100 to 900 colonies/100 ml. To meet the management measure for BOD, suspended solids, and pathogens a leaching field, either existing or new, must be included. Costs from $5,000 - $10,000.

(2) Upflow Anaerobic Filter (UAF) and Sand Filter - The UAF and sand filter are an emerging technology which could provide nitrogen removal from existing onsite disposal systems. The UAF is a tank resembling a septic tank filled with 3/8 inch gravel with a deep inlet tee and a shallow outlet tee. Dosed recycling between the sand filter and UAF has been shown in research to result in 60-75 percent overall nitrogen removal. This technology would have to be used between existing septic tanks and leaching fields to provide equivalent removal of other pollutants. Costs from $3,000 - $8,000.

c. Management measures for OSDS in new development

Use either a wastewater separation or siting approach to minimize nitrogen discharges from OSDS in areas of new development.

d. Practices available to implement this management measure

(1) Wastewater Separation with Holding Tank (Blackwater) and Conventional System (Greywater) - Wastewater separation consists of separating toilet wastes (blackwater) from other residential wastes (greywater) using watertight holding tanks, hauling the blackwater offsite, and treating of greywater in a conventional septic tank and absorption field.

Coupled with elimination of garbage disposals, the waste separation with holding tanks for blackwater and conventional treatment for greywater is expected to result in a reduction of 55 percent of the BOD, 75 percent of the suspended solids, 83 percent of the nitrogen, and 32 percent of phosphorus. The remaining pollutant loadings in greywater, except for nitrogen, will be removed by conventional treatment. The effectiveness of this measure is dependent on periodic inspections of the holding tank, routine pumping and hauling, and effective treatment of the hauled waste. The incremental cost increase in new construction will be for the

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additional plumbing, for which EPA, soliciting cost information, and a water-tight holding tank, which should cost about $1,000. The costs to haul and treat the blackwater will be about $200/yr to haul it a reasonable distance plus treatment costs.

(2) Site Density Controls to Limit Loadings of Nitrogen to Coastal Waters - The total loadings of nitrogen from combined OSDS can be controlled to the equivalent treatment level of the nitrogen management measures using low density zoning or other site restrictions to limit the number of sources in a discrete area under the control of one or more jurisdictions.

D. Other Practices That May Be Used as Tools to Achieve OSDS Management Measures

Many practices are available or being developed which could treat pollutants from OSDS to levels equivalent to those obtained using the Management Measures above. These include:

(1) Wastewater Separation and Hauling for Existing Systems - Low volume toilets would result in pumping/hauling costs of 200 dollars per year (at $50 every 3 months), but the high cost and inconvenience for replumbing residences to separate sewer lines is expected to make this option less preferable than some practices discussed above. Estimated removals due to separation and hauling of blackwater (including elimination of garbage disposals) will be the same as in 5.d.i. above. Existing conventional treatment for greywater would likely remove pathogens and the remaining BOD and suspended solids unless the system is failing.

(2) Wastewater Separation and RUCK Systems - This system may be used in lieu of hauling separated wastes. A RUCK system is designed to nitrify blackwater in a buried sand filter and then mix the nitrified blackwater with greywater in an anaerobic tank. The greywater provides the carbon source for denitrification within the anaerobic tank. Final disposal of the effluent is in a conventional soil absorption system. The RUCK system requires blackwater/greywater separation, tanks and a buried sand filter. Supposedly, effectively treats BOD, suspended solids, and as much as 50 percent of the nitrogen. The Agency is soliciting for actual application and cost-effectiveness data.

(3) Holding Tanks for All Wastewater from Existing Systems - Holding tanks are most effective as controls for all pollutants but are usually too costly an option for existing housing due to the high cost of pumping and hauling. A watertight holding tank of a 1000 gallon capacity would have to be pumped out every 5-10 days at 50 gallons/capita/day and a family of four, even with flow reduction from high efficiency fixtures. At 50 dollars per load the operating cost is 150-300 dollars per month.

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(4) Elevated Sand Mounds - A mound system is a pressure dosed, absorption system that is elevated above the natural soil surface in a sand fill. The general design configuration overcomes certain site restrictions such as slowly permeable soils, shallow permeable soils over porous bedrock, and permeable soils with water tables somewhat higher than otherwise allowable by local codes. This system consists of a septic tank, dosing chamber, and the elevated mound, and can treat septic tank waste effluent to approach Primary Drinking Water Standards for BOD, suspended solids, and pathogens. Nitrogen is not usually removed. Costs are $7,000 with a septic tank.

(5) Evapotranspiration Systems - Evapotranspiration (ET) Systems combine the process of evapotranspiration from the surface of a bed and transpiration (water used by plants) to dispose of wastewater. Wastewater is given pretreatment by some mechanism, such as a septic tank or aerobic unit. It then flows into the ET system for final treatment and disposal. An ET bed usually consists of a liner, drainfield tile, and gravel and sand layers. ET systems can be a viable means of on-site disposal where evapotranspiration rates consistently exceed rainfall. A majority of the systems in use in the United States are combinations of evapotranspiration and soil absorption systems. Properly designed, sited, and maintained, this system should provide no discharge of wastewater. Construction costs are expected to be high. Careful inspection of the linerbed and periodic checks of the ground water are required to insure integrity of the liner.

(6) Wetlands and Greenhouses - These are new, innovative approaches which are climate specific, delicate, and expensive to operate and maintain. The Agency solicits data on design, effectiveness and cost.

E. Implementation

Effective implementation of the OSDS measure generally depends on formation of specific wastewater management entities. With adjoining communities, local governments should consider adoption of joint wastewater management districts to complement inter-local facilities planning and community education for sewage and septage disposal. Public education and outreach can effectively address the ineffectiveness and dangers associated with use of septic tank cleaners/additives, and disposal of paint/thinners in OSDSs. Density zoning and similar practices also become valid alternatives to these management measures when developed jointly by districts that represent large coastal areas.

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VIII. URBAN RUNOFF IN DEVELOPING AREAS

A. Applicability

This management measure is applicable to areas which currently contain significant undeveloped areas which are or will be experiencing development. This measure is in addition to other applicable management measures contained in this chapter that may apply to such areas.

B. Urban Runoff Problems in Developing Areas

The problems caused by urban runoff in developing areas are the same as those discussed generally for urban runoff elsewhere in this chapter.

C. Management Measures for Urban Runoff in Developing Areas

Undeveloped areas provide the opportunity for local communities to implement solutions that are either unavailable or costly to implement in areas that are already heavily developed. These opportunities include the ability to apply siting criteria and processes, as specified in section 6217(g)(5), to encourage development to take place in a manner that is compatible with maintaining water quality. This section contains management measures that focus on those opportunities:

(1) Maintain natural hydrology at both the watershed and site levels. In practice, this often is achieved by: 1) minimizing impervious surface area 2) protecting natural vegetation and 3) retaining natural drainageways to the maximum extent possible;

(2) Minimize disturbance of unstable areas: locate development on the most suitable areas within the watershed and within individual sites; direct development away from critical areas within the watershed such as steep slopes and highly erodible soils;

(3) Protect natural forms which contribute to beneficial water quality impacts within the watershed, i.e., wetlands, forest areas and riparian areas; where possible, contiguous buffer areas within the watershed should be retained.

D. Practices Available as Tools to Implement the Management Measures

This section discusses practices that available as tools to achieve the management measures set forth in section VIII.C. The key opportunity to protect water from urban nonpoint pollution occurs prior to development. Local communities and state and regional agencies have found that pre-development protection can best be provided through the adoption of environmentally-based decisions to govern the development process. The greatest level of coastal protection is afforded where a single development ordinance is adopted by a community, and administered by a single

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authority within that community. Practices available to the regional and local authorities include:

1. District Classification System

District classification systems can be used to direct heavy development away from sensitive areas and assure any development in sensitive areas is limited in a manner that protects and sustains water quality. The use of districting controls allows local authorities to address preservation of critical areas necessary for coastal water quality protection and retain flexibility in planning development.

2. Environmental Reserves

Environmental reserves include, but are not limited to, establishing a comprehensive buffer system for protection of environmentally sensitive coastal areas. The preservation of these areas can greatly reduce the detrimental impacts commonly associated with coastal NPS pollution. The following buffers and development restrictions are useful tools to help coastal communities maintain the integrity of coastal environmental resources.

(1) Stream Buffers - A stream buffer is a variable width strip of vegetated land for protection of water quality, aquatic and terrestrial habitats. Development should not be allowed within a variable width buffer strip on each side of an ephemeral and perennial stream channel. Minimum widths for buffer strips of 50 feet for low-order headwater streams and 200 feet or more for larger streams, are recommended. Stream buffers should be expanded to include floodplains, wetlands, steep slope areas, and open space to form a contiguous system.

(2) Wetland Buffers - No habitat disturbing activities should occur within tidal or non-tidal wetlands and a perimeter buffer area (a 25 - 50 foot buffer is recommended).

(3) Coastal Buffers - A coastal buffer is a variable width strip of vegetated land preserved from development activity to protect water quality, aquatic and terrestrial habitats. A 100 foot minimum buffer of natural vegetation landward from the mean high tide line is recommended to remove or reduce sediment, nutrients, and toxic substances from entering coastal waters.

(4) Expanded Buffers - Buffers should be expanded to include contiguous sensitive coastal areas which, if developed or disturbed, may impact streams, wetlands, or other aquatic environments. Expansion of buffers is a good practice whenever new land development or other disruptive activities occur.

3. Site Design

Site design can be used to identify the best site-specific practices to minimize site imperviousness, attenuate runoff from development and also improve the effectiveness of the conveyance and treatment components of a runoff control system. Two highly effective tools are clustering and fingerprinting.

(1) Cluster - Clustering concentrates development and construction activity to a limited portion of the site while leaving the remaining portion undisturbed. Concentrating developed areas allows stormwater to be more effectively treated by a system of runoff management practices.

(2) Site Fingerprinting - The total amount of disturbed area within a site can be minimized by fingerprinting development. Fingerprinting can reduce impacts to surface waters by locating development outside of environmentally sensitive areas which buffer runoff or which may be more prone to erosion (steep slopes). Further erosion and sediment control is achieved by disturbing areas only where structures, roads, and rights of way will exist after construction is complete.

E. Additional Practices Available as Tools to Control Urban Runoff

(1) Floodplain Limits - Limiting development to areas outside of the boundaries of the recommended post development 100 year floodplain will preserve streamside buffers necessary for biofiltration and generally eliminate any needed future flood protection.

(2) Steep Soils Limits - Slope restrictions help reduce erosion and sediment loading. Clearing or grading should generally not occur on slopes in excess of 25%.

(3) Watershed plans - Watershed plans identify existing or potential water quality problems within the watershed, define goals to address water quality problems, and specify measures or practices to prevent or mitigate degradation of water quality.

(4) Environmental Impact Statements (EIS) - An EIS identifies significant environmental impacts from potential development, including water quality impacts, and provides alternatives to minimize short and long term impacts of the proposed development.

(5) Offsets - Structures or actions that compensate for undesirable impacts. Offsets can be a tool to help communities minimize the construction of impervious surfaces and provide other forms of water quality protection. Methods used to meet this goal include reduced side walk widths, the use of porous or gritted pavement and the design of narrow-width roadways in low density residential development.

(6) Capital Improvement Plans (CIP) - Localities may use the development of capital facilities, roads, and sewage lines and POTWs, to guide development in coastal areas away from sensitive areas which protect coastal water quality. Localities can adopt CIPs which describe the location and timing for capital improvements, etc. By establishing development schedules, the locality finalizes those improvements it will implement within a given period (usually 5 years). This type of development may provide incentives to developers to cluster around these improvements and reduce development of critical areas.

(7) Wetland Protection - Tidal and Non-tidal wetlands are vital to the maintenance of water quality in addition to providing flood control benefits. In many cases, the establishment of a stream or coastal buffer will have already protected these important areas. (See the Biofiltration section of this guidance.)

(8) Forest Protection - Forests filter runoff and are a protective land use which provides significant water quality and wildlife habitat benefits. Where possible, tree-save areas should be large blocks and linked to the buffer system rather than small isolated stands. Studies have indicated that linked areas provide more effective sediment filtration and erosion control. (See Chapter 7 of this guidance.)

F. Examples of State and Local Implementation of Management Measures for Development

Maryland Chesapeake Bay Critical Areas Program
Oregon State Land Use Program
Austin, TX Comprehensive Watershed Protection Act
North Carolina Coastal Area Management Act

G. Effectiveness and Cost

Table VIII.1 provides information on effectiveness and cost for various environmental reserve and site design practices.

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Table 4-8. Zoning/Land Use Effectiveness

	Legend	Minimize Imperviousness	Flexible Road Layout	Soil Infiltration	Site Fingerprinting	Performance Criteria	Cluster	Open Space Protection	Habitat Protection	Forest Protection	Wetland Protection	Septic Limits	Steep Soils Limits	Floodplain Limits	Expanded Buffers	Coastal Buffers	Wetland Buffers	Stream Buffers	Performance Zoning	Overlay Zones	Protection Zones	Rural Zones	Intense Zones
		SITE PLANNING						ENVIRONMENTAL RESERVES											COASTAL DENSITY SYSTEMS				
General		●	●	●	◐	●	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	●	●	◐	◐	◐
Nutrient Control	● 0-40% High Level of Control ◐ 30-40% Moderate Level of Control ○ 0-20% Low Level of Control ⊗ Ineffective	○•	○•	◐	○•	●	○•	○	○	○	●	◐	○	◐	●	◐	◐	◐	◐	◐	◐	○	○
Shellfish	● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	○•	○•	○•	◐	●	◐	○	○	◐	◐	●	○	○	●	●	○	◐	◐	●	●	◐	○
Estuarine Habitat Protection	● Directly Protects ◐ Indirectly Protects ○ No Protection ⊗ Not Related	○	○	○	◐	●	○	◐	●	◐	●	○	◐	●	●	●	●	●	◐	●	●	◐	○
Sedimentation	● 80%+ High ◐ 30-80% Med ○ 0-30% Low ⊗ Ineffective	○	○	○	●	●	○	○	○	◐	◐	○	●	○	●	◐	◐	◐	◐	◐	●	◐	○
Sediment Toxics	● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	◐	◐	●	◐	○
Stormwater Control	● Highly Effective ◐ Moderately Effective ○ Low Effectiveness ⊗ Ineffective	◐	○•	◐	◐	●	○•	○•	○•	○•	◐	⊗	◐	◐	○•	○•	○•	○•	●	◐	●	◐	○
Feasibility in Coastal Areas	● Widely Applicable ◐ Applicable Depending on Site ○ Seldom Applicable ⊗ Not Applicable	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Maintenance Burdens	● Low Burden ◐ Moderate Burden ○ High Burden ⊗ Not Applicable	●	◐	◐	○	●		●	●	●	●	●	●	●	●	●	●	●	⊗	⊗	⊗	⊗	⊗
Longevity	● Long Lived ◐ Long Lived w/Maintenance ○ Shortlived ⊗ Not Applicable	●	◐	◐	○	●		●	●	●	●	●	●	●	●	●	●	●	⊗	⊗	⊗	⊗	⊗
Community Acceptance	● Positive ◐ Neutral ○ Negative ⊗ Mixed	◐	◐	●	○	◐		●	●	●	●	◐	◐	◐	◐	●	●	●	○	○	○	○	○
Secondary Environmental Impacts	● None or Positive ◐ Slight Negative Impacts ○ Strong Negative Impacts at Some Sites ⊗ Prohibited	●	◐	●	○	●		●	●	●	●	●	●	●	●	●	●	●	◐	◐	●	◐	○
Cost to Developers	● Low ◐ Moderate ○ High ⊗ Very High	●	○	◐	○	●		○	◐	○	◐	○	◐	◐	◐	○	○	◐	◐	◐	●	◐	○
Cost to Local Governments	● Low ◐ Moderate ○ High ⊗ Very High	●	●	●	○	●		●	●	●	●	◐	●	●	●	◐	●	●	◐	◐	◐	◐	◐
Difficulty in Local Implementation	● Easy ◐ Moderate ○ tough ⊗ Very Tough	◐	◐	◐	○	○		◐	◐	◐	●	○	●	◐	○	○	●	◐	◐	◐	◐	○	○
Site Data Required	● Simple ◐ Moderate ○ Complex ⊗ None	◐	◐	◐	○	◐		◐	○	◐	○	◐	●	◐	○	●	●	●	○	○	◐	◐	◐
Water Dependent Use	● Can Be Used Moderately in These Areas ◐ Sometimes Can Be Used ○ Seldom Used ⊗ Not Used	○	●	●	●	●		●	●	●	●	◐	◐	○	●	●	●	○					

• Indicates Site Rating

Source: Metropolitan Washington Council of Governments, Draft, 1991

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CHAPTER 5. MANAGEMENT MEASURES FOR MARINAS AND RECREATIONAL BOATING

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CHAPTER 5

MANAGEMENT MEASURES FOR MARINAS AND RECREATIONAL BOATING

I. INTRODUCTION

Properly designed and operated marinas can reduce impacts to the marine environment, as well as benefit the boating public. Many NPS impacts of boats can more easily be prevented and contained at the centralized site a marina provides, than at individual docks and moorings. Denying opportunities for marina development does not necessarily prevent NPS impacts. Ensuring the best possible siting for marinas, as well as best available design and construction practices and ensuring appropriate marina and boating operations and maintenance procedures can greatly reduce NPS pollution from marinas.

The management measures or systems of best management practices described in this chapter are designed to reduce NPS pollution from marinas and recreational boating. Effective implementation will:

- Prevent the introduction of nonpoint source pollutants (or impacts) at the source and/or,

- Reduce the delivery of pollutants from the source to water resources.

This chapter specifies the management measures (in Sections III.B., IV.B., and V.B.) that represent the best systems of practices available to prevent NPS pollution from marinas and recreational boating or reduce NPS pollutant delivery from these sources to coastal waters. The management measures are grouped in three categories: siting (III.B.), design (IV.B.), and operation and maintenance (V.B.). For each of these three categories, following the management measures, the guidance provides information on a variety of practices that may be used as tools to accomplish the management measures. An attempt is also made to identify effectiveness of these measures, or performance goals that can be achieved by these measures. Comments are welcome on the composition, effectiveness and cost of these management measures.

It is expected that each coastal State's decision on implementation of these management measures will be based on the management strategy developed as part of its vision for the future. Pollution prevention should be at the fore of any such strategy. Hence, while flexibility is a keystone we expect that all States will need a process for State or local-level review/ management of environmental impacts from marinas and recreational boating.

A site selection process based upon a clear understanding of potential water quality impacts is the most important factor for avoidance of NPS pollution from marina development and operation. Determination of potential water quality impacts as part of the marina siting process can avoid NPS pollution impacts and degradation of the water body, also protecting designated uses.

A. Nonpoint Source Pollution Impacts from Marinas and Associated Boating Activities

Nonpoint pollution from marinas and recreational boating activities may result in detectable adverse environmental effects to nearby water column and benthic resources. These impacts can be caused by physical and chemical disturbances. A few important examples of these impacts include:

- Toxicity in the water column, both lethal and sublethal, related to decreased levels of dissolved oxygen and elevated levels of metals and petroleum hydrocarbons,
- Increased levels of metals and organic chemicals in the tissues of organisms such as algae, oysters, mussels or other filter feeders,
- Increased levels of pollutants in sediments resulting in toxicity or avoidance of the area by benthic organisms,
- Levels of pathogen indicators that result in shellfish bed or swimming area closure,
- Disruption of the bottom during dredging and positioning of pilings may destroy habitat, resuspend bottom sediment (resulting in the re-introduction of toxic substances into the water column), and increase turbidity which affects the photosynthetic activity of algae and estuarine vegetation, and
- Shoaling, and shoreline and shallow area erosion due to bulkheading, motorboat wake, or changes in circulation.

Degradation of the nearby biological community and sediment should also be considered during the process of assessing NPS pollution impacts from marina development and operation. (EPA is developing methods for assessing risks associated with toxic substances in sediments and standardized bioassays to assess chronic effects and bioaccumulation resulting from sediment contamination. Guidance for the development of biological and wildlife criteria are also being developed by EPA.) Following is a list of specific pollutants and measures of pollution, as well as affected communities that should be considered in siting a marina:

(1) Chemical
- (a) dissolved oxygen (DO)
- (b) nutrients (nitrogen and phosphorus)
- (c) pathogens (coliform as indicator)
- (d) metals (copper, lead, tin)
- (e) petroleum hydrocarbons
- (f) total suspended solids

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(g) biochemical oxygen demand (BOD)

(2) Biological
  (a) endangered species
  (b) bird rookeries
  (c) benthos
  (d) fish, shellfish and corals
  (e) submerged aquatic vegetation
  (f) wetlands

(3) Sediments
  (a) contaminated sediments (criteria under development)
  (b) turbidity

B. Sources of NPS Impacts

Some sources at marinas are point sources. These include sewage discharges, both from marinas and from boats, and stormwater discharges. In addition, an entire marina may be potentially be required to apply for and receive permits under the NPDES stormwater permit program. to the extent they are required to do so, they are not covered by the coastal nonpoint source pollution control program. However, many marinas are not currently required to apply for and receive NPDES permits. The nonpoint source pollution control program and these management measures guidelines are applicable to these marinas. Similarly, some aspects of marina dredging may be subject to the section 404 permits for the discharge of dredge and fill material. This guidance is not applicable to dredging subject to section 404 permit requirements. There are essentially three source categories of marina and boating operations that may cause nonpoint pollution:

(1) Marina Construction

(2) Marina and boat operation, repair, and maintenance

(3) Dredging and dredge disposal

The most important step in controlling the impacts of these source categories is appropriate marina siting. Marinas should be sited adjacent to deep waters, in locations where flushing is adequate to avoid shoaling and contamination problems, and where effects on important habitat are minimized.

Runoff from marina construction activities is similar to that of any type of urban development. (See discussion under appropriate chapter for management measures.) Installment of pilings can cause considerable turbidity (as well as possible contaminant resuspension), impairing

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photosynthesis and harming benthos. Dredging during construction has essentially the same effects as dredging for maintenance, as discussed below.

Day-to-day marina operation can be a source of stormwater runoff from impervious surfaces, including car parking lots and buildings and sanitary and greywater disposal on land (e.g., poorly functioning or overloaded septic systems in sandy coastal soils). Contaminants from land-side boat maintenance projects, including hull scraping, sanding, welding, painting and varnishing can be carried in stormwater runoff or by air.

Boat maintenance that occurs in the water will be a direct source of contaminants (as described above). Chemicals, such as chromated copper arsenic-, copper- and tributyltin-based antifouling paints used to protect boats and wooden docks from destruction and fouling, may leach heavy metals directly into surrounding waters. Debris lost or thrown overboard is another problem area.

Concerns related to boat operation include fueling operations, bilge water discharge, accidental fuel or oil spills, propwash within channels (causing turbidity and resuspension of possible contaminated sediments) and shoreline erosion due to motorboat wake. Disposal of sanitary wastes, both legal and illegal (both from boats fitted with marine sanitation devices (MSDs) and those without), and discharge of greywater are other sources.

Another category of NPS pollution from marinas is dredging. For the purposes of this chapter, only the dredging within the marina itself and dredging to ensure access from the marina to the channel is discussed.

Dredging disturbs bottom habitat communities temporarily, increases turbidity (possibly disrupting photosynthetic activity), and may resuspend contaminated sediments. Disposal of dredged material in shallow water or in wetlands may smother habitat, contaminate sites and increase turbidity.

Some of the most visible controversy associated with recreational boating deals with the disposal of sanitary wastes. As a source of fresh pathogen pollution, untreated sewage discharges from boats have a greater potential for the presence and survival of disease-causing organisms than do discharges from treated municipal sewage sources. However, boats are considered point sources under the CWA, and sewage discharges from boats are regulated under section 312 of the CWA.

C. Federal Programs that Apply to Marinas and Recreational Boating

The siting and permitting process which marinas are subject to varies from State to State. State and Federal agencies both play a role in this process. Boats are not required to be equipped with a MSD. However, if a boat does have a MSD, the MSD has to meet certain standards. Section 312 of the CWA required EPA to develop standards for MSD discharges to prevent the discharge of untreated or inadequately treated sewage into or upon the navigable waters of the

U.S. from new and existing vessels. To meet those standards, the CWA required the Coast Guard to promulgate regulations governing design, construction, installation, and use of MSDs. Management measures to address regulated MSDs will not be a part of this chapter, since they are already regulated under the CWA. However, sanitary wastes will be included in regard to siting and design of marinas. In addition to EPA standards for MSDs, EPA may allow a State to prohibit all discharges (treated or untreated) from marine toilets, thus declaring the area a "No Discharge Zone." Any State may petition the EPA Administrator for a "No Discharge Zone" to be designated in some or all of the waters of the state. However, EPA must ensure these waters meet certain tests before considering granting the petition.

Under Section 10 of the Rivers and Harbors Act of 1899, the Army Corps of Engineers (COE) regulates all work and structures in navigable waters of the United States. Under Section 404 of the CWA, COE permits are issued or denied to regulate discharges of dredged or fill materials in navigable waters of the United States including wetlands. Guidelines which the COE applies in evaluating disposal sites for dredged or fill material are developed by EPA. The expressed goal of the 404 program is to protect water quality, aquatic resources and wetlands.

The Food and Drug Administration has established fecal coliform standards for certified shellfish growing waters. Shellfish cannot be harvested in waters with fecal coliform counts of 14/100 ml or higher. Each coastal State regulates its own shellfish sanitation program under the voluntary National Shellfish Sanitation Program. States must participate if they wish to export shellfish across State lines. Various approaches are used to comply.

D. State Programs

Some States issue separate dredge and fill, marshlands or wetlands permits for marina developments, while other States review Federal permit applications and do not issue State permits. All States with Federally approved coastal programs have the authority to object to Section 10/Section 404 permits if the proposed action is inconsistent with the State's Coastal Zone Management Program. Some States require permits for the use of State water bottomlands. All States have authority under the Clean Water Act to issue Section 401 water quality certifications for Federally permitted actions as part of their water quality standards program.

Some States also have a State coastal zone management permit providing them authority over development activities in areas located within their defined coastal zone. Alternatively, or in addition to this permitting authority, some States have regulatory planning authority in given areas of the coast, allowing them to affect the siting of marinas, if not their actual design and construction.

E. Management Measures

Control of NPS pollution from marinas and recreational boating requires the combination and coordination of many management measures: siting and design considerations, implementation

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of operation and maintenance plans, and public education. Management measures for marinas and recreational boating are organized under the following activities:

- Siting,
- Design, and
- Operation and maintenance.

As with all other management measures in this guidance, there may be more than one way to achieve the same or better pollutant reduction than achieved with the specified management measure. Approaches that equal or exceed the performance of the specified management measures, without resulting in harmful side effects, are for purposes of this guidance considered as alternative management measures.

F. Applicability of Management Measures

These management measures are applicable to:

- Any commercial facility which contains five or more slips, or any facility where a boat for hire is docked, or a boat maintenance/repair yard that is on or adjacent to the water.
- Any residential or planned community marina with ten or more slips.
- Public or commercial boat ramps.
- Any mooring field where 10 or more boats are anchored on a regular basis.
- Any Federal, State, or local facility that involves docking of five or more boats or involves boat maintenance/repair that is on or adjacent to the water.

States may wish to apply these measures to other situations as well.

II. MANAGEMENT MEASURES FOR MARINA SITING

A. Environmental Concerns

The marina siting Management Measures, listed in Section B below, are designed to address the following water quality concerns.

Maintaining water quality within a marina basin depends primarily on how readily the marina renews its waters, a process aptly known as "flushing." If a marina is not properly flushed, pollutants will concentrate to unacceptable levels resulting in impacts to biological resources.

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Methods approved for analyzing the flushing potential of a marina are discussed under the Water Quality Assessment section of this chapter.

As discussed in more detail in another chapter of this guidance, wetlands perform many vital functions, such as serving as highly productive nursery areas for aquatic and terrestrial organisms, providing nutrients, reducing flood damages, and maintaining water quality by trapping sediment and filtering pollutants. There is a significant possibility that NPS pollution from marinas could result in loss of are values.

Marinas are commonly located in biologically productive areas that are sensitive to disturbances. The popularity of shellfish make them significant commercial and recreational resources. Submerged aquatic vegetation (SAV) are important because of the shelter which they provide to aquatic organisms, the food source which they provide to waterfowl, and their natural filtering capability to remove suspended solids and disperse wave energy. Benthic resources should be protected because they are important in the food chain, they are also valuable as commercial and recreational food sources. Critical habitats are areas which are essential for maintaining wildlife, particularly for winter survival and breeding, and as nesting areas for migrating species. Highly productive primary nursery areas for aquatic organisms (e.g., fish or crustaceans) should also be considered critical habitats. Marina-related dredging may impact shellfish beds, SAVs, or other benthic resources and habitats directly through construction activities or indirectly through increased turbidity and sediment deposition. Resuspension of sediments by boats also may affect biological resources adversely.

B. Management Measures

This section contains the management measures to be applied in the siting of marinas:

(1) Site marinas such that tides and currents are adequate to flush the site, or renew its water regularly. Marina construction should only be allowed in areas where a water quality assessment reveals that standards will not be violated and biological resources dependent upon clean water will not be degraded.

(2) Site marinas adjacent to deep water to avoid or minimize dredging needed. The area to be dredged should be the minimum needed for the marina itself, including the docking areas, fairways, and channels, and for other maneuvering areas that are needed. In no case should the bottom of the marina be deeper than the adjacent open water. During dredging operations, turbidity should be minimized through the proper placement of silt screens or turbidity curtains.

(3) Site marinas near currently permitted public areas for disposal of dredged materials.

(4) Site marinas away from wetlands, shellfish resources, submerged aquatic vegetation, and critical habitat areas.

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(5) Locate piers such that shading of submerged aquatic vegetation is minimized.

(6) Site marinas such that they have easy access to roads, utilities, public sewers (where available), and water lines, to avoid NPS impacts associated with developing these services.

(7) Site marinas away from surface or ground water that is used for water supply.

C. Marina Siting Practices

This section provides technical guidance on practices that may be used as tools to assist in the implementation of the management measures set forth in Section III.B. above.

1. Water Quality

To aid in the determination as to whether a site is appropriate for marina construction, a water quality assessment of the proposed project is recommended. Also, the cumulative impacts of proposed new and existing development projects should be considered. For instance, if a group of small marinas were proposed in one area, whether by design or by chance, the impact of the marinas taken together should be examined. Therefore, even if any one of the projects would cause negligible impacts on water quality, one or more projects may be precluded based on the cumulative impacts. Alternately, each marina developer may be required to modify their project so that the cumulative impacts of all the projects can be made acceptable. In any event, based on the ecological sensitivity of the proposed site, a water quality monitoring plan may be required for the periods of time prior to, during, and after construction.

A water quality assessment should include appropriate modeling, monitoring, and data analysis to determine the proposed marina's impact on:

(1) Fecal coliform concentrations (to indicate potential impacts due to microbial pathogens),

(2) Dissolved oxygen concentrations, and

(3) Other parameters, if there is a concern that the water quality standards for those parameters may be violated.

Examples of other types of parameters which could be of concern include:

- Various polycyclic aromatic hydrocarbons (derived from petroleum products) - Other toxic organics (i.e. PCB's, benzene, various solvents, etc.)

- Heavy metals such as chromium, copper, cadmium, mercury, lead, nickel, and zinc, and

- Nutrients (i.e. nitrogen and phosphorus).

The discussion below provides guidance in assuring adequate flushing, compliance with water quality standards, and protection of shellfish harvest areas. The water quality assessment may be divided into a two tiers, as follows:

Tier 1 - If screening methods are determined to be appropriate for the system being investigated, the initial screening methods described in this guidance can be used. Screening methods are acceptable provided that they are appropriate for the system and they do not predict water quality problems.

Tier 2 - If screening-level analysis predicts water quality problems, then additional, more detailed, investigations of water quality impacts should be performed.

A valid water quality assessment should include, at a minimum, appropriate modeling, monitoring, and data analysis to determine:

- The flushing characteristics of the proposed marina.
- The spatial extent of the shellfish harvest closure zone resulting from presumed or actual pathogen contamination.
- If the 24-hour average dissolved oxygen concentration and the one-hour (or instantaneous) minimum dissolved oxygen concentration both inside the marina and in adjacent ambient waters would violate state water quality standards. (The national recommended water quality criteria are dependent upon water temperature.)

For each of the items described above, the analyses should be conducted based on the following conditions:

(1) Average ambient water temperature and salinity for the critical season of marina operation. The critical season is defined as the season which has the highest potential for adverse water quality impacts.

(2) For tidally influenced sites, the average tidal conditions (high and low tide elevations, tide range, and current velocities) for the critical season of marina operation.

(3) Sediment Oxygen Demand (SOD) rates of at least 2.0 gm/sq m/d at 20 degrees C. SOD varies from area to area. The default value should be used unless it can be demonstrated that another value is more appropriate. This base rate should be adjusted to the temperature of the analysis based on the following formula:

$$SOD_T = SOD_{20}\,(1.065)^{(T-20)}$$

Where,

SOD_{20} = SOD at 20° Celsius
SOD_T = SOD at temperature of analysis
T = Temperature in degrees Celsius

(4) Seasonal average background BOD_5 and BOD_{20} concentrations of the adjacent ambient waters.

(5) Seasonal 24-hour average background dissolved oxygen concentrations of the adjacent ambient water.

(6) A typical instantaneous minimum and maximum dissolved oxygen concentration determined by continuous dissolved oxygen, temperature, and possibly salinity monitoring of the adjacent waters at the site. The monitoring should be conducted during the season of interest. Temperatures should approximate the average critical season temperature identified in 1) above.

(7) Additional or alternative conditions may be required or approved if there is documented evidence that the additions or alternatives are appropriate.

a. <u>Flushing of marina sites</u>

The method chosen to estimate expected flushing from a marina site depends upon the hydrographic characteristics of the location. Marinas anticipated to be located within a confined area with one or two relatively narrow openings would have flushing characteristics considerably different from marinas located directly on larger bays or estuaries or along river shorelines. Two openings may improve flushing in semi-enclosed marina basins.

Flushing time within a semi-enclosed area can be estimated using simplified dilution calculations. The parameters required for the estimation are:

- Average marina depth at low and high tide following completion of dredging, based upon the representative tidal range of the area,
- Volume of non-tidal freshwater inflow into the marina,
- Surface area of the marina, and
- The percentage of discharged water returning to the basin on the following tidal cycle.

The flushing time of a semi-enclosed marina can be approximated by the following equation:

$$T_f = \frac{T_c \mathrm{Log} D}{\mathrm{Log} \dfrac{AL + BAR - IT_c}{AH}}$$

where:

T_f = Time of flushing (hours)
T_c = Tidal cycle, high tide to high tide (hours)
A = Surface area of marina (m^2)
D = Desired dilution factor
R = Range of tide (m)
b = Return flow factor (dimensionless)
I = Non-tidal freshwater inflow (m^3/hour)
L = Average depth at low tide (m)
H = Average depth at high tide (m)

The parameter "b" represents the percentage of the tidal prism ("AR" in Equation 1) that was previously flushed from the marina on the outgoing tide; has returned on the subsequent incoming tide; and is expressed as a decimal fraction. For example, if a river had a relatively low flow rate, water discharged from a marina at the completion of one tidal cycle may still exist in proximity to the marina inlet and portions may flow back into the marina on the incoming tide. This water mass portion would not be considered as aiding flushing for water quality considerations.

Non-tidal freshwater inflow from runoff or stream discharge into the marina basin can be estimated using hydrologic techniques. If "IT_c" is much less than "AL + BAR," this component of the equation can be ignored. Estimating the flushing time of a marina may be dependent upon several factors. Additional information on estimating flushing time can be found in the Coastal Marinas Assessment Handbook (EPA, 1985) or Draft Final Report on Marina Water Quality Models (Morton, M. and Moustafa, Z., 1991). Many characteristics of the marina site, including location relative to other water bodies, ambient water quality, biological activity, total volume and expected marina activity, and type and volume of discharge, would all affect flushing time. For most cases a two to four day flushing time is satisfactory while longer flushing times could result in unacceptable buildup of toxic pollutants or decrease in dissolved oxygen.

b. Shellfish harvest closure zones

Federal regulations administered by the Food and Drug Administration require that States establish closure zones around marinas to protect the food supply from contaminated shellfish. Good water quality is an absolute necessity in order to provide this protection. This is because shellfish are filter feeding organisms and are therefore able to concentrate pollutants. Even if overlying waters contain low levels of pollutants, shellfish can assimilate and magnify both biological and chemical contaminants.

Construction of a marina or docking facility may result in short term localized water quality problems due to alteration of existing upland vegetation and changes in the area's watershed. However, the long term effects of marina maintenance and operations cause the greatest concern. Marina operation may contribute pathogenic organisms as well as petroleum hydrocarbons and heavy metals. The concentration of human activity in the area of a marina also poses a particular water quality concern because of the potential problem of sewage disposal.

Fecal coliform bacteria are used as an indicator of the pathogenic organisms (viruses, bacteria, and parasites) that may be present in sewage. Therefore, all water quality assessments for water-based marina designs should identify and document potential fecal coliform loadings and the shellfish closure zones that would result from those estimated loadings (see Figure 5-1).

The shellfish harvest closure zone for the proposed project should be determined based upon a water quality standard for fecal coliform of 14 organisms MPN (most probable number) per 100 milliliters of water. Once the closure zone has been determined, it should be determined if the shellfish closure zone would result in any impact to existing shellfish harvest areas. If the closure zone intersects productive shellfish areas that are approved for shellfish harvesting, development of the marina should not be allowed as planned.

c. Dissolved oxygen concentrations

All water quality assessments should address the potential for violations of water quality standards for dissolved oxygen concentrations. In most States' waters, a standard exists for the 24-hour average concentration and an instantaneous minimum concentration. The assessment must present reasonable estimates of these concentrations for the planned marina and adjacent waters. The estimates should be based on monitoring or modeling, depending on the nature of the marina.

The water quality assessment should be based on marina location and configuration. The first and most basic distinction made is that of open versus semi-enclosed marinas (marinas located within an embayment which effectively partitions the marina from the open ambient waters). Within the semi-enclosed marina category, further distinctions are made for existing versus proposed embayments, and whether the waters at the site are completely mixed or vertically stratified due to temperature and salinity gradients.

i. Tier 1 assessments: open marinas

Marinas are considered to be open if they are located along an existing shoreline and have no man-made or natural barriers which tend to restrict the exchange of water between ambient water and water within the marina area. These marinas generally consist of a number of piers or docks which extend from the shoreline (Figure 5-2). The water quality assessment for dissolved

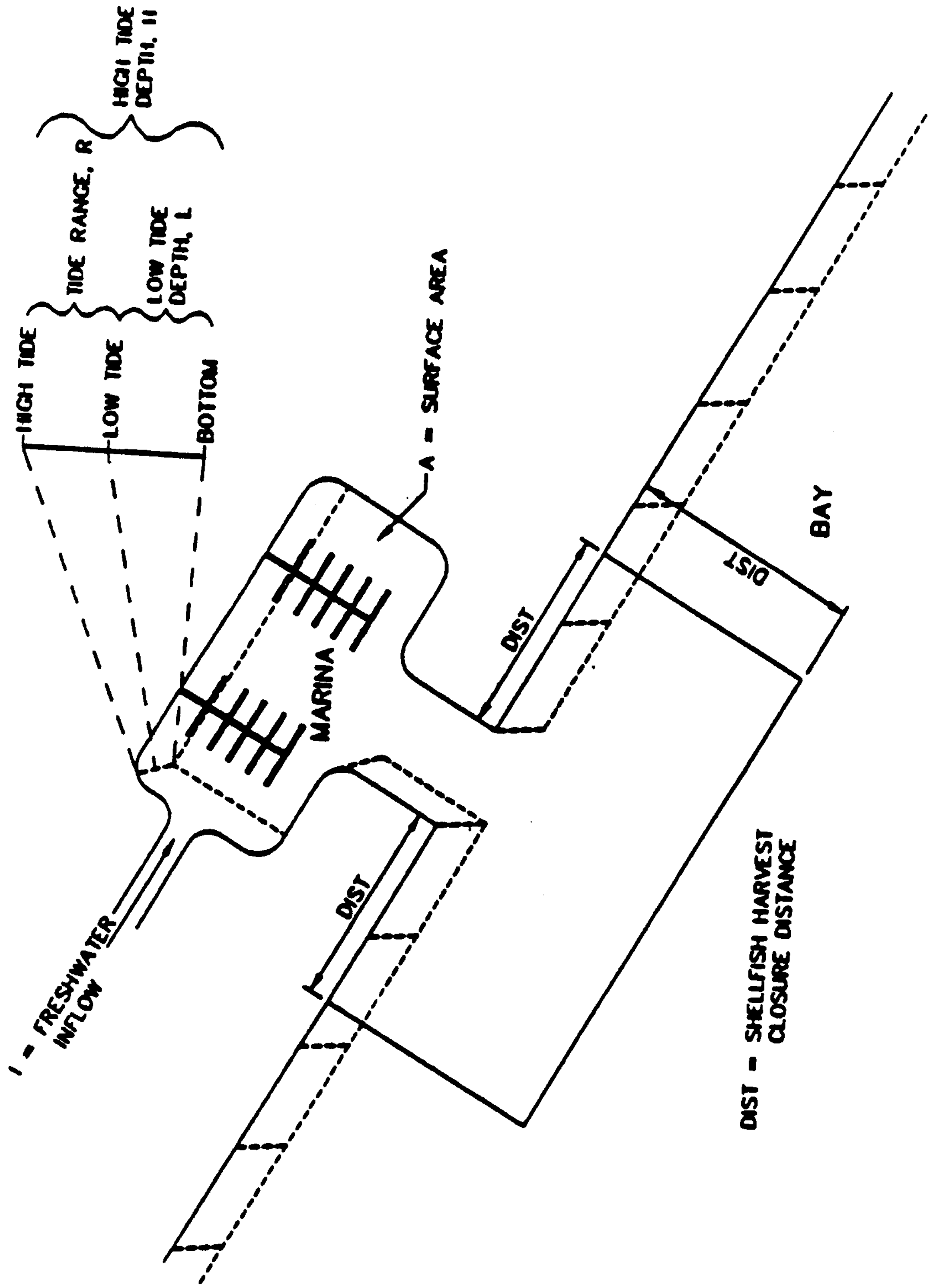

FIGURE 5-1 – REPRESENTATIVE UPLAND BASIN MARINA WITH ASSOCIATED SHELLFISH HARVEST CLOSURE ZONE

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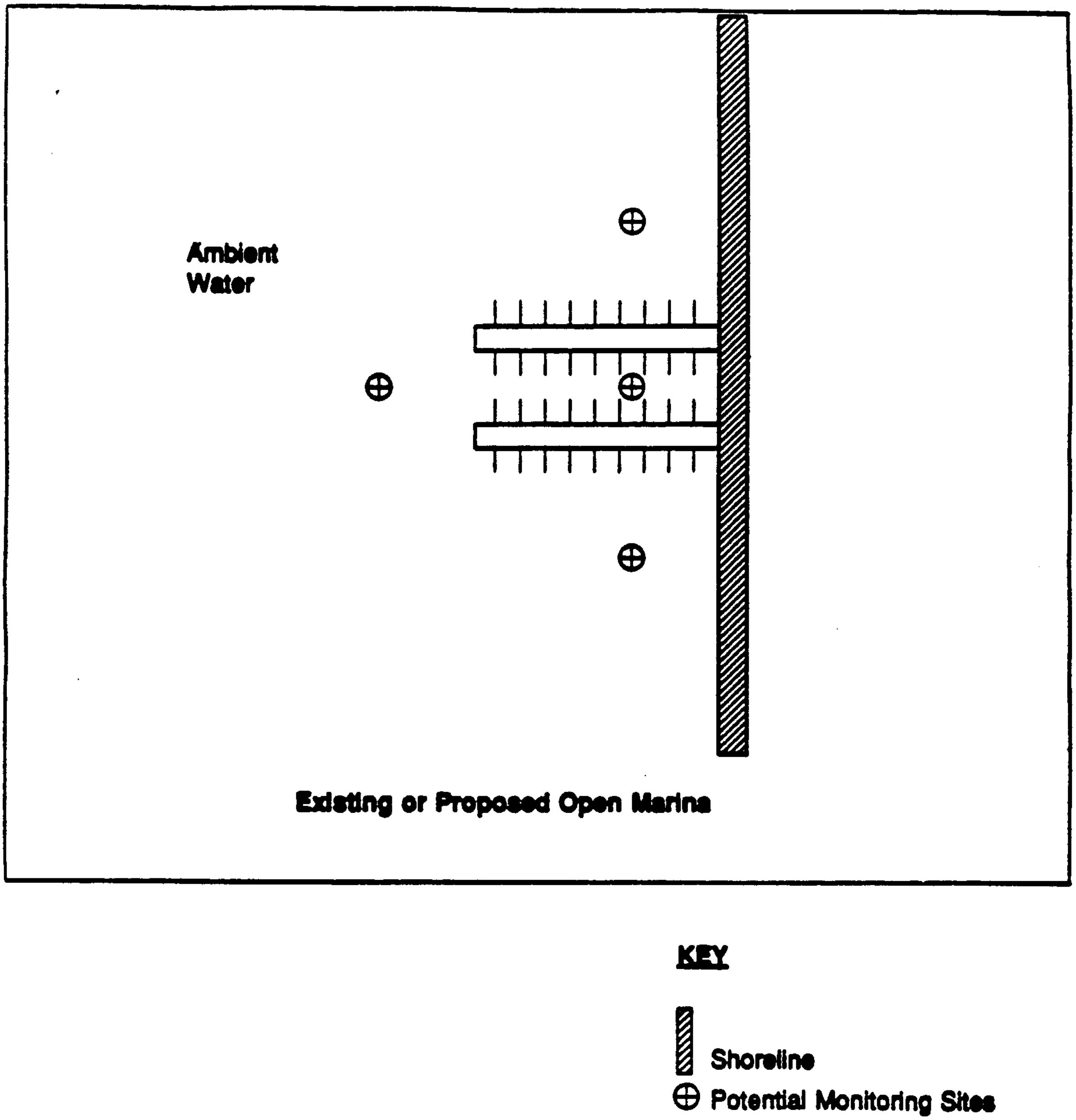

Figure 5-2. Illustration of Open Marinas and Potential Monitoring Sites

oxygen should rely on actual monitoring of dissolved oxygen concentrations within the proposed marina area. The monitoring should be representative of conditions which will be most critical in terms of meeting dissolved oxygen standards. These conditions generally occur during periods of high water temperature and low freshwater flow. In tidal areas, the monitoring should occur during average or neap tide conditions since mixing will be restricted during these periods. Occurrences of algal blooms or other conditions may influence when the critical condition occurs for a particular site.

A minimum of two days of dissolved oxygen monitoring should be collected. The monitoring should be conducted at no less than two-hour intervals and should include dissolved oxygen concentration, temperature, and salinity (if in estuarine or marine waters). The site or sites selected should be representative of the range of conditions found within the marina area. If the water column is stratified at the site, samples should be collected near the bottom, middle and surface of the water column. From the data collected, the twenty-four hour average, maximum, and minimum dissolved oxygen concentrations should be reported and compared to water quality standards to assess the potential for violations.

ii. Tier 1 assessments: **semi-enclosed marinas**

Marinas are considered to be semi-enclosed if they are located in a natural or man-made embayment which limits the mixing of waters in the marina area with ambient waters (Figure 5-3). The water quality within the embayments may differ significantly from the water quality of adjacent ambient waters. In cases like these, a combination of monitoring and modeling may be needed to estimate dissolved oxygen concentrations. If the embayment for the marina exists, the analysis may rely primarily on monitoring similar to that discussed for open marinas. If the embayment does not exist, a combination of monitoring and modeling may be necessary.

iii. Tier 1 assessments: existing embayments

For semi-enclosed marinas in which the embayment currently exists and no changes are proposed that would change the hydrodynamics of the embayment, the analysis may be limited to diel monitoring of dissolved oxygen concentrations during the critical period. The monitoring guidance provided for the open marinas applies. Modeling may be required if additional loadings of oxygen demanding substances are likely to be introduced during the operation or construction of the marina. The models discussed below in the Proposed Embayments section would be applicable.

iv. Tier 1 assessments: proposed embayments

For semi-enclosed marinas which have not yet been excavated, or for which changes have been proposed that would affect the hydrodynamics of the embayment, the water quality assessment should rely on monitoring and the application of appropriate models to predict dissolved oxygen concentrations. The dissolved oxygen screening procedures will serve as an initial assessment to determine if dissolved oxygen water quality standards are likely to be violated. If problems

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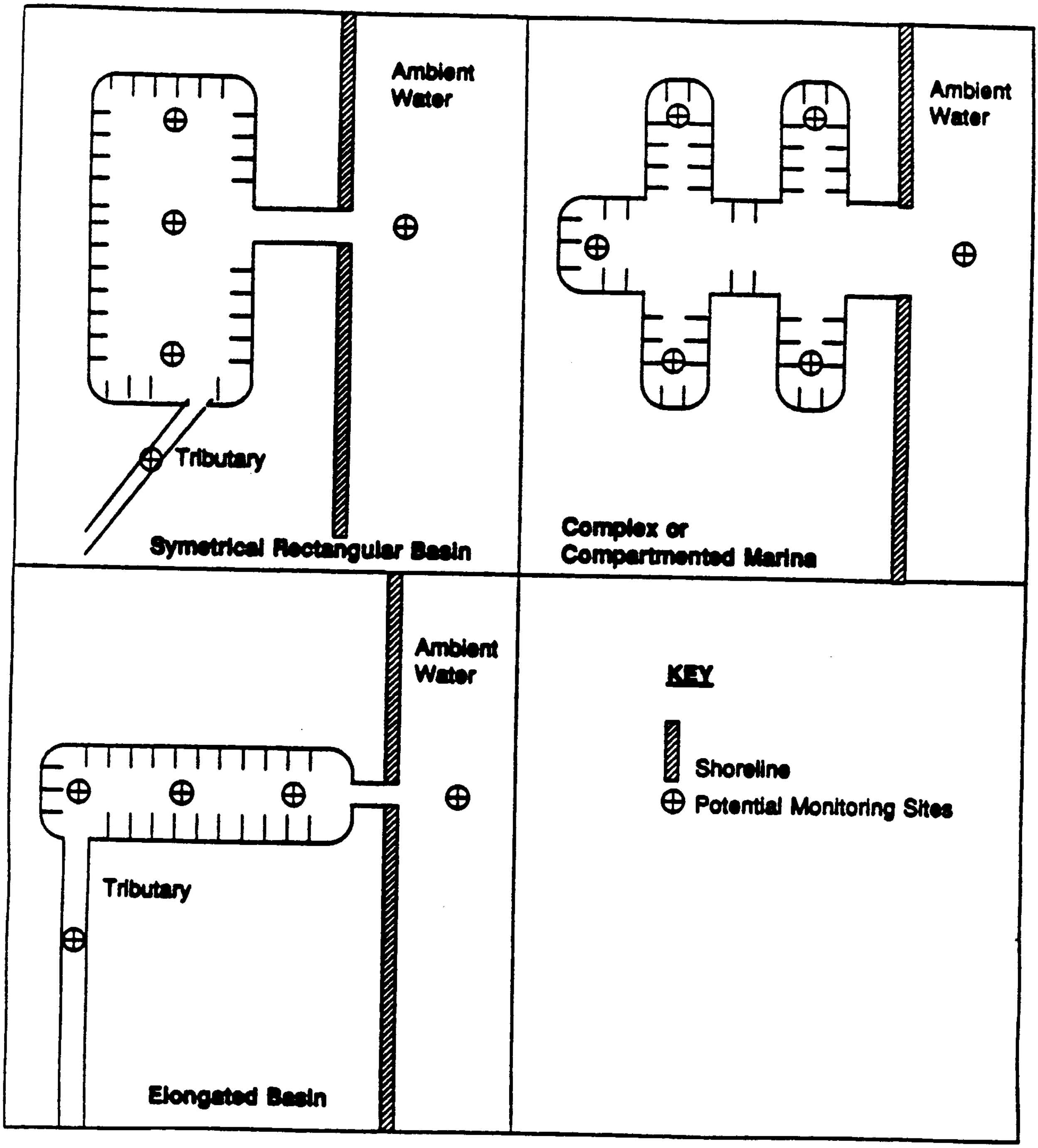

Figure 5-3 -Illustration of Enclosed Marinas and Potential Monitoring Sites

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are indicated at the screening level, more detailed procedures may be applied to examine dissolved oxygen concentrations (see Figure 5-4).

The presence of salinity, dissolved oxygen or temperature gradients that result in stratification (as discussed in the open marina monitoring section) will require detailed procedures. The screening procedures for dissolved oxygen concentrations for proposed marinas located in semi-enclosed embayments should be based on a combination of dissolved oxygen monitoring coupled with the application of a steady state, tidally averaged water quality model and a flushing model. The monitoring guidance provided in the Open Marina section, above, should serve as the basis for the screening procedure. In addition, the average tide range and high and low water depths of the adjacent ambient waters, as well as the proposed marina, should be required to implement the screening models. Flow rates (seven day, ten year low), BOD, and dissolved oxygen concentrations of tributaries that will enter the proposed basin should also be provided or monitored. Additional monitoring may be necessary in areas where there is significant algal productivity, or in cases where detailed models are applied. Typical sampling sites for enclosed marinas are illustrated in Figure 5-3.

The screening level assessment of the minimum dissolved oxygen concentration should be based on the average dissolved oxygen concentration for the proposed basin as calculated above, and on the deviation between the average and minimum dissolved oxygen concentration measured in the ambient waters.

v. Tier 2 assessments: detailed procedures

Detailed procedures for dissolved oxygen analyses are recommended for proposed marinas that are not expected to be completely mixed due to stratification within the water column or due to the configuration of the marina basin. For example, proposed marina basins that are significantly elongated or segmented will prevent thorough mixing and will require detailed modeling. Detailed procedures may also be necessary to evaluate potential problems indicated by the screening level analysis. The detailed procedures used will be dependent on the specific site and model being considered.

As with the screening-level analysis, the detailed analysis should include a combination of monitoring and modeling. The model selected for the detailed analysis should have demonstrated applications in predicting average and minimum dissolved oxygen concentrations for systems that are similar to the marina basin configuration being proposed. The most available and accepted model with these abilities is the WASP model, which was developed and is supported by EPA. In most situations it will be the model of choice. The monitoring required to support a detailed model will vary with the model and the specific site. Sufficient data should be collected to calibrate the hydrodynamic and water quality components of each model for the specific site.

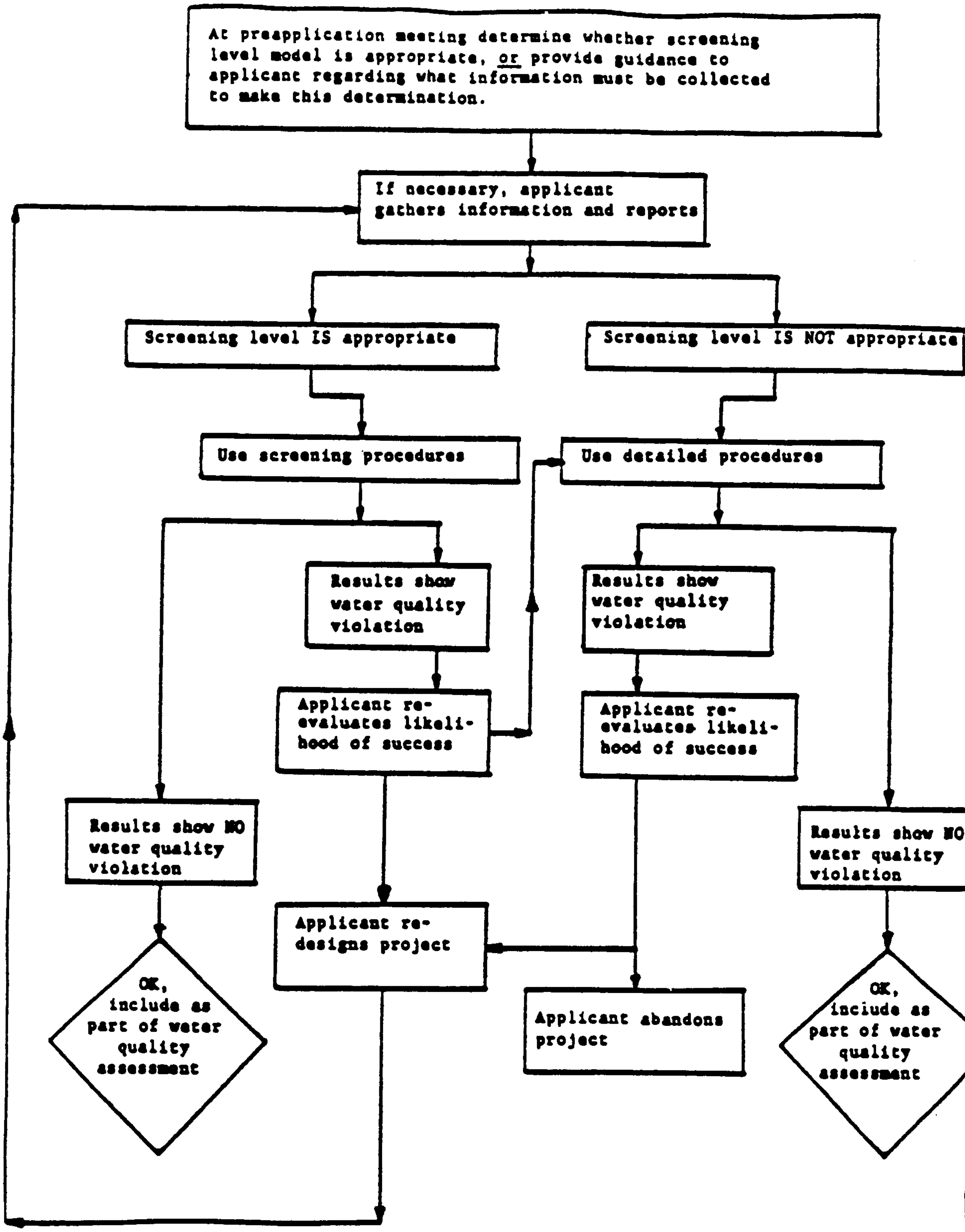

Figure 5-4. Flow Chart for Water Quality Assessments Requiring Modeling Analysis

d. Other parameters

Other parameters need only be investigated if there is a concern about the potential for violation of water quality standards.

2. Wetlands

The despoliation and destruction of public and private wetlands during marina construction and operation should be avoided. Further discussion on wetlands can be found in another chapter of this guidance.

3. Submerged Aquatic Vegetation

The net loss of submerged aquatic vegetation (SAV) should not be allowed. In no case should highly productive SAV be adversely impacted. If a marina is sited in the proximity of SAV, any related disturbance of these SAV areas should require compensation measures. Before such measures are approved it should be determined that substantial, prudent, and reasonable measures have been taken to avoid the impacts. Since this kind of vegetation cannot survive when heavily shaded, shading of SAV by piers crossing over them should be avoided.

4. Benthic Resources

The benthic community at the marina site should be evaluated using rapid bioassessment techniques (EPA, 1989; Luckenbach, Diaz and Schaffner, 1989). Benthic areas that are found to have degraded benthic communities should be considered for marina siting over those areas that are found to be healthy and productive. It is recommended that each state should develop rapid bioassessment techniques and criteria appropriate to their bioregions.

5. Critical Habitats

Marinas should not be sited in proximity to such areas if the project would adversely affect natural populations. A buffer zone should be established around critical habitats located near the project. The size of this zone should be decided on a case-and species-basis. No general or specific guidance regarding the extent of these buffer zones can be given because of the wide variation in requirements between species.

6. Dredging and Dredged Material Disposal

Ideally, marinas should be located where dredging will not be necessary to allow safe navigation. In many locations, unfortunately, this is not possible. Therefore, marinas should be sited at locations that require the least amount of dredging for the draft of the boats that will use that marina. In some cases, the draft may have to be limited to avoid or to minimize the amount of dredging. The area to be dredged should be the minimum needed for the marina itself, including the docking areas, fairways, and canals, and for other maneuvering areas that are needed. In

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no case should the bottom of the marina be deeper than the adjacent open water. Marinas should not be built in sites that will require maintenance dredging more frequently than once every four years.

Previous sections of this guidebook have described natural resources which may be impacted by the construction and operation of a marina. Dredging to construct or maintain a marina can result in losses of these resources and/or adverse impacts to nearby resources because of the turbidity associated with dredging. In addition, because certain times of the year are more critical than others due to migration, spawning and early development of important species, dredging should not occur at all at such times.

During dredging operations, any project-related turbidity should be contained, thus minimizing adverse impacts to the surrounding habitat and avoiding possible violations of water quality standards. Proper placement of silt screens or turbidity curtains is a common and relatively effective method of containment. Marinas should not be built in sites that will require maintenance dredging more frequently than once every four years.

Whenever dredged material may be contaminated, disposal in an upland diked containment area is the preferred disposal method. Wherever feasible, applicants should use existing diked disposal areas. Diked disposal areas must be sized and designed to prevent resuspension or erosion of the dredged material and subsequent transport back into adjacent waters. They must also be sited to avoid ground water contamination.

Another disposal option, available only for clean, uncontaminated fill, is placement on or near shore, where it is desirable to enhance beach profiles, stabilize shorelines, and/or build or enhance wetlands.

Dredging in waters of the United States is regulated by the Army Corp of Engineers, as discussed earlier in the introduction. This guidance on dredging and dredge disposal is provided so that prospective marina owners have an indication as to what they may expect from efforts to site a marina.

7. Water Supply

Marinas should be sited and designed to preclude any contamination of surface water or groundwater that is used for water supply. Runoff from potential areas of contamination, such as maintenance areas should be treated, as described under the Stormwater Management Section of this section.

Upland basins should not be excavated in areas upgradient or within 1000 feet of public or private well fields, nor should excavation occur within water supply protection areas, or where an increased threat of saline water encroachment is likely. A danger exists that dredging may improve the hydrologic "connection" between brackish water and the fresh water aquifer, which, when coupled with a head loss from pumpage within the aquifer, may result in contamination of the aquifer. A buffer of less than 1000 feet may be used if it can be demonstrated that a lesser distance will result in no adverse impact on groundwater.

It should be demonstrated that there is an adequate water supply to serve all of their project needs. As a rule of thumb, 30 gallons/slip/day will be needed during peak usage periods.

D. Pollutant Reductions and Costs

Proper siting of marinas can completely avoid some of the NPS pollution impacts associated this type of development. Direct impacts to shellfish areas, wetlands, SAVs, and other benthic resources and habitats can be averted. Water quality problems can be greatly reduced or eliminated entirely through proper siting. The costs of identifying a good site for a marina and preparing a water quality assessment will be dependent upon regional and local conditions. Past efforts have varied from $2,000 to $16,000.

III. MANAGEMENT MEASURES FOR THE DESIGN OF MARINAS

A. Environmental Concerns

The management measures, listed in Section B below, are designed to address the following water quality concerns.

Design considerations for the minimization of NPS pollution associated with marinas should include: shoreline stabilization, location of navigation channels, stormwater, dryboat storage, boat maintenance areas, fueling areas, and control of spills. Improper shoreline design can result in erosion or degradation of habitat. Placement and design of navigation channels is a major factor in flushing and resulting water quality. Boat maintenance activities that can result in NPS pollution include:

- Painting and paint removal,
- Welding, brazing, soldering, and metal cutting,
- Woodworking,
- Engine repair and service,
- Servicing LPG and CNG systems, and
- Boat washing and hull cleaning.

Rainfall runoff from areas where these activities occur becomes polluted with oils, greases, organic and inorganic wastes, and other potentially harmful substances. Introduction of these substances into adjacent waters can have significant adverse water quality impacts.

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Marina fueling systems typically consist of storage tanks (usually underground) and pumps on shore, with fuel meters and dispensers mounted on a fuel pier or dock. Areas where boats are fueled are subject to contamination from petroleum hydrocarbons from leaks and spills.

B. Management Measures

This section contains the management measures to be applied in the design of marinas:

(1) Use natural vegetation to stabilize shorelines wherever possible.

(2) Navigation and access channels should be located in areas with safe and convenient access to waters of navigable depth, based on the kind of vessel expected to use the marina, but in no case exceeding the depth of adjoining channels and waters.

(3) The first one-half inch of runoff from the entire marina property for a 10-year 24-hour storm should be detained and released over a 24-hour period.

(4) All stormwater management systems should be provided with a bypass or overflow system so that the peak discharge from a 10-year 24-hour storm will be safely conveyed to an erosion and scour-protected storm water outfall.

(5) Dry boat storage should be utilized over wet slips wherever feasible.

(6) Boat maintenance areas should be designed so that all maintenance activities that are significant potential sources of pollution can be accomplished over dry land and under roofs (where practical), allowing for proper control of by-products, debris, residues, solvents, spills, and stormwater runoff. All drains from maintenance areas should lead to a sump, holding tank, or pumpout facility from which the wastes can later be extracted for treatment and/or disposal. Drainage of maintenance areas directly into surface or ground water or wetlands should not be allowed.

(7) Fueling stations generally should be located such that they are accessible by boat without entering or passing through the main berthing areas in order to avoid collisions.

(8) Marina operators should have a spill contingency plan and the proper equipment and training to implement the plan.

C. Marina Design Practices

This section provides technical guidance on practices that may be used as tools to assist in the implementation of the management measures set forth in Section IV.B. above.

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1. <u>Shoreline Protection and Basin Design</u>

Natural vegetation should be used wherever feasible to stabilize shorelines. However, when additional stabilization becomes necessary, sloping riprap revetments are preferred over vertical bulkheads, since they generally provide greater habitat and reduce wave reflections. Shoreline intertidal areas should be preserved to the greatest extent possible.

In instances where bulkheads are to be installed, they should be constructed in such a manner that they are effective against erosion and provide adequate bank stabilization. The potential for erosion and scour at the mudline should be evaluated. Bulkheads should be constructed to prevent losses of fine material through joints or cracks from the land side to the water side, which could ultimately lead to failure of the wall. Bulkheads should be stabilized by providing adequate anchorage (such as batter piles or tie backs) or adequate embedment, depending on the type of bulkhead. Where public walkways, steps, or ramps run adjacent to bulkheads, handrails or other safety provisions should be provided along the top of the wall where the vertical drop to the current mean low water line or mud line exceeds three feet, unless local or State building codes stipulate otherwise. Any interference with public access should be avoided.

Basins that are constructed with square corners or other stagnant water areas will tend to trap sediment and debris. If this debris is allowed to collect and settle to the bottom, an oxygen demand will be imposed on the water and water quality will suffer. Therefore, square corners should be avoided in critical down-wind or similar areas where this is most likely to be a problem. If square corners are unavoidable because of other considerations, then points of access should be provided in those corners to allow for easy clean out of accumulated debris.

Riprap revetments are considered to be flexible since they can accommodate minor consolidation and settlement of their foundations. Still, adequate provisions should be made to prevent migration and loss of fine materials through the riprap, such as placement of a filter fabric beneath the armor layer. The slope of the revetment should be sufficiently flat to maintain stability, but in no case should the slope be steeper than one vertical to 1.5 horizontal. In addition, adequate toe protection should be provided to compensate for known or anticipated scour.

Considerations for new construction are addressed in the urban section of this document. Control measures such as turbidity curtains, vegetative barriers, etc. should be used to contain erosion.

2. <u>Navigation and Access Channels</u>

Channels should be located in areas with safe and convenient access to waters of navigable depth, based on the kind of vessels expected to use the marina, but in no case exceeding the depths of adjoining channels and waters. "Safe and convenient" access should be determined on a case-by-case basis, taking into account such factors as existing water depths, distance to existing canals and their depths, and tidal and wave actions. Before considering dredging,

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should attempt to gain access to deeper water by extending docks and piers farther from shore. The maximum extent to which a pier should extend into the waterway should be determined by each state and applied in a consistent manner (10% of the width of the channel has been set in some cases). In some cases, rather than dredging (and possibly having to develop a compensation plan), it may make more sense to simply limit the maximum boat drafts in the marina or utilize dingy access to moorings. Where channels are narrow, dry stacking of boats should be considered.

Where dredging is unavoidable, natural or existing channels should be used to minimize the amount of dredging. Also, naturally existing channels are less likely than surrounding shallow areas to contain shellfish beds, submerged aquatic vegetation, or other resources which may complicate permitting and require mitigation or compensation measures.

3. Wastewater Facilities

Three types of onshore collection systems are available: marina-wide systems, portable/mobile systems, and dedicated slipside systems. Marina-wide collection systems include one or more centrally located sewage pumpout stations. These stations are generally located at the end of a pier, often on a fueling pier so that fueling and pumpout operations can be combined. Boats requiring pumpout services dock at the pump-out station, a flexible hose is connected to the wastewater fitting in the full of the boat, and pumps or a vacuum system move the wastewater to an on-shore holding tank, a public sewer system, a private treatment facility, or other approved disposal facility. In cases where the boats in the marina use only small portable (removable) toilets, a satisfactory disposal facility could be a toilet into which the portable (removable) toilets can be dumped. Portable/mobile systems are similar to marina-wide systems except that the pumpout stations are mobile. The mobile unit includes a pump and a small storage tank. The unit is connected to the deck fitting on the vessel, and wastewater is pumped from the vessel's holding tank to the pumping unit's storage tank. When the storage tank is full, its contents are discharged into one of the previously listed approved disposal facilities. Dedicated slipside systems provide continuous wastewater collection at a slip. Slipside pumpout should be provided to live-aboard vessels. The remainder of the marina can still be served by either marina-wide or mobile pumpout systems.

Note that chemicals from holding tanks may retard the normal functioning of septic systems. Neither the chemicals nor the concentration of wastes has proven to be a significant problem for properly operating public treatment plants provided there is adequate dilution between the marina and the treatment plant. In some cases, the effluent from the marina may have to be diluted before introducing it to the sewer system.

Shoreside restroom facilities for the use of marina patrons should be required at all marinas. Adequate restroom facilities for any given marina are dependent upon the nature (recreational or public, or residential or planned community) and size of the marina and its ancillary features. Restroom facilities should be conveniently located and well-maintained to encourage their use by boaters at the marina. At residential or planned community marinas public restrooms may not be required unless there are non-residents who routinely use the marina who do not have access to a private bathroom, or unless the convenient travel time from the slips to the residences is longer than five minutes.

Marina operators should post ample signs prohibiting the discharge of sanitary wastewater, dishwater, or greywater from boats into the waters of the State, including the marina basin, and also explaining the availability of pumpout services and public restroom facilities. Signs should also fully explain the procedures and rules governing the use of the pumpout facilities.

4. Stormwater Management

All stormwater management systems should be provided with a bypass or overflow system so that the peak discharge from a 10-year 24-hour storm will be safely conveyed to an erosion and scour-protected storm water outfall. All discharges shall be calculated using methods developed by the U.S. Soil Conservation Service and described in either their Technical Release 20 or 55.

For new construction:

(1) The first one-half inch of runoff from the entire marina property for a 10-year 24-hour storm should be detained and released over a 24-hour period. Runoff to should be controlled with a weir that will direct the first one-half inch of runoff to the are and bypass the rest to the receiving water body. This is known as control of the first flush and is important because this first one-half inch of runoff has high concentrations of pollutants compared with the bulk of the remaining runoff.

(2) Use of infiltration practices may also be an acceptable alternative. Paving materials which allow for increased infiltration include permeable asphalt paving, paving blocks, and, in lighter use areas, coquina, gravel, oyster shells, or similar surfaces. Such infiltration practices are acceptable only in areas with appropriate soils, slopes, and depths to ground water. A strict maintenance schedule should be prepared and adhered to by the marinas operator. Porous asphalt should be used only as a last resort and only after a regular vacuuming schedule has been approved. This is needed because porous pavements can quickly become impermeable when clogged with small quantities of fines. Once they have become impermeable, their storm runoff benefits are nullified.

(3) Other treatment practices for storm runoff may be considered on a case-by- case basis if they can achieve an equivalent removal efficiency of 80% of suspended solids in addition to removal of other pollutants as needed.

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5. Dry Boat Storage

Dry boat storage is the storage of boats on dry land (inside or outside) when they are not in use, often in multi-level vertical racks using a forklift truck or crane system. Dry storage of boats drastically reduces the in-water requirements for structures, typically requiring only a few wet staging slips for short term berthing of vessels after being taken from storage for subsequent boarding, and then upon their return before being placed back into storage. Dry storage should be utilized over wet slips wherever feasible due to the reduced potential for adverse environmental impacts from NPS pollution.

Construction of dry storage buildings must conform to all applicable requirements of municipal, county, or State housing, electrical, plumbing, fire protection, and building codes. In the absence of any such fire protection codes, fire protection procedures for dry storage areas are covered in the National Fire Protection Association (NFPA) 303, Fire Protection Standard for Marinas and Boatyards.

6. Boat Maintenance Areas

Boat scraping, sanding, washing, etc. should only be done in areas designed to handle runoff in a manner that prevents it from reaching adjacent waters and wetlands (see sections on stormwater and operations and maintenance).

7. Fuel Storage and Delivery Facilities

In the event of a spill of fuel, oil, or other toxic or hazardous substance, it is the responsibility of the marina operator to properly contain and clean up the spill in a timely and diligent manner. This is true even if the spill has been caused by some negligent or inadvertent action of a patron of the marina. Coast Guard regulations require that all spills that cause a visible sheen on the water must be reported. All spills should also be reported immediately to the proper state authority. A spill contingency plan should be posted and include:

(1) Posting of notification procedures in the event of a spill.

(2) Immediate on-site availability (less than 1/4 hour) of containment equipment such as booms, absorbent materials, or skimmers. This equipment should be conveniently stored on site. Responsible marina personnel should be trained in the proper use of this equipment. Marina personnel should be required to participate in annual drills to demonstrate their readiness in the event of a spill and to assure that containment equipment is in working order.

(3) Disposal of the collected fuel or other material contaminated by the pollutant in accordance with applicable State and Federal regulations.

8. Piers and Dock Systems

All timber used for construction above the water line should be pressure treated with a preservative such as chromated copper arsenate (CCA) or creosote to avoid damage by wood borers. Underwater, or periodically submerged portions of timber structures should not be constructed with CCA or creosote-treated timber. Treated piles that project above deck level should be protected with battens or some protective sheathing.

The use of concrete pilings should be seriously considered both in planned marinas and those undergoing expansion or repair/replacement of piers. Use of concrete pilings eliminates leaching of preservatives and decreases pier maintenance costs.

D. Pollutant Reductions and Costs

Actual numbers on pollutant reductions and costs are not currently available. The following discussion is on the relative pollution reduction of the management measures.

The proper design of marina channels and basins will result in avoidance of impacts to important habitat and protection of water quality. Properly flushed channels and basins will prevent build-up of natural and man induced substances that degrade the environment. Pollutant reductions and cost for the control of stormwater are discussed in the chapter of this guidance on urban management measures.

With dryboat storage, dredging is minimized since there is no large basin, only a small staging area. This will minimize water quality and flushing concerns, as well as flow disruptions caused by structures built to protect boats from wind and wave action. Large amounts of treated timber for docks and bulkheads are not needed, thus minimizing the leaching of wood preservatives into the water and the shading effects of docks, piers, pilings, and boats. The amount of contact time between pesticide-containing bottom paints and the water is minimized, perhaps even eliminating the need for the use of bottom paints. The use of construction material that does not contain CAA or creosote may not add to initial construction costs (unless concrete is used), but may add maintenance costs due to upkeep (unless concrete is used).

Proper design of fueling facilities and prepositioning of spill containment and cleanup equipment (100 feet of boom and absorbent material) will add approximately \$2000 to \$10,000 in cost to a marina project. Pollutant reduction is difficult to quantify because of the episodic nature of fuel spillage.

IV. MANAGEMENT MEASURES FOR OPERATIONS AND MAINTENANCE OF MARINAS AND BOATS

A. Environmental Concerns

The Management Measures, listed in Section B below, are designed to address the following water quality concerns.

The operation and maintenance of a marina and associated boating produces the same concerns as those addressed in the design of marinas as well as day-to-day activities such as disposal of fish wastes and the repair, maintenance, and operation of boats.

During the summer months, dissolved oxygen depressions, odor complaints and aesthetic problems may result from disposal of fish wastes into the water in concentrations that overload the natural ecosystem.

Small boat yards and marinas are confronted with handling a significant number of hazardous waste sources due to the variety of maintenance and repair operations that result from boat operations. Owners of marinas have a responsibility to see that no hazardous materials enter the body of water on which they are located.

Many of the wastes generated by boat yards and marinas must not be discharged into either sanitary sewers, storms or deck drains. Although there are some exceptions, most inside drains go to sanitary sewers and most outside drains go to natural waters. Wastes improperly, disposed down drains may cause water pollution, damage or impair sewage treatment plants and can be harmful to workers. Contaminants of concern include, antifreeze, oils, detergents, wash water from cleaning floors and decks and paint dust.

B. Management Measures

This section contains the management measures to be applied in the operation and maintenance of marinas and boats:

(1) Encourage the recycling of fish wastes back into the natural ecosystem in a manner that will not degrade water quality or cause other adverse environmental impacts.

(2) Tarps and vacuums should be used to collect solid wastes produced by cleaning and repair of boats. Such wastes should be prevented from entering adjacent water.

(3) Vacuum or sweep up and catch debris, sandings, and trash from boat maintenance areas on a regular basis so that runoff will not carry it into the water.

(4) An oil water separator should be used on outside drains and maintained to ensure performance.

(5) Curbs, berms or other barriers should be built or placed around areas used for the storage of liquid hazardous materials to contain spills.

(6) Tarps should be used to catch spills of paints, solvents, or other liquid materials used in the repair or maintenance of boats.

(7) Used antifreeze should be stored in a barrel labeled "Waste Antifreeze Only" and should be recycled.

(8) Valves should be used on the air vents of fuel tanks that prevent fuel from overflowing and spilling.

(9) All boats with inboard engines should have oil absorption pads in bilge areas and they be changed when they are no longer useful or at least once a year.

(10) Only phosphate-free and biodegradable detergents should be used for boat washing.

C. Marina Operation and Maintenance Practices

This section provides technical guidance on practices that may be used as tools to assist in the implementation of the Management Measures set forth in Section V.B. above.

1. Fish Wastes

A fish waste policy may need to be developed. In order to implement the policy in a consistent manner, guidelines could be established that meet the following requirements:

(1) Fish wastes should not be discharged into surface waters in any dead end lagoons, other poorly flushed locations, or other areas where such discharge could result in a water quality or public nuisance problem.

(2) Where fish waste disposal will not result in water quality or public nuisance problems, fish wastes could be recycled back into the ecosystem from which the organisms were originally harvested.

(3) Fish waste recycling within marina basins should only be allowed if in accordance with approved Operations and Maintenance Plans. Marinas should not provide fish cleaning stations unless the activity has been included in the Operations and Maintenance Plans. Marinas which are not approved for fish waste recycling

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should post signs warning fishermen that fish wastes should not be disposed of in the water at that location.

(4) Fish wastes should not be recycled into surface waters in such a way that they will wash up onto any shoreline, or cause odors or other nuisances.

2. Boat Maintenance Areas

Small boat yards and marinas are confronted with handling a significant number of hazardous waste sources due to the variety of maintenance and repair operations that result from boat operations.

a. Hydroblast containment

This practice entails the containment of hydroblast (pressure washing) wastewater to prevent paint chips and oil from being discharged into natural waters and storm drains. In most states, permission must be obtained to discharge these wastes to the local sanitary sewer. The local utilities should be consulted for pretreatment possibilities. Cleaning processes that use chemical additives such as solvents or degreasers must be done in a self-contained system that prevents discharge to storm drains or sanitary sewer. Wastewater without such additives should be directed into wetpond detention basins as described in another section of this guidance. Where feasible, wastewater from this operation can be collected and reused.

b. Abrasive blasting containment

Grit from abrasive blasting contains paint chips and other materials should be prevented from entering natural waters or storms. 'Dockside' blasting, outside a drydock or containment area should not be done. Workshops and yards must be kept clean of debris and grit from sand blasting operations so that runoff and wind will not carry any waste into the water. During blasting operations, outdoor areas should be enclosed in plastic tarps and no blasting should be done on windy days. The bottom edge of tarpaulins and plastic sheeting must be weighted so that it will remain in place during light breezes. A spray booth should be used whenever possible to capture the blast grit and should be used if sand is being used.

c. Spray booths

Spray Booths concentrate paints and as such represent a hazard to both employees and the environment. Booths must meet local building and fire code requirements and must ensure adequate ventilation for people working in them. Paint guns used in spray booths should be either High Velocity Low Pressure (HVLP) or High Efficiency Low Pressure (HELP) which are rated at 65% efficient paint transfer, or electrostatic paint spraying methods. In replacing existing spray guns, convert to HVLP or HELP types. Cleaning paint guns can also be hazardous since spent solvent must be treated as a hazardous waste and not discharged directly into drains. Cleaning should be done in an enclosed gun cleaner/recycler machine.

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d. <u>Waste storage</u>

Waste oil, fuels stored above ground and hazardous material must be protected by a berm (a built-in curb or barrier) in an area that is sufficiently large to contain a spill. Its purpose is to catch anything that spills or leaks, in case a container is tipped, overfilled or ruptured. No drains should be inside the secondary containment. If for some reason there is a drain, it should lead to a blind sump. Secondary containment should have a concrete floor and, if outdoors, be roofed. Other measures that count as secondary containment that may be used instead are;

(1) A sump, with no drain, near the tank to catch an accidental spill,

(2) Build a 2 to 4 inch sill across the doorway, high enough to contain a spill yet low enough to allow machinery to access the building,

(3) Buy or build double-containment tanks, and

(4) Or build high drip pans installed under existing tanks.

Outdoor storage of hazardous materials (drums, smaller container, batteries) must be covered and have secondary containment. Containers of hazardous materials should be placed under cover and on impervious pads (concrete is not impervious unless the surface is properly coated). Secondary containment may be a berm or a pallet with a tray. All drums must be labelled with the date, the words "Hazardous Waste", the associated hazards (ie, flammable) and the contents of the container.

e. <u>Waste oil storage</u>

Waste oil should not be contaminated with any other hazardous substances and if it does become contaminated, it should be labelled as a hazardous waste which entails expensive disposal procedures. Drums should be labelled "Waste Oil Only" to prevent mixing in other wastes, especially solvents. The labelling also aids fire fighters who, in case of fire, must treat an unlabeled drum as the worst case. Waste oil should be disposed of according to appropriate statutes and regulations. Recycling is strongly encouraged.

f. <u>Drainage systems</u>

Most local sewer utilities, via pretreatment ordinances and discharge permits, restrict what can be poured into inside drains since some contaminants are not removed by the treatment process. Drains connected to sanitary sewers may need sand traps and oil water separators. Lack of an oil-water separator for steam cleaning and pressure washing of engines and other oily parts may result in a violation of discharge limits. However, an oil-water separator is designed for the specific purpose of removing oil from water and will not remove all hazardous waste. Oil-water separators should be regularly maintained and cleaned whenever three inches of oil has accumulated. Local sewer utilities should be contacted for help in determining the best way to

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dispose of liquid wastes since discharge limits vary. Great care must be taken not to allow any contaminants to enter outside drains since most drain directly in streams or rivers without any type of treatment. Oil water separators should be installed on outdoor drains in areas where engine maintenance occurs.

g. Liquid waste management

Paints and solvents must be prevented from entering waterways by the use of drip pans, drop cloths or tarpaulins. Whenever possible, paints and solvents should be mixed in bermed areas away from storm drains, surface waters, shorelines and piers. Only one gallon (or less) of paint and solvent should be opened at a time when working on floats and should be contained within drip pans or tarpaulins. Paint and solvent spills should be prevented from reaching storm or deck drains, cleaned up and disposed of appropriately. Cleanup materials soaked with solvent must be handled as hazardous waste.

h. Solid waste management

Cleaning must be done in such a way that no debris falls into the water and is done to prevent the accumulation of waste material that may get blown onto surface waters. Cleaning with a vacuum is the preferred method for collecting sandings and trash. Sandblasting debris should be collected and stored with the spent grit and removed frequently. Hosing of decks and docks should not be done when it might cause debris to be washed into the drains. After the contents of a drum or a container is used they should be flattened and made unusable. If possible, reuse or recycle empty drums rather than dispose as solid waste.

Marina operators are responsible for the contents of their dumpsters and hazardous waste should never be placed in them. Dumpsters should be locked within an enclosure to prevent "midnight dumping". Liquid wastes should not be placed in dumpsters but disposed of properly by other methods. Recycling of non-hazardous solid waste such as scrap metal, aluminum, glass wood pallets, papers and cardboard is recommended wherever feasible. Dumpsters, that store items such as used oil filters should, while awaiting transfer to a landfill, be covered to prevent rain from leaching material from the dumpster onto the ground.

i. Antifreeze

Antifreeze from boat engines may be recycled if it is not mixed with other wastes. Some facilities elect to purchase on-site recycling equipment. However, filters from the recycling units must be handled as hazardous waste and may not be disposed of in solid waste. Runoff that contains antifreeze should be prevented from entering storm drains or natural waters.

j. Boating

Discharges from boats are subject to regulation under the Clean Water Act. However, many activities associated with the use of boats result in impact to coastal waters. Activities that may mitigate some of the impacts associated with boating include:

(1) Prohibitions on the use of environmentally damaging materials and encouragement of environmentally sensitive substitutes,

(2) Speed zones where erosion or other detrimental results could occur,

(3) No boating and/or anchorage zones where sensitive or critical habitats could be damaged by "prop-wash",

(4) No discharge zones where water quality standards could be violated by such a discharge,

(5) Limitations on in-the-water boat hull cleaning if it can be demonstrated that this is a significant local problem,

(6) If in-the-water boat hull cleaning can be an acceptable practice if it is done with a soft cloth (instead of scraping) several times a year, and

(7) Prohibitions of disposal of wastes from boats into State waters.

D. Pollutant Reduction and Costs

Pollutant reduction and costs have not been determined for the Management Measures related to the operation and maintenance of marinas and boats. NPS pollution resulting from some of the activities identified above can be eliminated entirely and others can be greatly reduced through implementation of the prescribed Management Measures.

V. RECOMMENDATIONS FOR STATE PROGRAMS TO IMPLEMENT MANAGEMENT MEASURES FOR MARINAS AND RECREATIONAL BOATING

The information in the remainder of this chapter does not represent management measures but are recommendations for States to consider in their overall approach to marina and recreational boating NPS pollution management. The draft program guidance to be published by EPA and NOAA in the summer of 1991 will contain information on State Coastal Nonpoint Pollution Control Program development and approval.

A. Management Process

It is recommended that a process be developed by every State to permit and regulate recreational boating and marina development and operation. This process should be the foundation on which the actual management measures identified in the rest of this chapter can be designated and implemented. Most States already have programs designed to accomplish many of the actions suggested in this guidance and States are not encouraged or discouraged from reorganizing their programs as described in this chapter. However, it is recommended that States review and, if needed, revise their programs to meet the performance goals identified. Marina and boating programs should consist of the following:

(1) Marina regulations,

(2) Marina development application form,

(3) Technical guidance for locating, planning, design and construction of marinas,

(4) Boating regulations,

(5) Chemical bans/controls of certain boat washing or stripping chemicals,

(6) Enforcement/ monitoring plans, and

(7) Public education.

Marina regulations should deal with potential pollution sources that may originate due to the physical presence or operation of marinas. The intent of the regulations should be three-fold. First, to apply strict environmental controls over the siting, design, construction, and operation of new marinas. The controls should be most comprehensive for new marinas because new construction offers the greatest opportunity for proper environmental planning and management. Second, to allow upgrading of existing facilities in ways which can benefit the environment by imposing reasonable restrictions which would effectively discourage or prevent environmentally detrimental impacts. In this case, it is recognized that physical constraints at existing sites may present insurmountable limitations over the scope of feasible improvements that can occur. Third, to provide for safe and environmentally sound operation of existing and future marinas through prevention of pollution by good housekeeping procedures.

B. Public Education

To improve success in reducing NPS pollution from marinas and recreational boating, a public education program is vital. The public should be educated about causes of NPS pollution and practices that will reduce NPS pollution. Specific areas in which boaters should be educated include:

(1) The types and sources of NPS pollution impacts associated with marinas and boats,

(2) Locations and types of sensitive coastal resources and wildlife habitat areas in local waters, and methods of minimizing boater impacts,

(3) New environmental protection initiatives and new operational measures implemented to respond to these initiatives,

(4) Marina operation and maintenance plans,

(5) Encourage limited use of detergents or use of detergents with 0.5% phosphates by weight,

(6) Proper collection and disposal of hazardous material (bottom paint scrapings and sanding dust, fiberglass resins, epoxy, MSD pumpout waste, dump station wastes, acid-type cleaners, wood bleaches, varnishes, etc.),

(7) Environmentally sensitive boat maintenance and upkeep procedures,

(8) Inform the public as to EPA and Coast Guard regulations prohibiting the discharge or oil or oily waste that causes a visible film or sheen,

(9) Proper use of sewage pumpout facilities, and

(10) Other boating regulations.

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CHAPTER 6. HYDROMODIFICATION, DAMS AND LEVEES, AND SHORELINE EROSION MANAGEMENT MEASURES

CHAPTER 6

HYDROMODIFICATION, DAMS AND LEVEES, AND SHORELINE EROSION

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CHAPTER 6

HYDROMODIFICATION, DAMS AND LEVEES, AND SHORELINE EROSION MANAGEMENT MEASURES

This chapter addresses nonpoint pollution caused by hydromodification and shoreline erosion. Hydromodification covers a wide range of different activities, each presenting varying degrees of a range of nonpoint source (NPS) problems. Identified below are a range of hydraulic activities that may cause NPS pollution. A subset of these activities is addressed through the management measures identified in the section. EPA is seeking suggestions on which activities to focus on most extensively over the next year as it develops the final guidance. Hydraulic modifications vary significantly depending on the geographic region of the country. Therefore, we are also soliciting suggestions on geographic-specific activities and accompanying management measures.

In addition, this chapter addresses shoreline erosion which, unlike the previous chapters, is a symptom or result of other activities, rather than an independent activity that causes a problem. Nonetheless, it is a source of nonpoint pollution that significantly affects many coastal waters.

I. HYDROMODIFICATION

A. Overview of Sources

The following is a list of major activities that can cause alterations of the hydrologic characteristics of coastal and non-coastal waters which, in turn, could cause degradation of water resources.

(1) Dredging (e.g., marina basin, channels, borrow pits, underwater mining activities) - These activities alter the depth, width, and/or location of waterways or embayments and potentially reduce flushing characteristics. The reductions in flushing may reduce dissolved oxygen and change bottom sediments. Specifically, there is a tendency for finer textured sediments to accumulate in these areas impacting the benthic biota. Such areas may attract organic material and concentrate pollutants. In addition, dredging for channelization may increase salt water intrusion from the ocean during low river flow periods but decrease salinities during high flow periods by hastening passage of flood flows.

(2) Dams and Impoundments - Dams and impoundments may alter the distribution 'of sediments in the estuary and may cause migration of the turbidity maximum zone (i.e., the zone of greatest sediment concentration) thereby increasing sedimentation rates in some areas and decreasing them in others. Also, by reducing the discharge volumes, downstream current velocities and total flows may be reduced which in turn may promote the accumulation of fine textured sediments with high organic matter content and the reduction of aquatic habitat

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dependent upon higher flows. Aquatic habitat may also be lost through inundation. These issues are addressed more extensively in the dams and impoundments section (section II below).

(3) Tidal Flow Restrictors (undersized culverts, transportation embankments, undersized bridges, tide gates, sluice gates, weirs) - These structures may reduce tidal flushing and decrease exchange volumes thereby creating or exacerbating water quality problems. Tidal flow restrictors also cause ponding and may cause a loss of vegetation. There may also be a concurrent change in the sediment quality. Such changes may also restrict movement and migration of fish and crustaceans and affect shellfish populations.

(4) Flow Regime Alterations (e.g. diversions, withdrawals, fixing banklines to accelerate flows or to prevent migration of waterway) - Removing freshwater that otherwise enters the estuary or increasing freshwater flows into an estuary can alter hydraulic characteristics and water chemistry, thus impacting shellfish, fisheries, and habitat. Changes to the distribution, amount, or timing of flows affects living resources. Hardening banks along waterways eliminates habitat, decreases organic matter entering aquatic system, and may improve the efficiency of NPS pollutant movement from upper reaches of watershed into coastal waters.

(5) Breakwaters and Wave Barriers - These activities may, through the dissipation of wave energy, cause sediment quality to degrade especially if accumulated sediment contain contaminants and organic material. These devices may also reduce the flushing characteristics of coastal and inland waters and may cause or exacerbate existing water quality problems.

(6) Excavation of Uplands to Increase Water Area (e.g., excavation of marinas from upland; artificial lagoonal systems) - This activity frequently results in poorly flushed areas. Depending upon the location along a tidal waterbody, there may be a reduction in the height of tides downstream. Such changes may create or exacerbate water and sediment quality.

B. Nonpoint Source Problems Caused by Hydromodification

Nonpoint source constituents/parameters of interest that may be influenced by hydromodification include: sediment, turbidity, salinity, temperature, nutrients, dissolved oxygen and oxygen demand, and contaminants. Hydraulic modifications alter the physical environment which may have either harmful or beneficial nonpoint source effects. The nonpoint source parameters can cause problems if they occur outside of normal or desired ranges. For example, salinity fluctuations within range of about 5 to 20 parts per thousand are needed for optimal production of oysters. Periods of lower salinity within this range enable the oysters to thrive and periods of higher salinity are needed to reduce population of predators that destroy oysters. However, extremes of either prolonged low salinity or prolonged high salinity can reduce oyster populations.

The significance of hydromodification lies not only in how such modifications alter the physical environment but, perhaps more importantly, how they ultimately affect freshwater and marine biota and habitat. In many cases, aquatic life is impacted due to disruption of flow, circulation patterns, and other changes in the characteristics of the waters on which these organisms depend. Hydromodifications have deprived wetlands and estuarine shorelines of enriching sediments, prevented natural systems from absorbing energy and filtering pollutants from other sources, and impacted fish and shellfish landings. Nonpoint source problems associated with hydromodification are characterized in this chapter into the following six areas:

(1) Changes in sediment supply. Erosion of bed sediments may increase turbidity, release nutrients, expose contaminants, or expose organic materials that increased oxygen demand. New or eroded sediments may deposit elsewhere, covering benthic communities, or altering habitat. Insufficient sediment supply may not keep up with subsidence and sea level rise, leading to marsh subsidence and loss, as in Louisiana. Erosion or deposition may lead to loss of habitat, migration pathways, or conditions unsuitable for reproduction and growth of biota.

(2) Loss of water contact with wetlands and non-wetland overbank areas during floods or other high water events. The loss of contact may result in reduced filtering of nonpoint source materials by vegetation and soils. (See Wetlands and Riparian Areas chapter.)

(3) Loss of ecosystem benefits such as habitat, pathways for migration, and conditions suitable for reproduction and growth. For example, in California, flow modifications have resulted in reversal of river/stream flow regimes resulting in disorientation of anadromous fish that rely on flow to direct them downstream to spawn.

(4) Reduced freshwater availability for municipal, industrial, or agricultural purposes. Salinity above threshold levels constitutes pollution of freshwater supplies or alteration of salinity regime such that vegetation die-off occurs. (Some cooling and process water uses are unaffected by salinity.)

(5) Increased delivery or rate of delivery of pollutants from upstream.

(6) Secondary effects such as movement of the estuarine turbidity maximum (zone of higher sediment concentrations caused by salinity and tide-induced circulation) with salinity changes, eutrophication caused by inadequate flushing, and trapping large quantities of sediments.

C. Management Measures

Nonstructural measures are one category of management measures that can be used to prevent or minimize water pollution due to hydrologic modifications. While consideration should be given to both nonstructural and structural measures during the early planning stages, nonstructural measures should be given preference in the planning stage given their potential to protect or restore habitat. Certain environmental conditions such as might exist in wetlands or other sensitive aquatic sites, for example, may rule out structural considerations. A nonstructural program will be easiest to implement if it can be developed and adopted for areas not yet experiencing rapid, urban, commercial or industrial expansion. Where circumstances and costs rule against a complete nonstructural program, an appropriate use of both structural and nonstructural modifications may be satisfactory.

Management Measures for the NPS problems listed above are given below.

1. Management Measures for Changed Sediment Supply

(1) Proper project design. Sediment erosion from (and deposition to) the bed of a coastal waterway can be managed by proper project design. Proper design is site and flow condition specific and cannot be generalized, but appropriate models should be used to design waterway modifications. The best available technology includes 2-dimensional numerical and hybrid (numerical plus physical) models. (McAnally, 1986, "Modeling Estuarine Sedimentation Processes," Proceedings, Symposium to Reduce Maintenance Dredging in Estuaries, National Academy of Sciences, Washington, DC.)

(2) Vegetative cover. Sediment erosion from overbank areas that flood during high water events can best be controlled by vegetative cover.

(a) In salt and brackish water areas, the best available technique is planting marsh grasses suitable to the salinity level. Grasses anchor the soil with roots and detritus and reduce flow stresses on the bed by sheltering it. (Allen, H. H., Webb, J. W. & Shirley, S.O., 1983, Proceedings, 3rd Symposium on Coastal Ocean Management, American Society of Civil Engineers, pp 735-748; Fredette, et al., 1985, "Seagrass Transplanting, 10 Years of CE Research, Wetlands Research Conference.)

(b) In fresh water areas, the best technique is planting of tree breaks, which function much as grasses do plus diminish downstream water flow energy. Tree breaks diminish the flow capacity of the overbank area, so evaluation of the tradeoff between upstream flood control and overbank erosion must be made. (Lower Mississippi Valley Division, U.S. Army Corps of Engineers).

(3) Using noneroding roadways. Noneroding roadways, such as board roads, should be used to access sites within and near wetlands.

(4) Effectiveness. Benefits of these measures consist of significant reduction (but not elimination) of sediment bed erosion during high flow events. Use of models to design projects can result in diminished amounts of sediment deposition away from the modification site.

2. Management Measures for Loss of Water Contact with Overbank Areas During Flood Events

(1) Setback levees and compound-channel designs. Contact between flood waters and overbank soil and vegetation can best be increased by a combination of setback levees (see section on Levees, Dams, and Impoundments) and use of compound-channel designs. Compound-channel designs consist of an incised, narrow channel to carry water during low (base) flow periods, a staged overbank area for the flow to expand into during design flow events, and an extended overbank area, sometimes with meanders for high flow events. Planting of the extended overbank as described above completes the design. (W.M. Linder. 1976. "Designing for Sediment Transport", Water Spectrum. Spring-Summer).

(2) Effectiveness. Benefits of this design practice include (a) improved conveyance with less sediment deposition during low and moderate flows, (b) improved habitat, (c) open migration pathways for fish, and (d) improved filtering with minimal erosion during high flow events.

(3) "Wing wall" impoundment for overbank flow in frequent storm events. Construct a notched impoundment within the stream channel immediately upstream of small stream culvert crossings. Designed to back up flows during frequent storm events and expand flow over streambanks into vegetated floodplain. Flow from larger storm events (typically two-year or greater) will overtop the wall and continue through stream culvert.

(4) Effectiveness. Benefits are directly associated with reduction of sediment loadings. Reduction of nitrogen and phosphorous estimated at 5-15%. Restores or maintains habitat of overbank areas and provides a pathway for fish migration.

3. Management Measures for Loss of Ecosystem Benefits

(1) Site specific design. Preserving ecosystem benefits is best achieved by site specific design to obtain pre-defined optimum/existing ranges of physical environmental conditions. The use of models is one way to achieve this. The process consists of these steps:

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(a) Define which ecosystem benefits may be placed at a risk by a project.

(b) Define the range of acceptable values for the system-significant parameters listed in part 1 and the range of flow and net transport values that will maximize/maintain ecosystem benefits. Note that specifying zero change in the parameters may not optimize ecosystem benefits.

(c) Use appropriate models to evaluate system behavior under project alternative plans and appropriate conditions of flow and climate. Verify that the models are capable of reproducing significant processes in the area of interest, then use the sequence of modeling hydrodynamic response, transports, and then water quality.

(d) Refine the project design so as to obtain an acceptable range of significant parameters.

Appropriate models may be 1-dimensional, 2-dimensional, or 3-dimensional, depending on system behavior and economics, and may be physical, numerical or hybrid models, depending on system characteristics and parameters/processes of interest. (Hudson, et al., Coastal Hydraulic Models, SR-5, Sept. 1979. U.S.A.E. Coastal Engineering Research Center, Vicksburg, MS).

4. <u>Management Measures for Reduced Freshwater Availability</u>

(1) For most cases, reduction in freshwater availability is best managed by the same techniques described in item 3 above. In this case, the salinity threshold levels should be selected using defensible criteria, not arbitrary specifications of "zero change" or "zero salinity," neither of which occur in nature.

(2) Salinity increases in fresh or brackish marshes that are caused by canal construction are best managed by the same techniques described in item 3 above.

(3) Artificial nourishment. Salinity increases caused by land subsidence, which lowers marsh levels faster than reduced sediment supply can maintain them are best managed by artificial nourishment with diverted sediment.

5. <u>Management Measures for Increased or Accelerated Delivery of Pollutants</u>

Increased or accelerated delivery of pollutants from upstream are best managed by the techniques described in item 3 above. (For example, the Chesapeake Bay Program's numerical modeling effort provides effective consideration of pollutant delivery. However, it may not adequately consider effects on habitat.)

6. Management Measures for Secondary Effects

(see problem description p. 6-3)

Secondary effects are best managed by techniques described in Section I.C.3 above.

D. Costs of Management Measures

Appropriate model studies described in the preceding best management practices have highly variable costs, but common cost ranges are:

(1) 1-dimensional hydrodynamics and water quality - $5,000 - $50,000.

(2) 2-dimensional hydrodynamics and water quality
  (a) Creeks, small river sections - $10,000 - $100,000
  (b) Sections of rivers to large estuaries - $25,000 - $500,000

(3) 3-dimensional hydrodynamics and water quality
  $100,000 - $5,000,000

Planting overbank and marsh grasses cost between $2,000 and $9,000 per hectare.

Planting overbank tree strips costs between $10,000 and $25,000 per acre.

Channel design and construction to incorporate compound channel design may increase initial and maintenance costs.

Costs of construction of concrete, notched wing wall are in the $10,000-$15,000 range.

E. Overview of Federal, State, and Local Programs and Processes

1. Existing Regulations

a. Administration and background for nonpoint sources

(1) Clean Water Act (Section 404)--permit program for the discharge of dredged and fill material

(2) National Environmental Policy Act--sets the policy requiring all Federal agencies to write an Environmental Impact Statement (EIS) for any major Federal action "significantly" affecting the environment. An EIS must include consideration of environmental factors which tend to help minimize nonpoint source pollution when it has been found abandonment of the proposed action is impractical.

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(3) US Army Corps of Engineers permit process for dredging and filling.

(4) Section 73 of Public Law 93-251 on nonstructural flood damage reduction measures.

b. Examples of present State guidelines

(1) Best Management Practices Guidelines for Virginia
(2) Better Quality Management Plan for the State of Louisiana
(3) Puget Sound Water Quality Management Plan, 1989
(4) San Francisco Bay Conservation and Development Commission (BCDC) policies on fill in tidal areas.

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II. DAMS AND LEVEES

A. Coastal Problems Caused by Dams and Levees

1. Overview

Dams and levees can adversely impact coastal and near coastal water quality, as well as the hydrologic regime of stream systems. Direct impacts associated with the siting, construction, and operation of dams and levees are due primarily to the disturbance of soil and ground cover, changes in stream hydraulics, and modification of existing ecosystems (i.e., loss or reduction of ecosystem filtering and uptake functions).

There are two large classes of impoundments (Virginia Department of Conservation and Recreation, 1979). First, there is the run-of-the-river impoundment, which is an impoundment that usually has a small hydraulic head (low dam), limited storage area (thus, a short detention time), and no positive control over lake storage. The amount of water released from this class of impoundments is dependent upon the amount of water entering the impoundment form upstream sources.

The second class is the storage impoundment, in which there is a large hydraulic head (high dam), large storage capacity (long detention time), and a positive control on the amount of water released from the dam. Flood control dams and hydro-power dams are usually of the storage class. Run-of-the-river impoundments generally have a much less pronounced overall effect on water quality than do storage impoundments.

There are several possible intended uses for impoundments:

(1) Flood control
(2) Power generation
(3) Navigation
(4) Water supply - domestic, industrial, irrigation
(5) Other - recreation, fish and wildlife propagation, low flow augmentation, etc.

These various uses often require differing design and management practices and, in cases of multiple-use objectives, present conflicting operational requirements. For example, flood control impoundments have large storage capacities to contain flood waters. As the wet or rainy season approaches, water is released to insure that adequate storage capacity is available for the periods of high flow. The dam is operated to trap excess flow during the wet season, and to later release this flow during periods of low stream flow.

In contrast, the operation of dams for power generation has traditionally been focused on meeting peak electricity demands. The dams, therefore, usually must impound and store large quantities of water, providing control over downstream releases to meet peak needs.

As a further contrast, dams for navigation purposes must be operated to maintain a minimum depth in the impoundment. These dams usually have locks to facilitate the movement of commercial traffic, and control over downstream releases. Water supply dams impound large quantities of water to meet user needs.

Multi-purpose impoundments can have conflicting operational requirements that must be balanced in order to meet all specified uses. For example, the Shasta Dam in northern California (U.S. Fish and Wildlife Service, 1976) is operated for flood control, irrigation, navigation, fish and wildlife conservation, hydroelectric power, recreation, and salinity control in the Sacramento-San Joaquin River Delta.

2. Siting and Construction

The siting of dams and diversions can result in the inundation of wetlands and special aquatic and terrestrial sites above the structures, and the drainage of aquatic and wetland habitats downstream. They can also impede or block migration routes of important sport and commercial fishes. For example, 95 percent of the historic spawning habitat for salmon and steelhead trout in California has been either destroyed or made unavailable by dams.

Construction activities can cause increased sedimentation of coastal and near-coastal waters due to vegetation removal, soil disturbance, and soil rutting. Fuel and chemical spills, and the cleaning of equipment (e.g., concrete washout) are also potential nonpoint source problems associated with construction. The proximity of most dams and levees to streambeds and floodplains heightens the need for on-site pollutant prevention.

Dam construction can have other effects on the local hydraulics (Virginia Department of Conservation and Recreation, 1979). In order to guard against dam failure, the flow of water under and around the sides of the dam site must be impeded. This is done by embedding an impervious core into the ground to prevent the flow of groundwater under or around the dam (piping). While this construction technique is necessary to ensure the safety of the dam, it can impede the flow of groundwater in the vicinity of the dam. This interference might not become apparent until the dam is fully constructed and the impoundment filled. These effects on the groundwater flow can cause drops in the water table below the dam site, and increases upstream. A rise in the water table can lead to the formation of marshes in areas that had been dry. Other effects include the possible accumulation of pollutants in the groundwater because the flow of the groundwater is disrupted.

3. Operation

The operation of dams and levees can also cause a variety of nonpoint source pollution impacts to coastal and near-coastal waters. For example, dams can severely reduce downstream movement of sediment, causing a change in stream hydraulics. This change in stream hydraulics can cause increased downstream scouring and streambank erosion, resulting in increased sediment and nutrient delivery to coastal waters. As another example, lower instream flows and flattening of peak flows associated with controlled releases from dams can result in aggradation of near-coastal stream beds and estuaries, degrading valuable spawning and rearing habitats. Dams can also limit recruitment of favorably sized substrate needed by aquatic fauna, and lower nutrient inflows to estuaries and near-coastal waters. In addition, dams can cause elevated downstream water temperatures and lower downstream dissolved oxygen levels.

Levees can cause increased transport of suspended sediments to coastal and near-coastal waters during high-flow events. Levees can also prevent the lateral movement of sediment-laden waters into adjacent wetland and riparian areas which would otherwise serve as depositories for sediments, nutrients, and other pollutants. This has been a big factor, for example, in the rapid loss of coastal wetlands in Louisiana. Levees also interrupt natural drainage from upland slopes and can cause concentrated, erosive flow of surface water.

B. Management Measures for Dams and Levees

Management Measure Applicability:

These management measures are to be utilized on all dams, and the erosion and sediment control for construction, erosion and sedimentation control for operation, habitat protection, and chemical and other pollutant control for construction apply to all levees.

These management measures do not apply to the extent that their implementation under State law is precluded under California v. Federal Energy Regulatory Commission, 110 S.Ct. 2024 (1990) (addressing the supercedence of State in-stream flow requirements by Federal flow requirements set forth in FERC licenses for hydroelectic power plants under the Federal Power Act).

1. Erosion and Sedimentation Control for Construction

a. Problems to be addressed

Erosion and sedimentation control techniques can be used to address the erosion problems resulting from dam or levee construction.

b. Erosion and sedimentation management measure for construction

The management measure for control of erosion and sedimentation during the construction of dams and levees is a combination of practices that minimizes the detachment and transport of soil by human-induced disturbance, water, wind, ice, or gravity such that the delivery of sediment caused by the construction activities, either directly or indirectly, to natural waterways is not significantly greater than the delivery of sediment from the construction area prior to construction activities.

c. Management practices

Following is a list of management practices for erosion and sedimentation control that are available as tools to achieve the erosion and sedimentation management measure for construction of dams and levees.

Soil Bioengineering - These techniques can be used to address the resulting erosion from dam and levee construction. Grading or terracing a problem streambank or eroding area and using interwoven vegetation mats installed alone or in combination with structural measures will facilitate infiltration stability.

Environmental Design of Waterways (ENDOW) - This problem-solving computer program is a practice that consolidates information on environmental features and facilitates their selection for use in the planning and design of streambank protection and flood control projects (Shields and Schaefer, 1990). The type of project, dominant mechanisms(s) of erosion, and environmental goals are entered into the ENDOW program. The program then lists and determines the relative feasibility of the environmental goals and features (e.g., pool/riffle complexes, preservation and creation of wetlands, low flow channels) within the program.

Other applicable practices are listed in the "Construction Management Measure" section of the urban chapter in this guidance.

2. Erosion and Sedimentation Control for Operation

a. Problems to be addressed

Erosion and sedimentation control techniques can be used to address the erosion problems resulting from dam or levee operation.

b. Erosion and sedimentation management measure for operation

The management measure for control of erosion and sedimentation during the operation of dams and levees is a combination of practices that minimizes the detachment and transport of soil by human-induced disturbance, water, wind, ice, or gravity such that the delivery of sediment caused by dam or levee operation, either directly or indirectly, to natural waterways is not significantly greater than the delivery of sediment from the area influenced by the dam or levee prior to establishment of the dam or levee.

c. Management practices

Following is a list of management practices for erosion and sedimentation control that are available as tools to achieve the erosion and sedimentation management measure for operation of dams and levees.

Downstream Erosion Controls - The release waters from an impoundment can cause problems downstream by eroding the stream channels and by scouring the stream bed (Virginia Department of Conservation and Recreation, 1979). The amount of erosion potential is determined by the erodibility of the stream channel and banks, and by the amount of "excess" energy the water possesses.

The usual method of controlling erosion is to place energy dissipators downstream of the water release to consume the excess energy, lowering the erosion potential. Energy dissipators can take many forms, including:

Riprap or quarried stone can be used to line the streambed, and is resistant to dislodgment because of its jagged shape. Riprap "liner" will not fail due to settling and shifting.

River Rock is frequently used to line the streambed and channels because it is usually available at the site. Advantage is that the rock "liner" is flexible and can withstand settling and shifting without failure. Problem is that river rocks are generally rounded, and, therefore, dislodged easily by flows.

Gabions are wire mesh baskets filled with rock, and can be placed in the stream to form a "liner." Gabions can be anchored into the stream banks or streambed for stability. Gabions are flexible and seldom fail because of settling or shifting. However, gabions require periodic maintenance to insure that none of the wire is broken or corroded.

Concrete Blocks and Liners can usually be made on-site since dam construction typically requires some concrete. Because concrete is less dense than either river rock or riprap, it is necessary to make concrete blocks larger to provide the same resistance to dislodgment. Concrete structures are inflexible, and therefore more likely to fail due to settling and shifting.

Soil Bioengineering techniques can be used to address the resulting erosion from dam and levee operation. Grading or terracing a problem streambank or eroding area and using interwoven vegetation mats installed alone or in combination with structural measures will facilitate infiltration stability.

Environmental Design of Waterways (ENDOW). This practice is described under the management practice for erosion and sediment control for construction.

d. Cost information

River rock is obtained at essentially no cost because it is obtained on site in most cases (Virginia Department of Conservation and Recreation, 1979).

Riprap is more expensive than river rock because of quarrying and transportation costs. In Tennessee, riprap is estimated to cost $2,000 per 100 feet, assuming 1 cubic yard of riprap per linear foot (Tennessee Department of Health and Environment, ca. 1990).

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Gabions are usually filled with rock found at the site; however, they require additional hand labor to place the rock and ensure that the containers are not damaged.

3. Habitat Protection

a. Problems to be addressed

The loss of aquatic and terrestrial habitat or habitat function associated with the construction or operation of dams and levees is addressed by this management measure. This includes the preservation and protection of wetlands, riparian zones, and adjacent terrestrial habitat.

The control of natural fluctuations in stream flow can cause an increase in the occurrence of rooted aquatic vegetation and an increase in the deposition of fine particles (U.S. Fish and Wildlife Service, 1976). Fine particles can compact spawning gravels, thus affecting spawning success.

b. Management measure

The management measure for habitat protection is a combination of practices that minimizes the loss of aquatic and terrestrial habitat and habitat function such that habitat function in the area affected by the dam or levee is not significantly degraded. Habitat function includes both the range of environmental benefits provided by habitat (e.g., spawning, food supply, protection), as well as the capacity to support the numbers and diversity of species dependent upon the habitat.

c. Management practices

Following is a list of management practices for habitat protection that are available as tools to achieve the habitat protection management measure.

Setback Levees - Setback levees avoid habitats which serve flood control functions and act as filters for sediment and other pollutants. They allow a given level of high flow to maintain existing floodplain habitats. They also allow the transport of lesser amounts of pollutants than rapid transmission structural systems, lowering the delivery of pollutants to coastal waters.

Low flow gates, channels, and weirs - Allow flow maintenance of fishery and other habitats with the same resultant benefits as cited for setback levees.

Flushing and Scouring Flows for Habitat Maintenance - This practice is intended to maintain habitats and substrates by periodically flushing away sandbars and excessive deposits of fine particles and rooted vegetation in areas downstream from the structure. It is essential to establish an actual ecological need for a flushing or scouring flow before proceeding to predict or prescribe the requirements (U.S. EPA, 1988). Predictive and evaluative methods should be selected which are compatible with site-specific conditions, such as the watershed characteristics, instream flow regime, bed material composition, and channel morphology. It is wise to compare results of several methodologies, which could vary by one or even two orders of magnitude, when predicting flushing or scouring flow requirements, and, if possible, provide field verification. An awareness of the assumptions and limitations inherent in any predictive methodology is important because sediment transport mechanics and channel maintenance theory are still in an early stage of development.

Environmental Design of Waterways (ENDOW) - This practice is described under the management practice for erosion and sediment control for construction.

4. Fisheries Protection for Dams

a. Problems to be addressed

This management measure addresses impacts to fisheries caused by the amount and scheduling of flow releases, downstream sedimentation of spawning areas, changes to water temperature, and fish passage. The generation of power at hydroelectric dams results from the movement of reservoir water through penstocks and turbines to downstream areas. Migrating young fish may suffer significant losses when passing through the turbines unless these facilities have been designed for fish passage.

b. Management measure

The management measure for fisheries protection is a combination of practices that minimizes the loss of desirable fish species by: (1) maintaining minimum instream flows for the protection of desirable aquatic species, (2) controlling flow fluctuations within seasonal bounds to protect against damage to aquatic life, (3) providing for flushing or scouring flows as needed for aquatic habitat maintenance, and (4) providing for adequate fish passage for spawning and migratory (both upstream and downstream) purposes.

c. Management practices

Following is a list of management practices for fisheries protection that are available as tools to achieve the fisheries protection management measure.

Maintaining Minimum Flows - In the design, construction, and operation of structures, the minimum flow requirements to support aquatic and other water-dependent wildlife in downstream areas are addressed. Instream flows are usually maintained to protect or enhance one or a few harvestable species of fish (U.S. Fish and Wildlife Service, 1976). Other fish, aquatic organisms, and riparian wildlife are assumed to also be adequately protected by these flows.

Reduction of Flow Fluctuations - Seasonal discharge limits are established to prevent excessive, damaging rates of flow release. Limits are also placed on the rate of change of flow and river

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stage (as measured at a point downstream of the release) to further protect against damage to aquatic communities (U.S. Fish and Wildlife Service, 1976).

Fish Ladders - Fish ladders or similar types of structures should be provided to enable upstream and downstream passage of mature fish. Safe downstream passage of mature fish and fry should also be provided (see screens and barriers to intakes). Some fish, such as steelhead and cutthroat trout, migrate to the ocean more than one time during a lifetime, making necessary the provision for safe downstream passage of mature fish.

Screens and Barriers to Intakes - Fish can be prevented from moving into intakes for water pumps and turbines through the use of various types of screens or barriers (U.S. EPA, 1979). The survival chances of the downstream migrating fish can be increased by providing facilities that bypass them into a gatewall before they enter the turbines and direct them into a channel where they can move safely downstream. Fish can be diverted into holding tanks, collected, and transported away from the area of influence of the pumps, and then released back into the water.

Created Spawning Beds - When the effects of a dam on the habitat of anadromous fish are severe, constructed spawning beds may be designed into the project (Virginia Department of Conservation and Recreation, 1979). Additional facilities are then required to channel the fish to these spawning beds. These can include electric barriers, fish ladders, and bypass channels.

Fish Hatcheries - Only use in existing dams where adequate fish passage not possible or as compensation for loss of fish passage (e.g., fish population supplementation). Native stocks should be used wherever practicable.

When reservoirs flood spawning beds for anadromous fish, hatcheries are established to collect, kill, and obtain the roe from migrating fish (U.S. EPA, 1979). The roe is fertilized and then placed in the hatchery under controlled conditions until the fish are hatched. After having reached an appropriate stage in their development, the fish are released into the river downstream (or above dam to enhance reproduction in the upper watershed) of the dam to migrate back to the ocean.

Transference of Anadromous Fish Runs - This practice involves the inducement of anadromous fish to utilize different spawning grounds in the vicinity of the impounded waters. The extent of the spawning grounds to be lost by blockage of the river is assessed, and the feasibility of transferring existing anadromous fish runs affected by the structure to alternative tributaries is determined.

Environmental Design of Waterways (ENDOW) - This practice is described under the management practice for erosion and sediment control for construction.

5. Temperature Control and Aeration of Reservoir Releases and Tailwaters

a. Problems to be addressed

This management measure is intended to increase dissolved oxygen levels from reservoir releases and tailwaters such that aquatic communities are maintained at levels of abundance, diversity, and function that existed prior to the construction of the dam. Changes in temperature are also addressed to prevent damage to fisheries.

One drawback associated with aeration of release water is the increased possibility of nitrogen supersaturation (Virginia Department of Conservation and Recreation, 1979). Water that discharges over the spillway of a dam and plunges into the spillway basin or plunge pool immediately downstream can become saturated with nitrogen, oxygen, and other gases. As the water plunges rapidly to depths, hydrostatic pressures increase. Entrained air is forced into solution by the pressure before it can rise to the surface and escape. Since air is approximately 80 percent nitrogen, the water becomes supersaturated with nitrogen. Nitrogen levels of 115 percent saturation have been documented to cause mortalities in fish.

b. Temperature and aeration management measure

The management measure for temperature control and aeration of reservoir releases and tailwaters is a combination of practices that restores dissolved oxygen levels to the levels existing prior to the construction of the dam, and maintains temperatures within ranges appropriate for desirable fishes.

c. Temperature control and aeration practices

Following is a list of management practices for temperature control and aeration of reservoir releases and tailwaters that are available as tools to achieve the temperature and aeration management measure.

The following information is taken from Tennessee's Section 319 (Clean Water Act) nonpoint source management program (Tennessee Department of Health and Environment, ca. 1990) unless otherwise noted.

Turbine Venting - Includes Hub baffle, draft tube wall baffle, compressed air through hub or wall. Modify air supply system to increase airflow.

Surface Water Pumps - Pumps surface water with higher dissolved oxygen downward to mix with deeper water as the two strata are entering the turbine.

High Purity Oxygen Injection - Used in combination with turbine venting or surface water pumps to add more oxygen.

Diffused Aeration or Oxygenation of the Reservoir - Used to lower concentrations of dissolved iron, manganese, and hydrogen sulfide.

Surface Water Intake - It may be feasible when constructing a new dam to provide upper elevation outlets to withdraw oxygenated surface water.

Multi-Level Discharge Systems - Multi-level discharge systems have been used successfully to mix waters from all levels of an impoundment to provide some control over the temperature and dissolved oxygen concentrations of the release waters (Virginia Department of Conservation and Recreation, 1979). This consists of providing a release structure with several intake structures at various depths, thus allowing controlled withdrawals from the different levels in the lake. Although this is normally provided during construction, such a structure can be added to an established impoundment. The use of such a system must be carefully considered and designed before implementation because multi-level discharge systems change the thermal structure of the impoundment as a function of withdrawal patterns.

Watershed Management - Control of all point and nonpoint sources of pollutants to achieve improved reservoir inflow quality.

Reregulation Weir - Used to capture hydropower release a short distance downstream and regulate flows to the desired level in reach below the weir.

Small Turbine - Provides continuous generation of power using small flow as opposed to peaking with large turbine units and high flow.

Pulsing - Provides pulse flow on a frequent basis to minimize draining or drying out of tailwater area. This technique requires off-peak operation and decreases the ability to produce peaking power where pulses are needed on a daily basis during certain parts of the year.

Sluice - Modification is made to existing sluice outlet to maintain continuous minimum flow.

Spillway Modification to Prevent Supersaturation of Gases - Spillways are designed or modified to cause the flows to be flipped as they are discharged. Upturned deflectors, cantilevered extension, "flip buckets," or "flip lips" can be designed for spillway terminal structures to deflect the water in a downstream direction and prevent the discharge from plunging straight down. Flows can even be caused to fan out into a thin sheet through the use of a flaring device.

Alternative measures to prevent nitrogen and other gases from reaching supersaturation levels include (1) decreasing spillway flows by providing additional reservoir storage, and (2) decreasing spillway flows by passing water through any available outlet conduit where turbulence will not entrain air.

d. Effectiveness information

The following information is taken from Tennessee's Section 319 (Clean Water Act) nonpoint source management program (Tennessee Department of Health and Environment, ca. 1990) unless otherwise noted.

Turbine Venting - Expect a 2 mg/L to 4 mg/L increase in dissolved oxygen. This is a proven method, but there is a question regarding cavitation resulting from venting.

While the actual design of the turbines is dependent upon many factors, the use of wedge-shaped deflector plates in the draft tubes, slightly below the turbine wheel will create a negative pressure in the flow and thus induce aeration (Virginia Department of Conservation and Recreation, 1979). Howell-Burger valves produce a spray discharge or release that reportedly (TVA) had reaeration efficiencies of 80 percent when the exit velocities exceeded nine meters per second.

Surface Water Pumps - Expect a 2 mg/L to 4 mg/L increase in dissolved oxygen.

High Purity Oxygen Injection - Used in combination with turbine venting or surface water pumps, dissolved oxygen levels can be increased beyond a 2 mg/L to 4 mg/L increase.

Watershed Management - Not expected to correct all dissolved oxygen depletion problems, but is used in combination with other techniques to provide better overall dissolved oxygen levels.

e. Cost information

The cost information provided in Table 6-1 is based upon data provided by the Tennessee Valley Authority (Tennessee Department of Health and Environment, ca. 1990).

6. Chemical and Other Pollutant Control for Construction

a. Problems to be addressed

This management measure addresses fuel and chemical spills associated with dam and levee construction, as well as concrete washout and related construction activities.

b. Management measure

The management measure for control of chemicals and other pollutants during the construction of dams and levees is a combination of practices that minimizes the risk of delivery to natural waterways of chemicals and other pollutants associated with the construction activities.

Table 6-1. Approximate Costs for Reservoir Release and Tailwater Practices (ca. 1990 dollars)

Practice	Cost Description
Turbine Venting	Capital cost can range from $15,000 to $1,000,000 per turbine unit. Annual operation and maintenance cost can range from $50,000 to $100,000 at a project like Norris Dam, and $10,000 to $20,000 at a project like Tims Ford Dam.
Surface Water Pumps	Capital costs about $200,000 per turbine unit. Annual operating cost about $25,000/unit. Operating cost consists primarily of power costs to run the pumps.
High Purity Oxygen Injection	Cost for an experimental system on one turbine unit is as much as $300,000, with an annual operating cost of about $50,000/unit.
Diffused Aeration the Reareation	Capital cost for a small non-power lake is $50,000 to $100,000 with an annual cost of $5,000 to $10,000.
Reregulation Weir	Capital cost of $500,000 to $750,000.
Small Turbine	Capital cost of $500,000 to $750,000, with operating costs at about the break-even point.
Pulsing	Annual cost can be as low as $5,000 to $10,000 where few pulses are needed. This technique requires off-peak operation, and may be subject to additional demand charge because it decreases ability to produce peaking power. Additional charge could range from $100,000 to $700,000 where pulses are needed on a daily basis during part of the year.
Sluice	Capital cost of $150,000, with annual operating cost of about $200,000 to $300,000.

Tennessee Valley Authority water use cost is based on the assumption of lost power-generating potential.

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c. Management practices

Following is a list of management practices for chemical and other pollutant control that are available as tools to achieve the management measure for chemical and other pollutant control for construction.

Nutrient Management - The nutrient management measure for agriculture should be applied for all use of nutrients associated with construction (e.g., revegetation).

Pest Management - The pest management measure for agriculture should be applied for all use of pesticides associated with construction.

Spills - Spill containment and cleanup procedures should be in place to address fuels and chemical spills.

Equipment Washout - Treatment or detention of concrete washout and related washout should be provided such that direct entry of washout contaminants to surface waters is prevented.

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III. SHORELINE EROSION

A. Introduction

This section addresses NPS problems related to shoreline erosion in bays, estuaries, tidal streams, and watersheds within the coastal zone. It does not address open coastal shorelines as erosion into open ocean is not likely to cause NPS problems.

Numerous factors affect the processes along the shore zone (see section D on planning and design considerations). Eroding shorelines and streambanks contribute NPS sediment loads and nutrients to the neighboring waterway. The sediment may have beneficial or harmful impacts. Beneficial impacts include beach nourishment, sandbar creation or nourishment of wetlands that combat erosion. Adverse water quality impacts (turbidity, BOD, sediment), burial of shellfish beds, smothering of submerged aquatic vegetation (SAV), impacts to spawning areas and property loss are several detrimental impacts of erosion. Eroding shorelines also contribute nitrogen, phosphorus and other pollutants to the waterbody.

[EPA requests additional information addressing more arid areas and shoreline measures further upstream in coastal watersheds.]

B. Specific NPS Problems

This section focuses on controls for erosion caused or exacerbated by human land use or water activities. Erosion rates ranging from 1 to 20 feet per year are typical in many coastal areas where the fastland along the shore is itself composed of older deposits of interbedded sand, silt, and clay. This type of eroded shoreline sediment may often contain adsorbed nutrients. It has been demonstrated that nutrient loadings from eroded shoreline sediments are significant. High nitrogen concentrations have been found in upper bank sediments, especially on eroding farm fields. For 14 sites in the Virginia portion of the Chesapeake Bay, for example, average loading rates were 0.51 lbs/ton for nitrogen and 0.35 lbs/ton for phosphorous of eroded sediments from the estuarine shorelines. Shoreline erosion can also adversely affect living bay resources by increasing sedimentation rates and turbidity.

C. Management Measures

To address the NPS problems identified in Section B above, shoreline management measures in the coastal bay/estuarine system should incorporate the upland, shore zone and nearshore regimes in order to accomplish the following objectives:

(1) Avoid the generation of NPS pollution from shoreline erosion during a "25-year" event. For fluvial environments (upstream), this event is the "25-year" flood. For estuaries or coastal bays, this event includes tidal storm surge and wind induced wave action.

(2) Achieve no significant sedimentation from the shoreline source and minimal visible loss of shoreline.

(3) Do not transfer erosion energy to or negatively impact other shoreline areas due to management actions. Minimize impacts of controllable erosion potential (form wave energy and overland storm runoff) such as boat wakes or channelized runoff.

(4) Protect natural shoreline vegetation and aquatic habitats such as wetlands, submerged aquatic beds, riffle pool complexes, and riparian habitat. Restore damaged habitat as a shoreline stabilization practice when conditions allow.

Nonstructural management practices are preferred. Structural shoreline erosion practices should be used only in areas where nonstructural practices are ineffective (i.e., areas with high wave energy). Satisfaction of all of the measures for any reach may be difficult. For example, management practices that are effective for certain water quality objectives may be ineffective or even counter productive in achieving other water quality objectives. For instance, even though bulkheads effectively reduce sediment input, they provide little benefit for restoration of habitat, and in some cases, they have caused other NPS problems due to leaching of chemical wood preservatives from the structure.

D. Planning and Design Considerations to Select Management Practices

The following process outlines an approach for selecting the appropriate management practices to achieve the management measures described in Section C above.

(1) Identify extent of erosion problem. The rates of shoreline erosion can be estimated by comparing present and historic shoreline locations through use of maps, photographs, or pre-existing surveys. Additional site-specific information on the bank height of the fastland can be considered with the historic recession rate, to identify areas contributing the greatest volumes of sediment and related pollutants (i.e., agricultural lands).

(2) Evaluate the effects of the adjacent land use. It is important to consider both the adjacent land use activities and water use activities (such as boat wake) that may cause or exacerbate shoreline erosion problems. Therefore, the shoreline management practice should be implemented in conjunction with the management measures prescribed in the earlier chapters of this guidance. (See Chapters on Agriculture, Forestry, Urban, and Marinas.)

(3) Evaluate the natural causes of shoreline erosion. Shorelines along rivers, bays, and estuaries may degrade gradually due to the daily action of tides, waves, and currents. Alternatively, only the most severe storm conditions may cause loss of fastland or wetlands along the shore. Shoreline erosion in coastal areas is

strongly related to an area's wave climate. A relatively simple measure of potential wave climate is the measure of fetch (the distance over open water that winds can generate waves). In coastal bays and estuaries, the fetch is limited to the distance to the opposite shore. For instance, a low energy shore may have a short fetch across a creek but a very long fetch toward the northeast (i.e., storm exposure). Further upstream, the driving factor may be overland runoff and velocities generated by storm events. The Great Lakes shorelines, on the other hand, may have an almost unlimited fetch due to their great widths and deep water. Selection of the appropriate erosion control measure should be directly related to the extent of the problem and an understanding of the underlying causes.

(4) Determine limits of the reach. A reach is a segment of shoreline wherein the erosion processes and responses are mutually interactive. For example, appreciable littoral sand supply would not pass the boundaries of the reach. A reach may also be defined as a shoreline segment wherein manipulation of the shoreline within that segment would not directly influence adjacent segments. That is, measures implemented on an individual property should minimize impacts to neighboring properties in the reach.

(5) Identify wetlands, riparian, submerged aquatic beds, and other nearshore habitats in the shoreline area of concern. Allow adequate flow and circulation to protect the functional value of adjacent wetlands or other aquatic habitat. If wave climate and other erosive conditions allow, consider nonstructural measures such as restoring pre-existing habitat or using a combination of low profile structures with re-establishing aquatic habitats.

E. Management Practices

This section discusses management practices that are available as tools to achieve the shoreline erosion management measures. There are various practices available to achieve the management measures. These practices range from biological and physical engineering processes to zoning/restrictions. The planning process described above is essential in selecting the appropriate management practice. Eroding areas may be influenced by wind-driven wave action, tidal fluxes, storm discharges from land, operation of water craft, or various land use activities. Selection of the appropriate management practice depends upon a comprehensive understanding of the driving forces behind shoreline erosion. The three basic categories of shoreline erosion control measures are:

(1) Nonstructural: includes bank grading and beach nourishment. Also include restoration and re-vegetation of wetlands (emergent marsh, shrub-scrub, or forested) and other vegetation re-establishment (see chapter on wetlands/riparian restoration for additional information).

(2) Combinations and Bioengineering: includes mixed use of structural and nonstructural approaches such as biological engineering practices, including live staking, live fascine, brushlayer, branchpacking, brushmatresses; also headland breakwaters and beach nourishment with vegetation re-establishment, bank grading and beach fill, groins with vegetation re-establishment.

(3) Structural: includes bulkheads, stone revetments, seawalls, groins and breakwaters.

There are various methods and combinations of methods available from which to choose once a decision has been made to stabilize a shoreline. The method or methods selected must be compatible with other methods (if combinations are selected) and with the objectives of the management strategy. Some methods, with price estimations, are as follows:

1. <u>Nonstructural</u>

a. <u>Bank grading</u>

Bank grading is basically the reshaping of the upper shoreface of a sediment bank to enhance upland vegetative growth. This method is typically used in combination with other methods described below. The cost for bank grading ranges from $2.50 to $5.00 per cubic yard of material moved.

b. <u>Marsh vegetation</u>

The use of marsh vegetation to abate shoreline erosion can be attractive in terms of cost. The initial cost of creating a substantial marsh grass fringe ranges from $30.00 to $60.00 per linear foot, depending on the desired width. Yearly maintenance of a marsh fringe generally involves fertilization and debris removal as well as additional planting. Not all estuarine shorelines are suitable for treatment with marsh grass plantings. Shorelines exposed to high energy categories would be excluded from the vegetative alternative due to more frequent damaging wave action (Knutson, 1977). However, it may be possible to establish a marsh fringe under these conditions in conjunction with some type of offshore breakwaters or other wave damping device.

c. <u>Other re-vegetation</u>

(See Wetlands and Riparian area chapter on restoration for additional information beyond emergent marshes like restoring vegetation in areas further upstream such as bottomland forest or scrub-shrub.)

d. Beach nourishment

There are a variety of techniques available to artificially re-nourish beach systems, however the source, quality, and grain size of material used for re-nourishment needs to be economically evaluated in order to determine its suitability for placement. Truck hauling, cutterhead pipeline dredging, hopper dredging, and combinations of these techniques can be used to effectively re-nourish a beach. In evaluating the quantity of material needed to construct the required beach width, the volume of the material needed to fill the offshore zone where the profile is not in dynamic equilibrium must be considered. If this subaqueous portion of the shore is not filled, the erosion rate of the new material might accelerate until the profile adjusts to the dynamic equilibrium condition. In this case the visible portion of the beach may be displaced offshore with little chance of returning.

The location of the optimum placement of material is another important aspect of beach re-nourishment. This location is mostly dependent on the physical characteristics of the shoreline and the desired result of the project. Placement on the visible portion of the beach can occur in the form of a dune and/or berm construction. The benefits of this type of erosion control measure are readily observed due to the increased beach width for recreation and as a storm protection method. However the berm life might be of short duration due to the previously mentioned processes. Other placement options exist in the foreshore zone and in an offshore zone in the form of a bar.

The cost for beach nourishment varies widely based on the distance to the sand source, the type of equipment used, and the method of placement.

2. Combinations and Bioengineering

Soil bioengineering provides an array of practices that are effective for both prevention or mitigation of NPS problems. This applied technology combines mechanical, biological and ecological principles to construct protective systems that prevent slope failure and erosion. Adapted types of woody vegetation (shrubs and trees) are initially installed as key structural components, in specified configurations, to offer immediate soil protection and reinforcement. Soil bioengineering systems normally utilize cut, unrooted plant parts in the form of branches or rooted plants. As the systems establish themselves and develop roots (fibrous inclusions), they provide an additional resistance to sliding or shear displacement in streambanks or upland slopes.

Specific soil bioengineering practices contributing to these systems include live staking, live fascine, brushlayer, branchpacking, brushmatresses, joint planting, live cribwall and live gully repair. Environmental benefits include diverse and productive riparian habitats, shade and organic additions to streams or small water bodies, cover for fish, aesthetic values and water quality.

Soil bioengineering systems contribute to the following partial list of desired effects:

- Protection of soil surface against wind, rain and frost erosion
- Improved water quality through higher interception of rainfall, and stabilization of soil against erosion.
- Increased shade and reduced temperatures in soil, water, and air layers near ground surface.
- Improved soil permeability.
- Improved riparian and aquatic habitat.
- Improved soil enrichment (decaying organics and symbiosis) and improved water retentive capacity of soil.
- Improved subsurface drainage.
- Reduced wave action.
- Stabilization of slopes prone to shallow failure.
- Control of rills and gullies.
- Filtration of runoff sediment.
- Restoration of aesthetically degraded areas of protection of existing aesthetic attributes.
- Minimum disturbance of existing desired site conditions.
- Reduced operation and maintenance costs.

3. Structural

a. Revetments

The primary purpose of a revetment is to protect the land and upland areas behind the structure from erosion by waves and currents. The stability of a revetment depends on the underlying soil conditions and should therefore be constructed on a stabilized slope. Erosion may continue or accelerate on an adjacent shore if it was formerly supplied with material eroded from the now protected area. The three basic components of a revetment are the armor layer which absorbs the wave energy, the underlying filter layer supporting the armor layer, and the toe protection to prevent displacement of the armor units.

Revetments are commonly constructed of graded quarrystone, precast interlocking blocks, gabions, stacked bags, or special mats. The size and quantity of the construction material and therefore the price of a structure varies with the energy category of the shoreline. Important design considerations include use and overall shape of the structure, location with respect to the existing shoreline, structure length and height, soil stability, normal and storm surge water elevations, availability of construction materials, economics, environmental concerns, institutional constraints, and aesthetics. Average costs for revetments constructed from Class II riprap range from $175 to $225 per linear foot.

b. Seawalls and bulkheads

A seawall is a structure that is built to protect the landward side of the wall from damaging tidal elevations and wave attack. Seawalls may be constructed with concrete, steel sheet piles or wood. Bulkheads have two functions. The first is to retain or prevent sliding of material seaward, and the second, to protect the upland against damage from wave action. Seawalls or bulkheads may be used in all three energy categories; however, the effects of these types of structures on the entire reach of shoreline must be evaluated. The costs of bulkheads varies with the energy category and the locality of the project. Typical costs (for timber bulkheads) are $200.00 to $275.00 per linear foot. These costs may vary $25% to 40% depending on the location of the project.

c. Groins

A groin is a shore protection device, usually oriented perpendicular to the shore, that may consist of one or more structures. The purpose of these structures is to trap littoral drift, thus creating a beach on the updrift side of the groin. Careful planning and design of a single groin or groin field is necessary to avoid adverse erosional effects on the downdrift side of a project. Groin fields usually require maintenance in the form of beach nourishment if the volume of longshore drift is insufficient to bypass around the groin tip. The cost per linear foot varies from $35 to $180 depending on the wave energy category and the locality of the project.

d. Breakwaters

The functions of breakwaters is to intercept incoming waves, dissipate their energy, and thus form a low-energy shadow zone on the landward side. This reduction in wave energy reduces the ability of sediment transport. Sand moving along the shore is therefore trapped behind the structures and accumulated. Breakwaters are often placed as segmented structures that allow for the protection of longer reaches of shoreline for less cost.

The headland control concept is to take advantage of the shoreline's natural movement toward equilibrium. Less resistant shorelines between stable headlands continue to erode until the equilibrium point is reached. As the shoreline reaches a stable configuration, a shallow embayment is formed between the headlands. This equilibrium state will depend on the wave climate and the sediment transport mechanisms acting on the shoreline. By maintaining natural headlands as focal points for stabilization or by inducing artificial ones, the shoreline should stabilize between these headlands. An extensive eroding shoreline reach may be controlled by structurally protecting only about 30 percent of the total reach. Breakwaters and headland breakwaters average $90.00 to $350.00 per linear foot.

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CHAPTER 7. MANAGEMENT MEASURE FOR WETLANDS PROTECTION AND BIOFILTRATION

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I. INTRODUCTION

A. Overview

The preceding five chapters of this guidance have specified management measures that represent the most effective systems of practices to prevent or reduce coastal nonpoint pollution from five specific categories of sources. Below, we specify a management measure that, in contrast, applies to a broad variety of sources. This measure addresses wetlands protection, riparian zone protection, and vegetative filter strips.

The loss of wetland and riparian areas as buffers between uplands and the parent waterbody allows for more direct contribution of NPS pollutants to the aquatic ecosystem. Often, loss of these systems is concomitant with other alteration of land features which increase drainage efficiency. As a result, excessive fresh water, nutrients, sediments, pesticides, oils, greases, and heavy metals from nearby land use activities may be discharged through storm events and seepage to the water column and downstream to the coastal waters without the benefits of filtration and attenuation that would normally occur in the wetland (riparian area), if present.

A study performed in the southeastern United States Coastal Plain illustrates, dramatically, the prevention role that wetlands and riparian areas play. The study examined the water quality role played by mixed hardwood forests along stream channels adjacent to agricultural lands. Based on the input/output budgets, these streamside forests were shown to be effective in retaining N, P, Ca, and Mg. It was projected that total conversion of the riparian forest to a mix of crops typically grown on uplands would result in a twenty-fold increase in NO_3-N loadings. (Lowrance, et al 1983).

Land use activities that alter the structure or hydrologic regime of wetlands and riparian areas may contribute significantly to NPS problems. When riparian vegetation is removed or degraded, the banks of streams, bays, or estuaries are destabilized and become more vulnerable to erosion from storm events, wave action, or concentrated runoff. Floodplain wetlands are very efficient in retaining sediments when the wetlands come in contact with flood waters. However, when the hydrology of these same wetlands is modified, such as by channelization, they may become exporters of sediments instead. Tidal wetlands perform many water purification functions. However, when they are severely degraded such as when drained by tide gates, they have been shown to be a source of nonpoint pollution. When such tidal wetlands underlain by a layer of organic peats are drained, the rapidly decomposing soils may release sulfuric acid that may significantly reduce pH in surrounding waters.

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Wetlands and riparian zones also offer important advantages in habitat protection. Protection and protective use of wetlands and riparian zones should allow for both nonpoint source control and other corollary benefits of these natural aquatic systems. Land managers should, therefore, utilize proper management techniques to protect and restore the multiple benefits of these systems. For these reasons, EPA recommends that land managers should factor both protection and restoration of wetlands and riparian areas into their NPS and coastal management programs.

Vegetative filter strips can also provide important benefits in protecting coastal waters from nonpoint source pollution. As discussed below, properly designed and maintained vegetative filter strips can substantially reduce the delivery of sediment and some nutrients to coastal waters from nonpoint sources.

B. Definitions

EPA provides definitions for wetlands, riparian areas, and vegetative filter strips below. These definitions are provided for clarification purposes only. Identifying the exact boundaries of wetland or riparian areas is less critical than identifying ecological systems of concern. In fact, in many cases, the area of concern may include an upland buffer adjacent to sensitive wetland areas to protect them from excessive nonpoint source impacts.

1. Wetlands Definition

Below is the regulatory definition used by EPA and the U.S. Army Corps of Engineers.

> "Those areas that are inundated or saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally includes swamps, marshes, bogs, and similar areas."

Wetlands are generally waters of U.S. and as such afforded protection under the Clean Water Act. Although we are focusing on the function of wetlands in reducing nonpoint source pollutants, it is important to keep in mind that they are ecological systems that perform a range of hydrologic and habitat functions as well as transforming or trapping pollutants.

2. Riparian Area Definition

Simply stated, a "riparian area" is the vegetated area along a waterbody. There is no one well-established definition; however, these areas are typically part of a "riparian system", a complex assemblage of organisms and their environment existing adjacent to and near waterbodies. Riparian areas are zones that are strongly influenced by an adjacent aquatic environment, have linear characteristics, and experience hydrological fluxes at least once within the growing season. These areas are associated with bays, estuaries, rivers, lakes, reservoirs, springs, seeps, and ephemeral, intermittent, or perennial streams. They occur as complete ecosystems or as an ecotone between aquatic and terrestrial ecosystems, but have distinct vegetation and soil characteristics because of high soil moisture. Topographic relief and presence of depositional soils most strongly influence the extent of water regimes and associated riparian zones. Riparian ecosystems may be classified as uplands, wetlands, or some mixture of the two. Generally, riparian wetland soils are high in clay content, organic matter, water-holding capacity, and natural fertility. The term "riparian ecosystem" does not convey definitive boundaries.

Riparian zones differ functionally from vegetative filter strips in that riparian zones have the ability to filter subsurface as well as surface flows, while filter strips are primarily involved in the filtration of surface flows.

3. Vegetative Filter Strips Definition

Vegetative filter (or buffer) strips (VFS) are permanent, maintained strips of planted or indigenous vegetation located between nonpoint sources of pollution and receiving water bodies for the purpose of removing or mitigating the effects of nonpoint source pollutants such as nutrients, pesticides, sediment and suspended solids. VFS employ strips of perennial grasses, legumes, and/or hay crops to act as a filter to remove sediment and suspended solids, to reduce runoff velocity, and to facilitate rain absorption into the soil.

The pollutant-removal mechanism of the filter strip results from a combination of functions, including a change in flow hydraulics and the process of neutralizing or assimilating pollutants. The physical process of removing pollutants involves filtering particulates and sediment through vegetation, its settling and deposition, and, in some cases, uptake by vegetation.

[EPA REQUESTS COMMENT: Should this chapter also address other aquatic resources that are important to maintaining water quality? A proposal to include two other categories of aquatic resources follows:

> Intertidal Flats: trap sediments and reduce the amount of suspended sediments in adjacent coastal waters; flats also influence the chemistry of adjacent coastal waters.
>
> Submerged Aquatic Vegetation: tend to dampen wave energy thereby promoting sedimentation. This in turn reduces amount of suspended sediments in the water.]

II. MANAGEMENT MEASURE FOR WETLANDS, RIPARIAN AREAS, AND VEGETATIVE FILTER STRIPS

Wetlands, riparian areas, and vegetative filter strips are important components of systems to control nonpoint sources of pollution. A principle of protection involves minimizing impacts to wetlands and riparian areas serving to control nonpoint source pollution, by maintaining existing functions of the wetlands and riparian areas, including: vegetative composition and cover; flow characteristics of surface and ground water; hydrology and geochemical characteristics of substrate; and species composition. In addition, vegetated filter strips have wide applicability and should be broadly employed to protect coastal waters from sediments and nutrients.

III. MANAGEMENT PRACTICES FOR WETLANDS

A. Benefits of Wetlands in NPS Control

Wetlands provide many beneficial uses including habitat, flood attenuation, water quality improvement, shoreline stabilization, and groundwater recharge and discharge. Wetlands can play a critical role in reducing nonpoint source pollution problems in open bodies of water by trapping and/or transforming pollutants before releasing them to adjacent waters. Their role in water quality includes processing, removing, transforming and storage of such pollutants as sediment, nitrogen, phosphorus, pesticides, and certain heavy metals in exchanges with adjacent waters or with waters that pass through the wetland. Wetlands are also major exporters of carbon and nutrients.

A wetland's position in the landscape, both in relation to the pollutant source and the wetland's position in the watershed, affects its water quality functions. Wetlands in the upper reaches of the watershed are believed to have the greatest overall impact on water quality because a larger percentage of water in the river has contact with adjacent wetland environments. It has been estimated that the first 20 meters of a wetland (both riparian and salt marshes) immediately below the source of nonpoint source pollution may be the most effective filter.

In its June 18, 1990, "National Guidance: Wetlands and Nonpoint Source Control Programs", EPA formally recognized and advised EPA Regional and State program managers of the importance of linking NPS and wetland program activities to enhance the effectiveness of both. That linkage can be extended to include the State coastal zone programs to address the new NPS requirements in the Coastal Nonpoint Pollution Control Program. This linkage between wetlands and nonpoint source programs is particularly appropriate given the special emphasis placed on wetlands within the enhancement grants provisions of the CZMA.

B. Management Practices to Protect and Restore Wetlands

There are two overall management practices for wetlands: 1) Establish a preference for protection of existing wetland systems adjacent to parent waterbodies (impact avoidance), 2) Identify wetland areas in a watershed to target for restoration for their NPS reduction and other benefits.

1. Management Practice - Protection

Establish a preference in NPS programs for protecting wetlands (impact avoidance). Avoiding impact to wetlands is fundamental to pollution prevention. A principle emphasizing protection advocates avoiding impact to wetland areas when practicable to maintain existing beneficial uses (functions) and to meet existing water quality standards.

(1) **Consider wetlands and riparian areas on a watershed or landscape scale so that they form a continuum of filters before waters enter an estuary.** This practice includes basin wetlands, riparian buffers and wetlands adjacent to streams and rivers that together serve important NPS functions to buffer the estuary from the sources of NPS pollution.

(2) **Identify wetlands with significant nonpoint source control potential within coastal watersheds.**

(3) **Existing wetlands should not be altered to maximize their water quality function at the expense of their other functions as waters of the U.S.** For example, the following practices should be avoided: location of stormwater ponds or sediment retention basins within a wetland; or extensive dredging and plant material harvest as part of nutrient or metals management in natural wetlands.

(4) **Conduct permitting, licensing, certification, and nonregulatory NPS activities in a manner that protects existing beneficial uses (functions) and meets applicable water quality standards for wetlands.** Because almost all wetlands are "waters of the U.S." they are provided the same protection under water quality standards as other waters. EPA has issued guidance for States to develop or improve standards for their wetlands no later than 1993 (U.S. EPA. 1990). These standards include not only chemical numeric criteria, but biological and physical narrative or numeric criteria designed to protect the designated uses (functions) of the wetland.

(5) **Use upland buffers around existing wetlands when necessary to prevent NPS impairment to wetlands.** For example, if sediment runoff is a problem in an area, consider the assimilative capacity of a wetland area to determine what other measures such as upland buffers are needed to handle the volume of sediment.

a. Effectiveness of protection practices

Inorganic solids (sediments) - The role of wetlands in trapping suspended sediments is well documented. Due to their relatively low slope, wetlands positioned between sediment sources and open bodies of water, such as a bottomland hardwood forested wetland, can remove moderate amounts of sediment from turbid runoff without ecological damage to the wetland. In addition, vegetated wetlands along streams or rivers stabilize soils and help to minimize sediments transported downstream to the estuary. Sediment removal rates of 80 to 90% are common in floodplain wetland and riparian areas.

Fecal coliform - Bacteria are generally associated with particulates in the water column. When sediments settle out in wetland areas, a long retention time of the particulates promotes die off of the bacteria.

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Nutrients - The vegetation in a wetland is important both for uptake of nutrients and as a carbon and litter source for the soil. The carbon, in turn, fuels the immobilization of phosphorus and nitrogen by microorganisms in the soil and the transformation of nitrogen into a gaseous form through denitrification. The layer of litter along the riparian area surface also serves to trap sediments which in turn also captures the particulate phosphorus.

Nitrogen - The effectiveness of wetlands in removing and transforming nitrates varies with retention time of the water in the wetland and the wetland type. Nitrogen is removed primarily from ground water flowing near the surface and is transformed and released as a gas. The net effect of wetlands is to reduce nitrate concentrations. However, nitrate may be flushed from wetlands during periods of high flow (Brown, 1985) (Johnston, Detenbeck, Niemi, 1990).

Riparian vegetation that borders first order streams appears to most efficiently remove nitrate due to contact of a large percentage of the water with the wetland or riparian area. In higher order streams, the primary contact with wetlands occurs during flooding periods (e.g., palustrine wetlands) or when water is impounded (Whigham and Chitterling, 1988). Some examples of effectiveness of nitrogen removal are (Whigham and Chitterling, 1988; Johnston, 1990):

Vegetation Type	Removal
Cypress swamp in Louisiana:	49%
Riparian zone in Piedmont of Georgia:	68%
Cypress dome in Florida:	74%
Riparian forest of North Carolina coastal plain:	86%
Riparian forest of Maryland inner coastal plain	89%

Phosphorus - The role of wetlands in retaining phosphorus has shown mixed results, depending on the wetlands location. Because total phosphorus is sorbed to fine silts and clays, the sediment retention functions of wetlands tend to trap phosphorus as well. In contrast, studies have shown that phosphorus is not efficiently trapped in upland riparian areas because the fine sediments with attached phosphorus either move through the riparian zone, or particulate phosphorus is trapped and released as dissolved phosphorus (Cooper, 1986; Whigham and Chitterling, 1988).

The most important wetlands for phosphorus removal appear to be palustrine wetlands further down the watershed from first order streams. In addition, phosphorus removal appears to be greatest where the surface water comes in contact with the wetland vegetation and litter zone.

Riverine wetlands have also been shown to reduce both nitrogen and phosphorus, but it depends on contact time with the wetland usually associated with flooding events. For example, one study shows a 10-17 percent retention of phosphorus when 50% of the wetland is inundated, and a 46-69 percent retention when more than 50% is inundated. When surface flow is diffuse rather than channelized, fine silts and clays along with attached phosphorus are deposited in wetlands along rivers.

b. Programs to protect wetlands

In highly developed urban areas, the riparian area may virtually be destroyed by construction, filling in wetlands, channelization or other significant alteration. In agricultural areas, the wetland and riparian systems may either involve no management, use of the area for grazing, or removal of native vegetation and replacement by annual crops or perennial cover. Significant hydrologic alterations may have occurred to expedite drainage of farmland. Agricultural impacts to riparian systems may involve clear cutting, filling for stream crossings, and other activities that may significantly affect hydrology and sediment deposition in the riparian zone and the neighboring stream, lake, or estuary. Similar destruction or significant impact may occur as a result of various other activities such as highway construction, silviculture, surface mining, deposition of dredged material, and excavation of ports and marinas. All of these activities have the potential to degrade or destroy the water quality functions of wetlands and riparian areas and may generate additional nonpoint source problems as well.

General approaches - There are many programs, both regulatory and nonregulatory, to protect wetland functions. The list includes elements such as:

Acquisition - Obtain easements or full acquisition rights for wetland and riparian areas along impaired streams, bays, and estuaries. There are numerous federal programs such as Soil Conservation Service Wetlands Reserve and Fish and Wildlife Service National Waterfowl Management Plan funding that can provide assistance for acquiring easements or full purchase.

Zoning - Control activities negatively impacting these targeted areas through special area zoning and transferable development rights.

Water Quality Standards - Put water quality standards in place for wetlands. Factor natural water quality functions into designated uses for wetlands, and include biological and hydrologic criteria to protect the full range of wetland functions.

Regulation and Enforcement - Establish, maintain, strengthen regulatory and enforcement programs. Include nonpoint source conditions in permits and licenses under CWA §401 and §404, state regulations, etc.

Restoration - Maximize opportunities to set aside and restore wetland and riparian areas using USDA's Conservation Reserve and Wetlands Reserve Programs and other federal assistance.

Education and Training - Educate farmers and urban dwellers and other agencies on the role of wetland and riparian areas in protecting water quality and BMP's for restoring stream edges. Teach courses in simple restoration techniques for landowners.

Comprehensive watershed planning - Establishes a framework for multi-agency program linkage and presents opportunities to link implementation efforts aimed at protection or restoration of wetlands or riparian areas. A number of State and Federal agencies carry out programs with compatible mechanisms and objectives to NPS implementation goals in the coastal zone. For example, the Corps of Engineers administers the CWA Section 404 program; USDA implements Swampbuster, Conservation Reserve and Wetlands Reserve Programs; EPA, the COE and States work together to perform Advance Identification of wetlands for special consideration (Section 404); and States administer the CZM program which provides opportunity for consistency determinations and the CWA 401 certification program which allows for consideration of wetland protection and water quality objectives.

As an example of a linkage to protect nonpoint source and other benefits of wetlands, a State could determine under CWA Section 401 or a State regulatory program that a proposed activity in wetlands is inconsistent with State water quality standards or the objectives of the established watershed strategy. Or, if a proposed permit is allowed contingent upon mitigation by creation of wetlands, such mitigation might be targeted in areas defined in the watershed assessment as needing restoration. Watershed or site specific permit conditions may be appropriate (i.e., specific buffer widths/structure based on adjacent land use activities). Similarly, USDA's Conservation or Wetlands Reserve Programs could provide landowner assistance in areas identified by the NPS program as needing particular protection or riparian zone re-establishment.

c. Examples from State and local programs

Baltimore County, Maryland, adopted a bill to protect the water quality of streams, wetlands, and floodplains that requires forest buffers for any activity that is causing or contributing to pollution including: nonpoint pollution of the waters of the State in that county; erosion and sedimentation of stream channels; or degradation of aquatic and riparian habitat.

The county has management requirements for the forest buffers including wetlands and floodplains tha specify limitations on alteration of the natural conditions of these resources. The provisions also call for public and private improvements to the forest buffer to abate and correct water pollution, erosion and sedimentation of stream channels, and degradation of aquatic and riparian habitat.

Washington has developed draft wetland water quality standards to protect wetlands that include enforceable provisions to address stormwater and nonpoint discharges into wetlands. The primary means for requiring compliance with standards will be through waste discharge permits, rules, orders, and directives issued by the Department of Ecology. In cases where BMPs are not being implemented, the Department may pursue voluntary corrective action, orders, directives, permits, or civil or criminal sanctions to gain compliance with standards.

2. Management Practice - Restoration

When conditions are appropriate, restoration of wetlands and riparian areas should be preferred over structural management measures to gain NPS and additional benefits for waters of the U.S. Restoration of wetlands refers to re-establishing a wetland and its range of functions where one existed previously by re-establishing the hydrology, vegetation, and other habitat characteristics.

Restoration of wetlands and riparian areas in the watershed have been shown to result in NPS benefits.

A restoration management practice should be used in conjunction with other measures addressing the adjacent land use activities and in some cases water activities as well.

A preference should be established for restoring multiple ecological functions of waters of the U.S. When conditions are appropriate, restoration of the aquatic ecosystem is a wholistic approach to water quality that addresses NPS problems while meeting the goals of the Clean Water Act to protect and restore the chemical, physical, and biological integrity of the nation's waters. Full restoration of complex wetland and riparian functions may be difficult or expensive, based on site conditions, complexity of system to be restored, availability of native plants, etc. The following are general approaches to factor into wetland and riparian restoration projects for NPS benefits. Specific practices under these approaches must be tailored to specific ecosystem type and site conditions. The preceding chapter's section on shoreline erosion also discusses restoration in the context of mitigating shoreline erosion in wetland or riparian areas.

(1) **Restoration of hydrology is a critical factor to gain NPS benefits and increase probability of successful restoration.**

(2) **Restore native plant species when possible either allowing natural succession or through selected planting.** When consistent with pre-existing wetland type, plant a diversity of plant types, or manage natural succession of diverse plant types rather than planting monocultures. Deep rooted plants may work better than grasses for transforming nitrogen because they reach the water moving under the surface. For forested systems, a simple approach to successional restoration would be to plant one native tree species, one shrub species, and one ground cover species and allow natural succession to add diversity of native species over time.

(3) **When possible plan restoration as part of naturally occurring aquatic ecosystems. Factor in ecological principles when selecting sites and designing restoration such as:** seek high habitat diversity and high productivity in the river/wetland systems; look for opportunities to maximize habitat connectedness (between different habitat types); and restore to provide refuge or migration corridors along rivers between larger patches of upland habitat -- animals are most likely to colonize new areas if they can move upstream and downstream under cover.

(4) **Seek a range of pre-existing functions:** Maximize the wetland functions restored to replicate pre-existing functions. In addition to pollutant transformation, functions to restore may include flood control, food chain support, and habitat. Additional measures (such as adjacent land use BMPs) and

monitoring should be used to ensure that there are no detrimental impacts to wildlife if loadings include pollutants toxic to wildlife. See chapters on Agriculture, Silviculture, and Urban Activities for specifications of applicable management measures.

a. Effectiveness of restoration practices

The ultimate goal of wetland and riparian restoration is to restore ecosystems as opposed to buffer strips, but this may evolve over time through managed succession.

- An ecosystem should be self-sustaining, whereas buffer strips are generally not.
- Restore targeted water quality functions.
- Restore a range of wetland or riparian functions that used to exist at that site.
- Do not degrade value of surrounding natural habitats through uncontrolled expansion of exotic species.

See section II.B.1.b. for typical removal effectiveness of NPS pollutants by these systems.

b. Planning and siting considerations

A relatively high degree of success has been achieved with revegetation of coastal, estuarine, and freshwater marshes because hydrology is relatively easy to restore, native seed stocks are often present, and natural revegetation often occurs. Marsh vegetation also quickly reaches maturity in comparison with shrub or forest vegetation. Success rates for marshes seem to be correlated to proper elevation. Spartina patens has been difficult to restore due to sensitivity to elevation requirements. Spartina alterniflora restoration has succeeded where the elevation and soils are within a given range (depending on the site) and the wave conditions are not extreme (Walker, 1988). Since many of the factors vary with site conditions and wetland type, a careful review of existing literature and case-studies (both successful and unsuccessful) is needed.

Planning:

- Identify sources of NPS problems. Consider the role of restoring sites within a broader landscape context.

- Set goals for the restoration project based on location and type of NPS problem; when practical, replicate multiple functions while still gaining NPS benefits.

- Locate historic accounts (i.e., maps, descriptions, photographs) to identify sites that were previously wetland or riparian. These sites are likely more suitable for restoration if the original hydrology has not been permanently altered.

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Site considerations:

It is difficult to establish any single methodology for identifying potential restoration sites on a national scale. Project goals, NPS problems, and site specific parameters all must be considered in restoration design. The following list identifies some important information or considerations for siting a restoration project. This should not be regarded as the final word on considerations, but should be adapted as appropriate for a given project or proposal.

- Site history. Past uses of site including past functioning as wetland.
- Topography. Surface topography including elevations of levees, drainage channels, ponds, islands.
- Slope and tidal range.
- Existing water control structures. Location of culverts tide gates, pumps, and outlets.
- Hydrology. Hydrologic conditions affecting the site. Wave climate, currents, overland flows and flood events.
- Sediment budgets. Sediment inflow, outflow, and retention.
- Soil. Description of existing soils with analysis of suitability for supporting wetland plants.
- Existing (or native) vegetation.
- Salinity.
- Timing of restoration project.
- Potential impact to site from adjacent human activities.

c. Cost considerations for restoration

The cost of wetland and riparian restoration projects will vary significantly depending on the degree of grading, hydrologic changes required, the availability and cost of native vegetation, and whether any physical structures are needed to help ensure success.

An example of restoration costs for an east coast coastal marsh includes the following:

- If substrate is already sufficient and minimal site preparation is required, costs average less than $30.00 per linear foot to plant a single marsh species (Spartina).
- If more extensive bank grading, preparation, or fill is required, the same marsh restoration costs may range from $60.00 to $100.00 per linear foot.
- If a protective structure, typically a low-crested sill, is necessary to reduce erosional forces, the costs can range from $120.00 to 150.00 per linear foot.

EPA requests additional cost data for other wetland and riparian types such as mangrove swamp, scrub-shrub swamp, forested wetland or riparian zone, or grassland riparian zone.

IV. MANAGEMENT PRACTICES FOR RIPARIAN AREAS

A. Benefits of Riparian Areas in NPS Control

Riparian areas are able to intercept surface runoff, wastewater, subsurface flow, and certain groundwater flows from sources upland of the area, removing or buffering the receiving water body from the effects of the pollutants, or preventing the entry of pollutants into the receiving water body. A riparian buffer strip should be used to protect a stream from land use activities adjacent to the stream, and normally consists of grasses, shrubs and trees in the streambank area (New York DEC, 1986). Riparian buffers perform much like wetlands by filtering, storing and even transforming nonpoint source pollutants (Stuart and Greis, 1991).

Like planted vegetation in riparian zones, naturally-occurring vegetation has been shown to be effective in removing sediment, nutrients, pesticides and other nonpoint source contaminants from upland runoff as well as in the abatement of streambank erosion (U.S. EPA, 1988). The pollutant removal mechanisms associated with riparian vegetation combines the physical process of filtering (much like the vegetative filter strip), and the biological processes of nutrient uptake and denitrification (Peterjohn and Correll, 1984). In addition to these two functions, the preservation of vegetation along the streambank shades the stream and helps to maintain lower water temperatures, which preserves fish habitat. The presence of riparian vegetation also helps to prevent streambank erosion.

B. Management Practices to Protect Riparian Areas

1. Management Practice - Protection

As for wetlands, the best way to ensure riparian areas provide NPS benefits in the watershed is to establish a preference for protection of existing riparian areas adjacent to parent waterbodies (impact avoidance). The nonpoint source goal in protecting riparian areas is to improve water quality (1) by removing nutrients, sediment and suspended solids, and pesticides and other toxics from surface runoff, wastewater, subsurface and groundwater flows from sources upland of the riparian area, and (2) by buffering the effects of upland nonpoint source pollution before its entry into waters of the riparian zone.

(1) **Consider wetlands and riparian areas on a watershed or landscape scale so that they form a continuum of filters before waters enter an estuary.** This practice includes basin wetlands, riparian buffers and wetlands adjacent to streams and rivers that together serve important NPS functions to buffer the estuary from the sources of NPS pollution.

(2) **Identify riparian areas with significant nonpoint source control potential within coastal watersheds.**

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The identification and designation of streamside areas is needed to determine the extent and distribution of highly valued and sensitive riparian resources. The boundaries of these areas are determined by the minimum distance needed to provide protection to the water quality and habitat functions. Distances needed may vary depending on soil type, slope, and riparian cover. Some States and forest management agencies have set minimum distances to protect water quality and ecosystem function. Additional distance is required if there is reasonable risk of pollution or loss of riparian functions.

This practice applies to the following water bodies where they are located downslope of croplands, pastures, etc.:

(1) Adjacent to streams (streambanks)

(2) Around lakes or ponds

(3) Adjacent to wetlands

(4) Near groundwater recharge areas

(5) In areas where soil erosion and sediment deposition is a significant problem

2. <u>Effectiveness of Protection Practices</u>

One study suggests that good water quality for streams and water bodies in agricultural watersheds is directly related to nutrient removal and uptake in the riparian ecosystem. It concludes that the absence of riparian vegetation will result in higher nutrient loadings and stresses that maintenance of the riparian ecosystem is vital to the preservation of high water quality (Peterjohn and Correll, 1984).

Research indicates that nonpoint source pollutant mitigation can also be achieved through the process of denitrification in the riparian zone. Bacterial denitrification in anaerobic sites has been shown to remove large quantities of nitrates from riparian zone groundwater (Schipper, et al., 1989).

A riparian buffer is most effective as a component of an integrated land management system which combines nutrient, sediment and soil erosion control management. The riparian ecosystem consists of a complex organization of biotic and abiotic elements. Like planted vegetative filter strips or grassed swales, riparian buffer strips have been shown to be effective in removing sediment, suspended solids, nutrients, pesticides and other contaminants from upland runoff. In addition, some studies suggest that riparian vegetation acts as a nutrient sink, taking up and storing nutrients, and that this function may be related to age (Lowrance, et al.).

It is clear that the long-term maintenance of natural riparian vegetation zones in areas subject to inputs from upland areas can be an effective management practice for reducing certain types

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of nonpoint source pollution and that efforts to improve watershed water quality should emphasize maintenance of riparian vegetation (Fail, et al.). Other studies confirm the important role of riparian ecosystems as nutrient sinks and buffers against runoff from surrounding lands.

Studies done in agricultural watersheds suggest that good water quality is directly related to nutrient removal and nutrient uptake in the riparian ecosystem (Lowrance, et al.). While some data supports the hypothesis that bottomland riparian ecosystems act as short- and long-term nutrient filters and sinks through vegetative uptake of upland-applied nutrients, these studies are not conclusive (Fail, et al.).

While the exact nature of the process by which pollutant reduction is achieved may be open to debate, numerous research studies have documented the effectiveness riparian buffer areas in removing nutrient loadings from runoff from upland agricultural areas. Three major studies from Maryland, North Carolina, and Georgia are summarized below Stuart and Greis, 1991):

Study	Total P	Total N
Peterjohn/Correll (MD)	76%	88%
Jacobs/Gilliam (NC)	50%	93%
Lowrance (GA)	50%	83%

Additional data regarding the effectiveness of riparian areas can be found under section II.B.1.b.

3. Cost Considerations

The following costs are provided to give some indication of the cost of restoring riparian zones.

$100/acre (conifer seedling)
$200/acre (deciduous seedling)
$1000-5000/acre (nursery stock)

There is no direct cost involved in preserving existing vegetation in the riparian zone.

C. Maintenance

The maintenance of riparian buffer areas is especially important in preventing sediment from entering streams where its effect on fish and spawning can be a serious problem.

V. MANAGEMENT PRACTICES FOR VEGETATIVE FILTER STRIPS

A. General Role

Runoff water quality management methods generically referred to as biofiltration methods have been shown to provide significant reductions in pollutant delivery. These include vegetative filter strips, grassed swales or vegetated channels, and created wetlands. These methods have been applied in a wide range of settings, including cropland, pastureland, forests, and developed as well as developing urban areas, where biofiltration methods can perform a complementary function in terms of sediment control and stormwater management. When properly installed and maintained, biofiltration methods have been shown to effectively prevent the entry of sediment and sediment-bound pollutants, nutrients, and oxygen-consuming substances into water bodies.

Vegetative filter strips are discussed and described in particular source category-specific chapters of this guidance, but it is clear that they should be considered to have wide-ranging applicability to various nonpoint source categories. Vegetative filter strips SHOULD be widely adopted as components of management systems to address nonpoint source pollutants in runoff from a wide variety of sources.

B. Management Practices for Vegetative Filter Strips

The purpose of vegetative filter strips is to remove sediment and other pollutants from runoff and wastewater by filtration, deposition, infiltration, absorption, adsorption, decomposition and volatilization and thereby reduce the amount of pollution entering adjacent water bodies (U.S.D.A., 1988). Vegetative filter strips are used in areas adjacent to water bodies which may be subject to sediment, suspended solid, and/or nutrient runoff. They improve water quality by removing nutrients, sediment, suspended solids, pesticides, etc., from surface runoff and waste water.

1. Effectiveness

A substantial body of research suggests that vegetative filter strips improve water quality and are an effective management practice for the control of silvicultural, urban, construction and agricultural nonpoint sources of sediment, phosphorus, bacteria, and some pesticides. There are also studies which suggest that the results are inconclusive and variable. However, the following are sources for which filter strips may provide some removal capability (Lanier, 1990):

(1) Forestry - Forest filter strips are used to prevent entry of sediment into riparian water bodies.

(2) Cropland - The primary function of grass filter strips is to filter sediment from soil erosion and sediment-borne nutrients. However, filter strips should not be relied upon as the sole or primary means of preventing nutrient movement from cropland.

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(3) Urban - Filtering and removal of sediment, organic material and trace metals. According to the Washington Council of Governments, filter strips have a low to moderate capability of removing pollutants in urban runoff, and have higher removal rates for particulate than for soluble pollutants (Schueler, 1987).

Filter strips are designed to be used under conditions in which runoff passes over the vegetation in a uniform sheet flow. The distribution of runoff across the filter in such a manner is critical to the success of the filter strip. If runoff is allowed to concentrate or channelize, the filter strip is easily inundated and its purpose defeated.

Filter strips need the following elements to work properly: 1.) a device such as a level spreader which ensures that runoff reaches the filter strip as a sheet flow (berms can be used for this purpose if they are placed at a perpendicular angle to the filter strip area to prevent concentrated flows); 2.) a dense vegetative cover of erosion-resistant plant species; 3.) a gentle slope of no more than 5%; 4.) length at least as long as the adjacent contributing area (Schueler, 1987). If these requirements are met, the VFS has been shown to remove a high degree of particulate pollutants. Its effectiveness at removing soluble pollutants, however, is not well-documented (Schueler, 1987).

The effectiveness of vegetative filter strips varies with topography, vegetative cover, implementation and use with other management practices, as well as the following key variables:

(1) Slope - Filter strips function optimally at slopes of less than 5%; slopes greater than 15% render them ineffective because surface runoff flow will not be sheet-like and uniform. Their effectiveness is strongly site-dependent, i.e., VFS have been demonstrated to be ineffective on hilly plots or in terrain which allows concentrated flows.

(2) Site Considerations - Filter strips are most effectively employed at sites which generate suspended solids, sediment and sediment-bound pollutants. As sediment increases in the filter, effectiveness decreases; if the filter strip becomes inundated, it becomes ineffective. Without maintenance, the effectiveness of filter strips will decline over time, as more runoff events occur (Magette, et al., 1989).

(3) Pollutant Type - Sediment and sediment-bound nitrates, phosphorus, and toxics are efficiently removed by filter strips. However, removal rates are much lower for soluble nutrients and toxics. Soluble nutrients are more effectively removed by riparian vegetation.

(4) Vegetated Area - Criteria for choosing the best vegetation type include dense growths of grasses and legumes which are resistant to overland flow. Effectiveness increases as the ratio of vegetated filter area to unvegetated area increases. A filter strip should be at least as long as the runoff-contributing area. "Contact time" between runoff and the vegetation is a critical variable.

Different filter strip characteristics such as size and type of vegetation can result in different pollutant loading characteristics as well as loading reductions. Following are some reduction rates based on strip size and vegetation:

Study/Source	Size	Vegetation	Reduction[1]
Barker/Young	21x91m	Fescue/rye	89.9% TSS 97.3% TN 98.4% TP
Dillaha et al	6x5m	Orchard grass	95% TSS 77% TN 80% TP
Overman/Schanze	5 ha	Bermuda grass	81.3% TSS 67.2% TN 38.8% TP

Dillaha, et al., (1988) found vegetative filter strips to be very effective at removing sediment and sediment-bound pollutants from feedlot runoff, but much less effective at removing pathogens, fine sediment and soluble nutrients such as nitrate (NO_3) and orthophosphorus (PO_4).

Filter width	Percent reduction/Pollutant
9.1 m	95% TSS 69% NH_4 4% NO_3 30% PO_4 80% P_t
4.6 m	87% TSS 34% NH_4 -36% NO_3 -20% PO_4 63% P_t

As the data above shows, the study found that the filter strips were not very effective at removing nitrate (NO_3) and orthophosphate (PO_4). Effluent nitrate loadings exceeded influent loadings, indicating that the filter strips not only did not trap nitrate, but through mineralization actually released previously trapped nitrogen as nitrate. Although sediment-bound phosphorus

[1]Reductions in concentration.

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was fairly effectively removed, soluble phosphorus (PO_4) also produced greater effluent loadings than influent ones (Dillaha, et al., 1988).

The universality of these results should not be assumed. The same researcher determined that VFS were frequently ineffective for water quality improvement because of the difficulty in assuring sheet flow of runoff. This study found that filter strips are most appropriate in small fields where runoff cannot concentrate before reaching the strip (Dillaha, et al., 1989).

Furthermore, the long-term effectiveness of vegetative filter strips is unclear. In addition, trials conducted under controlled experimemtal conditions may differ from on-site effectiveness in "real world" conditions.

2. Design Criteria

Whereas a grassed swale or waterway is used to control or reduce the pollutant load from concentrated stormwater runoff, **preventing concentrated flows** is the key element of filter strip design. Filter strips are designed to accept overland sheet flow of runoff only.

The primary factors in determining filter strip effectiveness are filter length; uniformity of runoff flow through the filter, field slope, type and density of vegetation, and sediment size. The following critical factors should be observed:

(1) The contour of the filter strip should be identical (in terms of elevation) to the adjacent area.

(2) A device, such as a berm placed at a perpendicular angle to the filter strip area, should be used to distribute runoff over the filter strip in an even manner.

(3) The filter strip should be directly adjacent to the impervious area to avoid runoff bypassing or short-circuiting the device.

(4) Minimum filter strip width for flat terrain should be 20 feet if a grass or turf strip. Studies suggest that a minimum 50-75 feet width is preferable, while others suggest attempting to achieve a one-to-one vegetated to unvegetated area ratio.

(5) Generally speaking, increasing slope steepness requires increased filter strip width to maintain effectiveness. Grass filter strips function best on slopes of 5% or less. They will not function effectively on slopes greater than 15%.

(6) Grasses with a high runoff retardance value, such as Bahia and Bermuda grass, are recommended for use in the filter strip.

(7) Contact time between runoff and the filter strip should be maximized to permit infiltration and sedimentation to occur.

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C. Cost

Vegetative filter strips can be an inexpensive component of an overall pollutant reduction system. If they are preserved before development occurs, they are virtually free (Schueler, 1987). There is, however, an opportunity cost for leaving land undeveloped.

Establishment of filter strips of grass, trees, or permanent wildlife plantings on cropland adjoining a stream, creek, river or other water body may be eligible for enrollment in the Conservation Reserve Program of the U.S. Department of Agriculture.

The following table briefly describes representative costs for establishing filter strip vegetation (Schueler, 1987):

Comparative Costs for Establishing Vegetative Control Practices

Method	Avg. Cost per Acre
Conventional Seeding	$1633
Hydroseeding	$1725
Sodding	$10,900
Riparian buffer	$100 (conifer seedling) $200 (deciduous seedling) $1000-5000 (nursery stock)

D. Maintenance

The design, placement and maintenance of filter strips are all very critical to their effectiveness and serious attention should be directed to prevent concentrated flows from occurring. Although intentional planting and naturalization of the vegetation will enhance the effectiveness of the larger filter strip, it should be inspected periodically to determine if concentrated flows are bypassing or overwhelming the device, particularly at the perimeter.

For shorter filter strips, where natural vegetative succession is not intended, the vegetation should be managed like a lawn. It should be mowed 2-3 times a year, fertilized, and weeded in an attempt to achieve dense, hearty vegetation. The goal is to increase vegetation density for maximum filtration.

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Accumulated sediment and particulate matter in the filter strip should be removed at regular intervals to prevent inundation of the device. Frequency of this type of service will depend on the frequency and volume of runoff flows.

Development of channels and erosion rills within the filter strip area must be avoided. To ensure effectiveness, sheet flow must be maintained at all times.

VI. MONITORING CONSIDERATIONS

The effectiveness of practices to protect and restore wetland and riparian systems as management measures should be monitored. Establish specific objectives and milestones to aid in assessing effectiveness. Following are examples of ways to monitor results. Additional monitoring tools which are more appropriate for specific projects and conditions may be needed. Establish a feedback mechanism to provide opportunity for management considerations during the implementation and maintenance period.

Assess effectiveness of protection/restoration through some or all of the following:

- Assess maintenance/restoration of beneficial uses
- Conduct baseline mapping (quantification and spatial distribution)
- Monitor water quality changes
- Track restoration and losses (acreage and type)
- Track structural changes (i.e., forest removal, restoration of pasture/cropland to wetland/forest)
- Monitor institutional progress in avoidance/protection such as: (1) State or local tax incentives (2) multi-agency participation in protection/restoration efforts, (3) watershed initiatives, (4) acreage protected through long-term protection/restoration through acquisition or easements, (6) number of zoning restrictions, local adoption of restriction ordinances, (7) citizen participation, (8) emphasis on wetlands/riparian protection/restoration across NPS activity areas (not limited to agriculture, but also urban, construction, silviculture, etc.), (9) number of Wetlands Reserve or Conservation Reserve sign-ups.

Success often depends upon the long-term ability to manage, protect, and manipulate wetlands and adjacent buffer areas. Restored wetland and riparian systems often require "mid-course corrections" and management over time. Careful monitoring of systems after their original establishment and, in some cases, active management of the systems, are often critical to long term success. To increase chances of success, restored wetlands should be designed as self sustaining or self managing systems. This is more likely if the project is re-establishing a wetland area where one existed previously.

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APPENDIX B. EFFECT OF COASTAL ZONE MANAGEMENT BMPS ON NONPOINT SOURCE CONTAMINANT LOADING IN GROUND WATER

Effect of Coastal Zone Management BMPs on Nonpoint Source Contaminant Loading in Ground Water

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INTRODUCTION

Coastal Zone Management (CZM) best management practices (BMPs) are designed to reduce or eliminate the degradation of coastal waters by controlling contaminant migration from agricultural, forest, and urban lands. In doing so, these BMPs can alter the quality and quantity of water discharging into coastal waters that either runs off the land surface or percolates through the soil. For example, BMPs that are designed to reduce surface water discharge of stormwater may substantially increase infiltration into ground water (Mannering et al., 1987; Baker, 1987). In addition, selection of BMPs should be coordinated with State ground-water protection priorities based on ground-water use value and vulnerability. Otherwise, certain BMPs that increase infiltration of water could contribute to contamination of private and public drinking water wells. As a result, BMPs should be assessed in terms of their impact on both surface-water and ground-water resources.

The transport of contaminants in subsurface waters is governed by the physical and chemical principles associated with soil-water flow and contaminant transport. An understanding of these principles will facilitate assessments of the potential effects that BMPs may have on contaminant loading in ground water and the subsequent pollution of coastal waters. Section I will discuss basic principles of contaminant transport associated with the flow of water through soil and aquifers. Section II will compare the effects of general BMP types on the quantity and quality of water movement to ground and surface waters.

I. PRINCIPLES OF CONTAMINANT LOADING IN GROUND WATER

Transport of nonpoint source pollutants to coastal waters through ground-water discharge is governed by physical and chemical properties of the water, pollutant, soil, and aquifer (Cheng and Koskinen, 1986). This section will discuss general influences of soil water flux, contaminant properties, soil properties and aquifer properties on the migration of contaminants through soil and ground waters.

A. Water Flux

Water is the transport mechanism most responsible for pollutant movement in the subsurface environment (Nielsen et al., 1989). Saturated and unsaturated water flow through the soil provide mass and diffuse transport of soluble pollutant constituents, as well as displacement of non-soluble constituents. This discussion influencing water flux through the soil addresses the following factors:

- infiltration;
- infiltration from impoundments; and
- water balance.

i. Infiltration

Transport of pollutants to ground water is a function of the amount of water that enters the soil (infiltration) over a specified area. Infiltration can be characterized by the following equation (Hanks and Ashcroft, 1980):

$$\text{Infiltration} = \text{Precipitation} + \text{Irrigation} - \text{Run-off} \qquad (1)$$

Precipitation and irrigation (influx) intensities and duration that exceed the water intake ability of the soil surface will result in run-off. Soils may accept brief periods of high intensity influx or prolonged periods of low intensity influx before run-off occurs (Taylor and Ashcroft, 1972). This is because infiltration is driven by soil hydraulic conductivity and hydraulic gradients that change rapidly during an infiltration event (Kirkham and Powers, 1972). These hydraulic properties are governed by soil physical properties. Infiltration rates will also generally decrease after tillage, in relation to run-off, with progressive infiltration events due to changing soil physical properties (Baker and Laflen, 1983; Onstad and Voorhees, 1987). Soil physical properties related to water intake ability are the soil texture, antecedent (previous) soil water content, and soil structure (compaction or bulk density). In general, coarser soil textures (larger soil particle size), lower antecedent water contents, and better soil structure (lower bulk densities) will provide increased infiltration. Time-related factors such as antecedent soil moisture contents, soil compaction, and the occurrence of frozen soil conditions significantly affect infiltration rates (Schepers, 1987).

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The presence of vegetation and organic matter on the soil surface also may substantially increase the water intake ability of the soil (Baker and Laflen, 1983). Vegetation will provide interception and limited storage of stormwater by the plant canopy (Banerjee, 1973). Interception of rainfall by vegetation will also reduce displacement of soil particles and degradation of surface soil structure due to direct impact of raindrops (Onstad and Voorhees, 1987; Brady, 1974). The presence of vegetation also has the effect of increasing soil moisture holding capacities, increasing surface storage of water, and slowing the rate of run-off (Baker et. at., 1987). These plant-related properties will change with season and site activities due to decomposition of organic matter and the seasonal nature of plant growth.

ii. Induced Infiltration from Impoundments

Rainfall in excess of soil infiltration capabilities can be collected in impoundments designed to control run-off (as cited in Nightingale et. al., 1985). This provides increased localized opportunity for water to infiltrate and carry pollutants through the soil by extending infiltration times over a limited area (Hannam and Leece, 1986). Infiltration amounts and rates will depend on the design and construction of the impoundment and the properties of the underlying soil. Impoundments built over soils with low hydraulic conductivities, lined with clay or other artificial liners, or that experienced substantial compaction of the soil during construction will reduce infiltration rates and prolong surface storage of the run-off.

Such prolonged surface storage in impoundments may reduce the total amount of stormwater infiltrating and discharging into surface streams by increasing the amount of run-off water evaporated into the atmosphere. This may be due to direct evaporation from the impoundment or from subsequent use of the stored water such as for irrigation or artificial wetlands (Edwards et al., 1985).

iii. Water Balance

The amount of pollutant that migrates to ground water is dependent upon the site-specific water balance. Drainage is calculated from the water balance as the amount of water entering the soil minus the amount of water leaving the soil surface. This is dependent upon site-specific rainfall, irrigation, vegetation, soil properties, and climatic energy. This relationship is characterized by the soil water balance equation (Hanks and Ashcroft, 1980):

$$Dr = Inf + Ds\,(\theta_{v,sat} - \theta_{v,fc}) - Es - Tp \qquad (2)$$

where:

- Dr = drainage in equivalent depth
- Inf = infiltration in equivalent depth
- Ds = maximum depth of soil subject to Es or Tp
- $\theta_{v,sat}$ = volumetric water content of the soil
- $\theta_{v,fc}$ = volumetric water content of the soil at field capacity
- Es = soil evaporation in equivalent depth
- Tp = plant transpiration in equivalent depth

Gravitational force will remove water from soils as drainage when their water contents are above a soil moisture level commonly referred to as field capacity (soil water holding capacity). This term is associated with a condition of equilibrium between gravitational forces and the attractive forces exerted on water by the soil particles (Brady, 1974).

Soil water can also be removed from the soil at soil water contents below field capacity by soil evaporation and plant transpiration. Soil evaporation and plant transpiration are inter-dependent and are often considered collectively as evapotranspiration (Hanks and Ashcroft, 1980). For areas where plants are not present or not actively transpiring, it may be inappropriate to include the plant transpiration or evapotranspiration component. Similarly, when plants completely cover the ground surface, the soil evaporation component may also be negligible (Kidman, 1990). Soil water loss due to evaporation is limited to a relatively shallow surface layer of the soil (Hanks, 1985). Transpiration, however, may remove soil water from depths corresponding to the depth of root penetration. Once water has infiltrated below the surface layer of bare soils, or below the root zone of vegetated soils, a discharge of water into the ground water (drainage) will be induced.

As infiltration induces drainage when soil moisture content in the root zone and/or surface soil layer exceeds field capacity, drainage can be minimized by reducing the soil water content. This can be accomplished on irrigated land by regulating irrigation amount and timing to maintain soil water contents at or below field capacity. This rigorous control of irrigation water may necessitate improved irrigation and water delivery systems. Drainage in non-irrigated areas can also be minimized through the establishment of appropriate plant species that will enhance extraction of soil water and provide increased capacity in the soil to store infiltrating stormwater.

B. Contaminant Migration

The amount of pollutant reaching coastal waters will depend on the physical and chemical properties of the pollutant. These properties will define, in conjunction with soil and water properties, the persistence, mobility, and migration pathway of the pollutant (Cheng and Koskinen, 1986). This discussion on contaminant migration through the soil includes an examination of the following factors:

- persistence; and
- mobility.

i. Persistence

Pollutant persistence is the relative measurement of the portion remaining after a period of time. The two major processes affecting persistence are, in general, volatilization and degradation (Helling, 1987). Volatilization is a potentially major movement pathway for contaminants with high vapor pressures, especially when exposed to the atmosphere at or near the soil surface (Glotfelty, 1987). Degradation of organic pollutants in the soil to non-toxic end products is the result of chemical reactions and soil microbial activities (Cheng and Koskinen, 1986). The rate at which this degradation proceeds is related to the concentration of the pollutant. Organic chemical degradation rates are commonly assumed to be described by the exponential decay function (Strenge and Peterson, 1989):

$$C(t) = C_o \cdot 0.5^{\left(\frac{t}{T_h}\right)} \qquad (3)$$

where:

C(t) = amount of pollutant present at time t

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C_o = amount of pollutant initially present
t = time in days from initial time
T_o = time in days for ½ the initial pollutant concentration to degrade

ii. Mobility

The rate of pollutant migration through the unsaturated zone, relative to soil water velocity, is dependent upon complex geochemical interactions such as precipitation/dissolution and adsorption/desorption (Strenge and Peterson, 1989). Pollutant properties affecting these interactions include water solubility, viscosity, density, volatility, and adsorptivity (Camp Dresser and McKee, 1986). Mobility of the contaminant is strongly related to its degree of water solubility (Wagenet, 1987).

For insoluble contaminants, viscosity and density determine its mobility through the soil and aquifer. Insoluble contaminants with a solution density greater than water tend to sink to the bottom of an aquifer and move slowly in relation to ground-water flow. In contrast, contaminants with a solution density less than water tend to remain at the top or float to the top as they move through an aquifer and upon discharge into coastal surface waters (Camp Dresser and McKee, 1986). The rate of migration for liquid contaminants that do not mix with water will depend, in large measure, on the viscosity of the contaminant. The physical and chemical nature of the soil provides charged surface area that can attract and immobilize contaminants in soil water (Jurinak, 1988). The adsorptivity of a pollutant is its relative attraction to these charged soil surfaces (Strenge and Peterson, 1989).

The complex physical and chemical interactions that dictate the mobility of the contaminant are not completely understood. However, their effects on contaminant mobility can be simplified by the use of distribution coefficients. This is a "bulk" chemical parameter that estimates the relative amount of the contaminant immobilized in the soil (Strenge and Peterson, 1989):

$$\text{Distribution Coefficient } (K_d) = \frac{\text{Concentration of Contaminant Immobilized}}{\text{Concentration of Contaminant in Solution}} \quad (4)$$

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For example, nitrate has a K_d of zero which means that its movement is not retarded in the soil and will move as fast as the soil water (Bouwer, 1989). Other contaminants, with higher retardation factors, such as chlorinated aromatics move as much as 40 times slower than the water (Bouwer, 1987). These less mobile chemicals will pose less immediate risk to ground water contamination but may concentrate at the soil surface and have a higher risk to surface water contamination due to migration with sediments in run-off (Baker and Laflen, 1983; Dick and Daniel, 1987).

These characterizations of contaminant degradation rate and mobility are generalizations based largely on laboratory studies and their application to field conditions should be viewed with some skepticism (Jury et. al., 1983). Application of these relationships should be limited to surface soils where organic carbon contents and microbial activities are high (Bouwer, 1987) as they may be of little value in predicting transport of pesticides in the ground water.

C. Soil Properties

The soil provides resistance to the movement of the pollutant by limiting the flow of water and providing surface area for adsorption of the pollutant. The amount of this resistance will vary with different soil materials, configurations of different soil materials, and the thickness of the unsaturated portion of the soil. Layering of differing soil materials or densities will affect the rate and direction of water flow (Taylor and Ashcroft, 1972). Palmer (1986) indicates that unsaturated flow might travel laterally as much as several kilometers before reaching the water table. This discussion on soil properties includes examination of factors governing:

- preferential soil water flow; and
- soil chemical properties.

i. Preferential Soil Water Flow

Preferential soil water flow is the principal factor responsible for underestimation of chemical movement in the soil by chemical transport models (Jury et. al., 1983). The amount of soil disturbance and the occurrence and frequency of preferential flow paths may differ significantly among forest, agricultural, and urban soils. Forest soils, and other undisturbed soils, have a

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higher potential for preferential water flow due to increased occurrence of animal burrows, root and worm holes, and cracks. Van Wesenbeeck and Kachanoski (1991) indicate that tillage of agricultural soils reduces bypass or channel flow by reducing the lateral variability of soil properties. Certain configurations of soil material, such as karst formations may also induce preferential soil water flow allowing very minimal resistance to percolating water (Palmer, 1986). Preferential flow conditions (enhanced contaminant migration rates) occur in relatively uniform soils and will be intensified by intermittent applications of non-uniform irrigation (Bouwer, 1987; Bouwer, 1989).

ii. Soil Chemical Properties

Chemical properties of the soil such as cation exchange capacity, pH, and organic matter content will affect the capacity of the soil to store and immobilize the pollutant. Cation exchange capacity (CEC) is a measure of the soil adsorption capacity for positively charged solutes (Brady, 1974). This capacity is related to the amount of surface area which is a function of the size of soil particles and the type of minerals within the soil. Representative surface areas of soils and clay minerals (Jurinak, 1988) include the following:

	Surface Area (m^2/g)
Montmorillonite	600-800
Illite	70-120
Kaolinite	10-20
Clay soil	150-200
Loam soil	50-100
Sandy soil	10-40
Humus	600-850

Effective CEC will generally decrease with lower pH levels, as hydrogen ions will dominate the exchange complex, and increase with higher organic matter contents (Wagenet, 1987; Tisdale et. al., 1985), largely due to increased surface area as shown above.

The pH of the soil solution will also have important effects on pollutant degradation and solubility (mobility) due to hydrolysis (Dick and Daniel, 1987; Glotfelty, 1987). For inorganic contaminants, hydrolysis determines metal species that exist in solution. For organic contaminants, the effects of hydrolysis

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are indirectly addressed through consideration of degradation rates or rate constants (Strenge and Peterson, 1989).

Cation exchange does not explain the retention by soils of heavy metals and organic anions. This retention is often determined by the formation of complexes between the pollutant and the organic matter or soil surface (EPA, 1983). Organic matter complexes within the soil are complicated and not well understood but do significantly contribute to the retardation or immobilization of pollutants.

D. Aquifer Properties

The release of contaminants into coastal waters from an aquifer is dependent on the discharge rate of ground water and the movement of contaminants in the aquifer. This discussion on aquifer properties includes examination of factors governing:

- ground water flow and
- contaminant movement in aquifers.

i. Ground Water Flow

The discharge of ground water is controlled by the permeability (hydraulic conductivity) of the aquifer, the distribution of hydraulic potential over the aquifer, and the cross sectional area of an aquifer perpendicular to the ground-water flow (Todd, 1960).

Gravitation is the primary force driving water flow in the unsaturated zone causing water flow, in the absence of interfering layers, tends to be mainly vertical. In the saturated zone, however, water flow will be in response to water pressure gradients along the flow path of the aquifer.

The rate of aquifer flow in response to pressure gradients will be determined by the permeability of the material comprising the aquifer. Permeability is a function of the interconnected pore space within the material. For consolidated material (rock formations), permeability will depend on the presence and extent of fractures, joints, or the inherent permeability of the material itself. Configurations of subsurface materials

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of differing permeabilities will determine the rate and pathway for water flow within the aquifer.

ii. Contaminant Movement in Aquifers

Transport of contaminants in an aquifer is controlled by the processes of advection and dispersion. Advection is the transport of a contaminant at an average ground-water velocity which is dependent on the hydraulic conductivity, hydraulic gradient, and effective porosity of the aquifer (Freeze and Cherry, 1979). Dispersion, on the other hand, refers to the spreading of a contaminant as it flows through the aquifer. Because dispersion causes the mixing of contaminated ground water with uncontaminated ground water, it is a mechanism for dilution. Both advection and dispersion are controlled by the physical properties of the aquifer, the distribution of hydraulic potentials within the aquifer, and chemical processes within the aquifer.

The advection of contaminants in an aquifer is directly associated with the flow of ground water. In aquifers of high hydraulic conductivity (i.e., permeable), rapid movement of contaminants is facilitated by rapid movement of ground water. The movements of ground water and contaminants are also dependent on the steepness of the hydraulic gradient in the direction of ground-water flow. Finally, in aquifer with high porosity (e.g., fine grain material), the movement of ground water is generally slow and the transport of contaminants is dominated by dispersion.

The dispersion of contaminants in an aquifer is controlled by mechanical dispersion and molecular diffusion. Mechanical dispersion is directly related to velocity of ground-water flow, and molecular diffusion can be determined by the contaminant diffusion coefficient and the particle size of the aquifer media. In aquifers with low hydraulic conductivity and small particle size, diffusive transport of contaminants is large when compared to advective transport. In this case, dispersion can cause contaminants to arrive at a discharge point (e.g., coastal water) prior to the arrival time derived from the average ground-water velocity.

The movement of contaminants in an aquifer is also controlled by properties of the contaminants. The properties affecting contaminant persistence and mobility, as previously discussed, generally apply to contaminants in the aquifer with the exception of chemical and microbial degradation processes. Degradation within the aquifer

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environment may be severely restricted due to limited amounts of oxygen and organic material.

II. ASSESSMENT OF BMPS

The preceding Section I, presented an overview of the factors influencing water and contaminant movement through the soil. The following section addresses the impacts that specific types of BMPs may have on surface water and ground-water supplies. The following describes the general types of agricultural, forestry, and urban BMPs and the rational for these impacts which are summarized in Exhibit 1.

A. Sedimentation Controls

Reduction of run-off velocity: BMPs which provide obstructions to surface water flow. These may include techniques that use soil surface alteration (pitting, primary tillage), slope modification (leveling, terracing), residue management (conservation tillage), and contour agricultural practices to slow run-off velocities. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters;
- increased infiltration and evaporation thus decreasing run-off; and
- increased ground water transport of soluble contaminants and/or decreased concentration of contaminants in the ground water.

Surface stabilization: BMPs which physically reduce or prevent displacement of soil particles. These may include techniques such as surfacing of rural and forest roads, use of surface mulches, and establishment of permanent vegetative cover on disturbed roadsides and fields. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters.

The effect on run-off, infiltration, and ground water contamination will depend on the permeability of the material used to stabilize the surface.

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Filtration of sediments: BMPs which remove sediments from run-off waters by passing run-off water through vegetated areas. These may include techniques such as strip farming, buffer zones around surface waters, and artificial wetlands. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters;
- increased infiltration and evaporation thus decreasing run-off; and
- increased ground water transport of soluble contaminants and/or decreased concentration of contaminants in the ground water.

Settling impoundments: BMPs which include diversion of run-off into impermeable surface impoundments thus reducing turbulence and allowing sediments to settle. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters and
- increased evaporation.

The effect on run-off, infiltration, and ground water contamination will depend on the use of the stored water and collected sediments.

Infiltration impoundments: BMPs which collect run-off water in permeable surface impoundments such that collected water will recharge ground water or evaporate. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters;
- increased infiltration and evaporation thus decreasing run-off;
- increased evaporation; and
- increased ground water transport of soluble contaminants and/or decreased concentration of contaminants in the ground water.

Watercourse stabilization: BMPs which physically reduce or prevent the displacement of soil particles lining watercourses. These may include techniques such as establishment of permanent streambank vegetation or the lining of streambanks with geotextiles, rocks, or concrete. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters.

The effect on run-off, infiltration, evaporation, and ground water contamination will depend on the permeability of the materials used to stabilize the watercourse.

Timing of activities: BMPs which reduce the disturbance of soils during periods when the potential for displacement of soil particles is high. These may include management practices that restrict site activities when the soil is excessively wet, dry, devoid of cover, or frozen and during periods when high winds or precipitation occurs or is expected to occur. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters; and
- increased capacity for soil to retard migration of adsorbed contaminants to ground water.

Localized use restriction: BMPs which restrict site activity on areas of high sediment producing potential. These may include techniques such as restricting livestock access to susceptible streambanks, restricting cultivation of areas with excessive slope, and restricting timber operations on sensitive watersheds. These BMPs affect ground and surface waters through:

- decreased transport of sediments and contaminants adsorbed on sediments to surface waters;
- decreased run-off;
- increased evaporation; and
- decreased contamination of surface and ground waters due to elimination of activity-related contamination.

The effect on infiltration will depend on the water use of the vegetation at the site.

B. Nutrient Controls

Reducing excess in soil: BMPs which include careful nutrient management techniques to meet but not substantially exceed the nutrient requirements of the managed vegetation (i.e., crops, pasture, turf, or timber). This also includes BMPs which maximize production (therefore

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nutrient uptake) through cultural management and control of pests and diseases. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the quantity of contaminant in the soil.

Application timing: BMPs which alter timing of nutrient applications based on climatic conditions which affect the transport and fate of nutrients. These may include techniques such as multiple fertilizer applications, fertigation, and the avoidance of applications during the fall, early spring or at other times when precipitation is in excess of evapotranspiration. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the quantity of contaminant in the soil.

Surface application of nutrients: BMPs which minimize soil disturbances, such as conservation tillage, may impose restrictions on the incorporation of soil-applied nutrients. Surface application of nutrients affect ground and surface waters through:

- increased surface water contamination due to concentration of nutrients at or near the soil surface and
- decreased ground water contamination due to a reduction in contaminant quantity through surface run-off, volatilization, or photodegradation.

The effect on ground water contamination may change if nutrient applications are increased to compensate for these losses.

Shelter of manure sources: BMPs which reduce or exclude precipitation from manure source and storage areas. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the quantity of contaminant in run-off water;
- increased run-off; and
- decreased infiltration.

Containment of manure sources: BMPs which prevent surface and subsurface migration of manure at manure source or storage sites. This includes BMPs which specify the use of cement floors or other restrictive liner materials in commercial animal and poultry producing operations. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by eliminating run-off and infiltration.

This effect may be dependent upon the final use of the manure and effluent.

C. Pesticide Controls

Biological pest control: BMPs which utilize biological competition and predators to control pests and reduce pesticide usage. These include techniques which introduce or enhance biological controls as well as those which minimize the disturbance to natural biological controls. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the usage of pesticides.

Mechanical pest control: BMPs which physically limit, remove, or destroy the pest without the use of pesticides. These include techniques such as cultivation, insect traps, timing of operations to afford maximum resistance or competition to managed vegetation from pests, and avoidance of diseased vectors such as the presence of certain plant residues. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the usage of pesticides; and
- increased infiltration and decreased run-off due to increased tillage.

Crop selection/rotation: BMPs which prevent buildup of pest populations due to a monoculture environment or the use of a crop or variety which has increased pest resistance. These include techniques such as crop rotation, use of varieties with increased resistance, or the use of a different crop type to facilitate pest control. These BMPs affect ground and surface waters through:

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- decreased contamination of surface and ground waters by reducing the usage of pesticides.

On demand pesticide use: BMPs which minimize pesticide usage through correlation of the amount and type of pesticide to actual pest conditions. These include techniques which monitor the presence and population of pests as a basis for pesticide usage instead of predetermined application schedules. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the usage of pesticides.

Pesticide application timing: BMPs which minimize pesticide usage through adventitious timing of pesticide applications. These include techniques that correlate applications to the most vulnerable periods of pest life cycles, those that prevent major infestations through monitoring of pest populations, and those that correlate applications with climatic conditions. These BMPs affect ground and surface waters through:

- decreased contamination of surface and ground waters by reducing the amount of pesticide used through control of pest populations and
- decreased contamination of surface and ground waters by restricting pesticide usage when storms are likely to occur.

D. Water Controls

Irrigation scheduling: BMPs which include continual evaluation of soil moisture conditions to determine the optimal irrigation timing and amounts to minimize ground-water recharge. These include techniques which combine soil moisture measurements with computer programs that forecast water demands of the crop so that irrigation applications do not produce excess ground-water recharge. These BMPs affect ground and surface waters through:

- decreased contamination of surface water by increasing infiltration and reducing run-off; and
- decreased contamination of ground water by reducing drainage.

Selective irrigation: BMPs which minimize irrigation quantities by limiting the area irrigated to the root zone of the crop. These include irrigation application techniques that utilize localized

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point- and line-source drip and seepage irrigation systems. These BMPs affect ground and surface waters through:

- decreased contamination of surface water by reducing run-off; and
- decreased drainage from the root zone.

Selective irrigation may tend to concentrate contaminants at specific locations within the soil. Therefore the effect of this practice on ground-water contamination may depend on site specific conditions.

Irrigation uniformity: BMPs which reduce the amount of ground-water recharge due to irrigation by increasing the ability to uniformly place irrigation water within the root zone. These include the use of higher technology irrigation systems such as center pivot, fixed line, and lateral move sprinklers. These BMPs affect ground and surface waters through:

- decreased contamination of ground water by reducing the amount of drainage from the root zone.

Soil moisture control: BMPs which manipulate soil moisture in non-irrigated areas. These include techniques which establish vegetation or crops for the purpose of extracting water from the soil to limit water table recharge. These BMPs affect ground and surface waters through:

- decreased contamination of surface water by increasing infiltration and reducing run-off; and
- decreased contamination of ground water by reducing drainage.

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EXHIBIT 1

COMPARISON OF BMP EFFECTS ON THE QUANTITY AND QUALITY OF GROUND AND SURFACE WATER

	IMPACT OF BMPs ON:			
General BMPs	Ground Water		Surface Water	
SEDIMENTATION CONTROLS	Recharge	Contamination	Recharge	Contamination
reduction of runoff velocity	increase	variable	decrease	decrease
surface stabilization	variable	variable	variable	decrease
filtration of sediments	increase	variable	decrease	decrease
settling impoundments	variable	variable	variable	decrease
infiltration impoundments	increase	increase	decrease	decrease
watercourse stabilization	variable	variable	variable	decrease
timing of activities	no effect	decrease	no effect	decrease
localized use restriction	variable	decrease	decrease	decrease
NUTRIENT CONTROLS				
reducing excess in soil	no effect	decrease	no effect	decrease
application timing	no effect	decrease	no effect	decrease
surface applications	no effect	decrease	no effect	increase
shelter of manure sources	decrease	decrease	increase	decrease
containment of manure sources	decrease	decrease	decrease	decrease
PESTICIDE CONTROLS				
biological pest control	no effect	decrease	no effect	decrease
mechanical pest control	increase	decrease	decrease	decrease
crop selection/rotation	no effect	decrease	no effect	decrease
on demand pesticide use	no effect	decrease	no effect	decrease
pesticide application timing	no effect	decrease	no effect	decrease
WATER CONTROLS				
irrigation scheduling	decrease	decrease	decrease	decrease

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selective irrigation	decrease	variable	decrease	decrease
irrigation uniformity	decrease	decrease	decrease	decrease
soil moisture control	decrease	decrease	decrease	decrease

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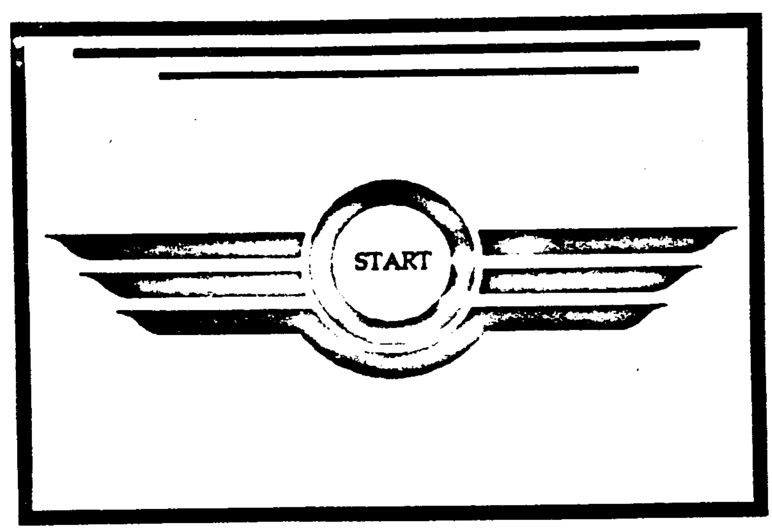

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CARLOS M. URRUNAGA
18 AUG 1995

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GUIDANCE MANUAL FOR IMPLEMENTING MUNICIPAL STORM WATER MANAGEMENT PROGRAMS

August 17, 1994

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U.S. Environmental Protection Agency
Municipal Support Division

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GUIDANCE MANUAL FOR IMPLEMENTING MUNICIPAL STORM WATER MANAGEMENT PROGRAMS

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CHAPTER 1

CHAPTER 1
INTRODUCTION

INTRODUCTION

Urbanization and industrial activities around the country have significantly altered the natural landscape of our Nation's watersheds. This, in turn, has adversely affected both the quantity and the quality of storm water runoff and has contributed to the chemical, physical, and biological impairment of receiving waters. Studies, such as the Nationwide Urban Runoff Program (NURP) study (EPA, 1983), have shown that storm water from urban and industrial areas is commonly contaminated by heavy metals, synthetic organics, pesticides, fuels, waste oils, and pathogens.

Congress, recognizing the importance of controlling these discharges, passed amendments to the Clean Water Act (CWA) in 1987 requiring that the U.S. Environmental Protection Agency (EPA) issue regulations addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Promulgated on November 16, 1990, the NPDES regulations establish permit application requirements for operators of certain municipal separate storm sewer systems (MS4), as well as of storm water discharges "associated with industrial activity." Regulated municipalities include those cities and counties operating medium and large MS4s (serving a population of 100,000 or greater) and other MS4s specifically designated by the permitting authority.

According to CWA mandate, municipalities regulated under the NPDES program must, at a minimum, achieve technology-based requirements (i.e., must reduce pollutant loadings in MS4s to the "maximum extent practicable" [MEP] and must effectively prohibit non-storm water discharges through their MS4s) as a first step toward achieving loading reductions consistent with applicable water quality standards. While MEP was not explicitly defined by Congress, EPA interpreted it to mean that municipalities will develop and implement comprehensive storm water management programs. These programs, proposed by the regulated municipalities under Part 2 of the permit application, are required to address a number of storm water control measures, including methods to detect and remove illicit discharges entering municipal storm sewer systems, as well as appropriate best management practices (BMPs) to address discharges from industrial, commercial, and development activities.

At this time, all regulated Phase I[1] municipalities should have submitted both Parts 1 and 2 of the municipal storm water permit application and will soon begin implementing the storm water management programs they have proposed.

PURPOSE OF THIS MANUAL

The purpose of this manual is to provide hands-on guidance for municipalities on how to best implement their storm water management programs. As mentioned above, most municipalities have already proposed these programs under Part 2 of the application. Upon approval by the permitting authority, these programs will then be incorporated into the municipality's permit and will serve as the blueprint for the municipality's storm water management activities. Permit requirements, however, cannot specify all the procedures necessary to put storm water management programs into effect. Municipalities will need to take steps to ensure that storm water management programs are implemented in a practical, cost-effective manner. As noted throughout this manual, the storm water program is a watershed protection program. Storm water sources include a host of source categories, many of them associated with residential, commercial, and industrial land uses. Thus, a host of controls is available for this diverse set of sources. An effective Storm Water Management Plan (SWMP) program will consider all sources and make decisions on establishing control priorities on an holistic, watershed basis.

This manual is intended to help municipalities through this implementation process. A basic seven-step planning process described in this chapter provides a framework for effective decision-making and long-term planning. Municipalities are encouraged to revisit decisions made during Parts 1 and 2 of the permit application process to reassess their overall planning strategies, selected controls, policies, and programmatic measures. In addition, this manual is intended to help municipalities transform their storm water management program elements from words into action. For example, many municipalities pledged to develop "public outreach programs" to promote awareness about the effects of storm water runoff. But how should such programs be structured? What are the most cost-effective methods for educating

[1]Pursuant to Section 402(p)(2) of the Clean Water Act, Phase I of the storm water program covers the following: A) a discharge with respect to which a permit has been issued under Section 402 before February 4, 1987, B) a discharge associated with industrial activity, C) a discharge from a municipal separate storm sewer system serving a population of 100,000 or more, and D) a storm water discharge that the administrator or State determines may be contributing to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. Phase II of the storm water program potentially could cover any sources not covered under Phase I. A request for public comment on Phase II targeting and control options appeared in the *Federal Register* on September 9, 1992.

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community members? What are the advantages of pursuing a public outreach program versus a public participation event? This manual will help municipalities answer such questions and provide guidance on implementing storm water management program activities into the future.

Finally, this manual emphasizes a watershed protection approach, an integrated, holistic strategy for more effectively restoring and protecting aquatic ecosystems and protecting human health. This approach represents a renewed effort by EPA to focus on hydrologically defined drainage basins—watersheds—rather than on areas defined solely by political boundaries. For a given watershed, regulated municipalities are encouraged to consider not only the water resource (e.g., stream, lake, estuary, or aquifer) but all the land from which water drains to that resource. As water drains off the land, it carries with it the effects of human activities throughout the watershed. Consequently, to protect water resources, it is important to address the condition of land areas within the watershed. By concentrating on natural resources and systems, it is possible to detect and take remedial action for such problems as declines in living resources and habitat loss, as well as to identify the more commonly recognized problems associated with elevated pollutant concentrations. This manual provides guidance for municipalities to implement their storm water management programs within a watershed protection framework.

INTENDED AUDIENCE

This manual is intended to provide guidance for regulated municipalities as they begin implementing their storm water management programs. Regulated municipalities include cities and counties operating municipal separate storm sewer systems that serve populations of 100,000 or more, as well as certain municipalities specifically designated by the permitting authority. Individuals from a variety of different municipal departments could potentially be involved with program development and implementation and will benefit from reading this manual. Table 1-1 identifies the municipal agencies and personnel who may be involved in implementing the storm water management program. This manual is also intended for use by State and Federal employees administering the NPDES storm water program.

ORGANIZATION OF THIS MANUAL

This manual provides specific guidance on how to implement particular aspects of the storm water management program. The manual does not track all requirements of the two-part permit application;

TABLE 1-1. AGENCIES AND PERSONNEL INVOLVED IN STORM WATER MANAGEMENT PROGRAM DEVELOPMENT/IMPLEMENTATION

Municipal Agencies	City/County Personnel	Other Members of Community
Building Department	Council members or other elected officials	Community representatives
City/County Attorney's Office	Emergency response teams	Educators
Department of Environmental Management	Engineers and environmental planners	Environmental advocates
Engineering Department	Financial officers	
Fire Department	Inspectors	
Health Department	Public health officers	
Planning Department	Public outreach personnel	
Police Department	Public works directors	
Public Works Department	Site/building inspectors	
Site Plan Review Department	Site plan reviewers	
Water and Sewer Department	Treatment works operators	
Zoning Department	Zoning board members	

rather, it addresses certain elements of the storm water management program (developed under Part 2 of the application) that could be problematic for municipalities to implement, such as illicit detection and removal procedures, public education efforts, and ongoing monitoring programs. Case studies from municipalities around the country have been provided at the end of each chapter. Wherever possible, worksheets, pictures, maps, and charts have been included to help illustrate a particular process. Chapters are organized as follows:

- **Chapter 1:** Provides an overview of the NPDES storm water program, reviews the topics addressed by the manual, outlines the storm water management program planning process, and examines the relationship between the NPDES program and other urban runoff management programs.
- **Chapter 2:** Helps municipalities establish priorities for storm water management activities to ensure the greatest return on their investment. The chapter also provides methods for ranking problems (i.e., pollutant sources and receiving waters) and appropriate controls.
- **Chapter 3:** Offers hands-on guidance for fulfilling certain administrative requirements, including procedures for developing effective public outreach/public participation programs, financing the storm water management program, and completing required annual reports.
- **Chapter 4:** Provides specific guidance on how municipalities may develop effective programs to detect and remove illicit discharges and illegal dumping into their MS4s.

- **Chapter 5:** Provides matrices of source control and structural BMPs indicating applicability, effectiveness, advantages, and disadvantages of particular controls.
- **Chapter 6:** Provides guidance on operation and maintenance required for structural BMPs and residuals management practices.
- **Chapter 7:** Offers detailed guidance on developing in-stream MS4 water quality monitoring programs.
- **Chapter 8:** Presents appendices, including (A) BMP Fact Sheets, (B) Fact Sheets on Other Federal Regulations Affecting Storm Water Management, (C) Case Studies, (D) Storm Water Contacts Lists, (E) References, (F) Glossary, (G) List of Hazardous Substances and Reportable Quantities, (H) List of Emergency Planning and Community Right-to-know Act (EPCRA) Title III Section 313 Water Priority Chemicals.

DIFFERENCE BETWEEN THIS MANUAL AND OTHER PUBLICATIONS

A number of guidance materials address municipal storm water permit application requirements and urban runoff management (see Chapter 1 References), including the following EPA publications:

- *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (April 1991). EPA-505/8-91-002.
- *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (November 1992). EPA-833-B-92-002.

This manual differs from most of the other publications because rather than focusing on completing municipal permit application requirements, it provides guidance on how to plan and implement a long-term, cost-effective storm water management program. Specifically, the manual will help municipalities set priorities for successful program implementation. While the manual concentrates on NPDES requirements, it also encourages municipalities to consider a broad range of related storm water/watershed management programs (e.g., nonpoint source programs or coastal zone pollution control programs). This holistic approach to storm water management provides a framework that allows a municipality to integrate its storm water program effectively with other watershed protection efforts at the local, State, and Federal levels. This manual is part of a family of literature available from EPA and other sources. Where information is already provided in other publications, the manual will direct the reader to those documents.

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OVERVIEW OF PART 1 AND PART 2 PERMIT APPLICATION REQUIREMENTS

Before outlining the seven-step planning process of storm water management program development, it is important to review briefly the municipal permit application requirements at 40 CFR Part 122.26(d). The regulations established a two-part application requirement for municipalities operating large or medium MS4s.

Part 1 of the application required municipalities to gather information about existing watershed conditions and storm water management activities. In addition, they were to examine existing legal authorities to enforce their storm water management programs. Part 1 also required that field screening of major outfalls be conducted to characterize storm water discharges and detect illicit connections in the storm sewer system.

Part 2 of the application required municipalities to elaborate on information provided in Part 1. Applicants were to establish adequate legal authority, provide additional information on pollutant sources, collect quantitative data from selected sampling points, and analyze fiscal needs versus available resources. Once existing conditions had been assessed and monitoring data collected, municipalities were required to propose a comprehensive storm water management program.

Deadlines for submitting Parts 1 and 2 of the permit applications were as follows:

- Large Municipal Systems with a Population of 250,000 or More: Part 1 - November 18, 1991; Part 2 - November 16, 1992
- Medium Municipal Systems with a Population of 100,000 To 250,000; Part 1 - May 18, 1992; Part 2 - May 17, 1993.

Figure 1-1 briefly summarizes the application requirements for Part 1 and Part 2.

DEVELOPING A WATER MANAGEMENT PROGRAM: THE PLANNING PROCESS

As noted above, this manual delineates a basic seven-step planning process that will help municipalities design cost-effective and sensible storm water management programs. For municipalities that have already completed Parts 1 and 2 of the NPDES municipal permit application, this planning process may suggest ways to improve or enhance the proposed storm water management program. The flow chart

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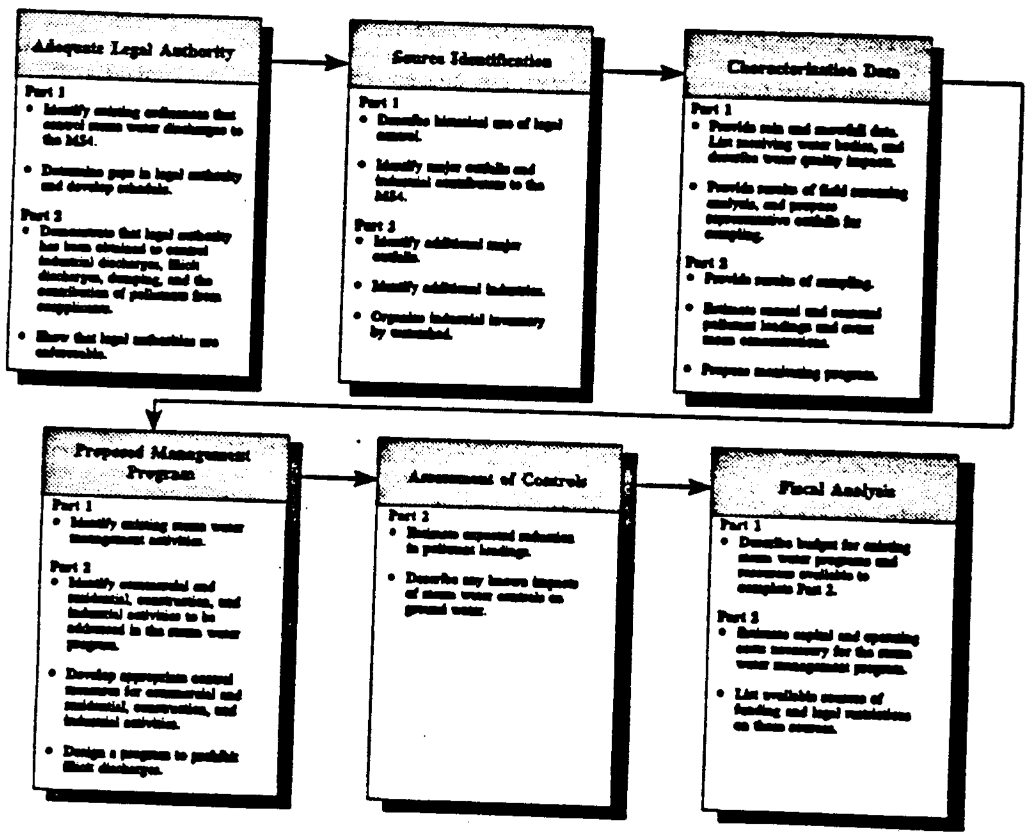

FIGURE 1-1. PART 1 AND PART 2 STORM WATER APPLICATION REQUIREMENTS

appearing in Figure 1-2 has been developed to give municipalities a sense of how each step in the planning process logically leads to the next and ultimately of how the process feeds back into itself, thereby forming a cycle.

After the flow chart, a brief description of each planning step is provided. Other useful guidance materials are listed under the Reference section at the end of this chapter.

- For detailed guidance on Steps 1 and 2 (setting goals and assessing existing conditions), refer to *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Storm Water Discharges From Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Storm Water Discharges From Municipal Separate Storm Sewer Systems* (November 1992).
- Steps 3 and 4, which describe methods for ranking pollutants sources and impaired watersheds and for ranking control measures, are addressed in Chapter 2.
- Step 5, which identifies storm water management program administrative requirements, is further discussed in Chapter 3 (guidance for developing public outreach/public participation programs) and Chapter 4 (guidance for developing an illicit detection/removal program).
- Step 6, which addresses data collection programs, is further discussed in Chapter 7.
- Step 7, which addresses evaluating the effectiveness of the program, is elaborated upon at the end of Chapter 3. Other useful guidance materials are listed under the Reference section at the end of this chapter.

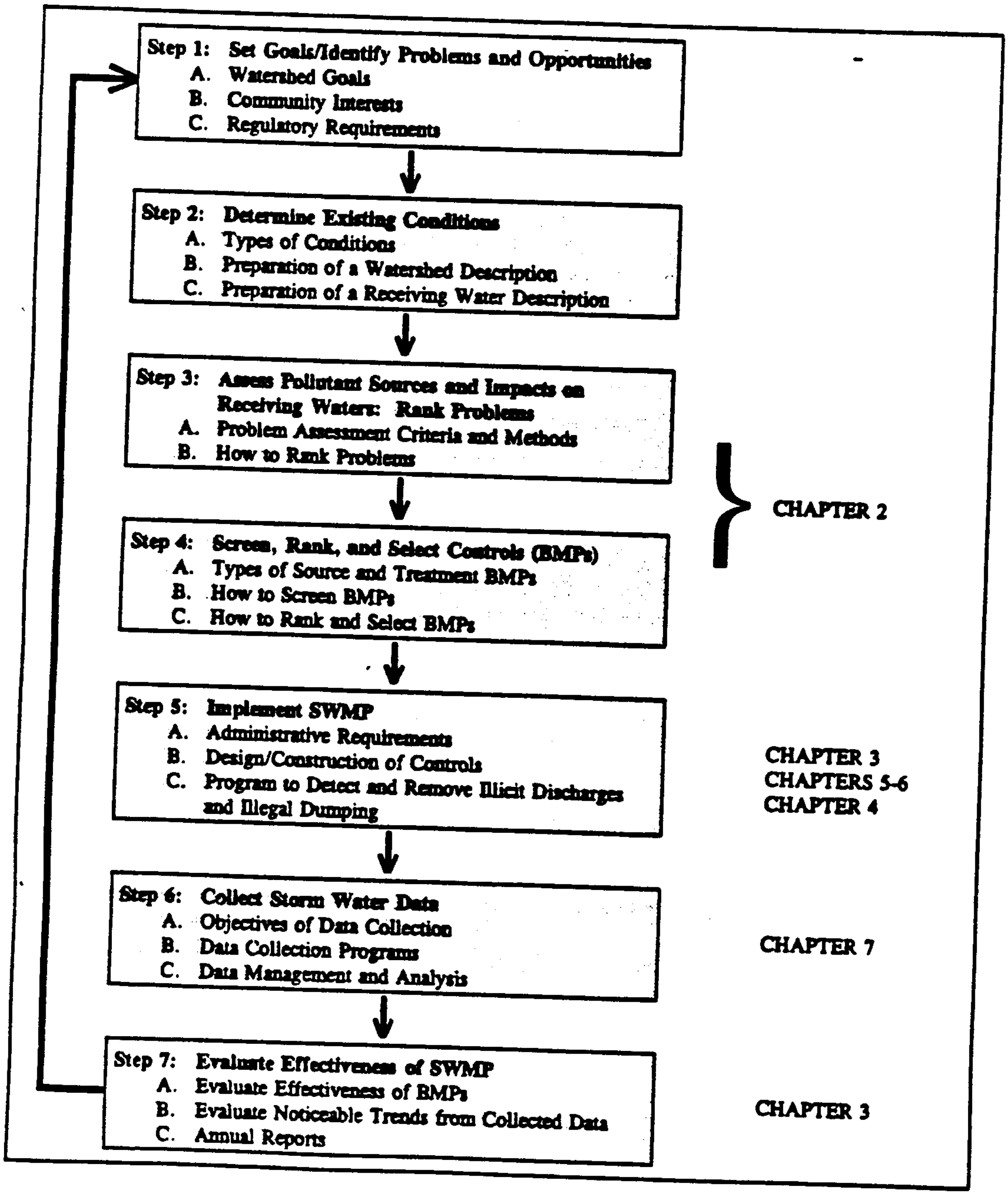

FIGURE 1-2. THE SEVEN-STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

THE SEVEN-STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

Step 1: Set Goals/Identify Problems and Opportunities

The primary goal of the Clean Water Act and the NPDES permitting program is to protect the physical, chemical, and biological integrity of our Nation's waters. Toward this end, municipalities are required to develop storm water management programs that will control discharges through their storm sewer systems to the "maximum extent practicable" and to prohibit non-storm water discharges through their MS4s. Within this statutory and regulatory framework, regulated municipalities will define their own set of goals that address all aspects of water quality, including chemical water quality (e.g., toxics and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., channel morphology, composition, and biotic communities), and biodiversity (e.g, species number and range). Table 1-2 identifies sample goals for a municipal storm water management program.

Step 2: Define Existing Conditions

Types of Conditions

Once initial program goals have been articulated, the municipality must assess existing water resource conditions. Much of this information was collected during Parts 1 and 2 of the municipal permit application. Guidance on how to begin to assess existing conditions may be found in the *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer System*. Existing conditions that should be assessed for the SWMP include those identified below..

Pollutant Sources

Municipalities must identify areas or sources known or suspected to contain significant concentrations of pollutants, including industrial sites (those required to obtain permits under the NPDES program), commercial areas, residential areas, and construction activities. In some cases, these areas of concern may be defined on a categorical basis (e.g., all service stations), while in other cases, the area of concern may be more site-specific (e.g., a particular service station). A significant nonpollutant source of concern is excessively high flow, which results in bank erosion, channel scouring, and sediment deposition.

Receiving Waters

Understanding the characteristics of receiving waters is essential for storm water management program development. Municipalities should evaluate available data on the physical, chemical, and biological conditions of receiving waters—and examine existing uses versus designated uses for particular resources—to determine which waterbodies and which specific areas demand highest priority. A wide range of information should be available from State and Federal agencies and local universities. Similarly, the planning and public works department should have relevant information on receiving waters in its possession.

TABLE 1-2. EXAMPLES OF SPECIFIC WATER QUALITY, ECOLOGICAL, AND RESOURCE MANAGEMENT GOALS

Parameter	Goal	Reference
Examples of Water Quality Goals		
Dissolved Oxygen	At least 1 mg/l at all times throughout the Chesapeake Bay Dissolved oxygen monthly means concentrations of at least 5 mg/l at all times throughout the Chesapeake Bay, with the exception of subpycnocline waters	Part of quantitative criteria established for dissolved oxygen by the Chesapeake Bay Program
Dissolved Oxygen	3.0 mg/l minimum (for other than early life stages) 4.0 mg/l weekly average minimum 5.0 mg/l minimum for early life stages 4.0 mg/l minimum 5.0 mg/l daily average minimum 5.0 mg/l minimum	EPA water quality criteria Virginia standard Pennsylvania criterion District of Columbia standard Maryland standard
Nutrients	Low enough to prevent nuisance growth of algae, weeds, and slimes	Specific objective under the Great Lakes Water Agreement
Solids (settleable and suspended) and Turbidity	Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life	EPA Water Quality Criteria
Mercury	Less than 2.1 ppb/0.025 ppb	Quantitative water quality acute criteria/chronic criteria for priority metal (EPA criteria under development)
Polynuclear Aromatic Hydrocarbons (PAH)	Less than 300 ppb/ND	Preliminary marine water quality criteria under development by EPA
Examples of Living Resource Goals		
Wetlands	No overall net loss	Federal Policy
Wetlands	"...diking, filling, or dredging in existing estuaries and wetlands shall maintain or enhance the functional capacity of the wetland or estuary. Any alteration of coastal wetlands...shall be limited to very incidental public facilities, restorative measures, nature study, commercial fishing facilities in Bodega Bay, and development in already developed parts of south San Diego Bay..."	Specific objectives set forth in the California Coastal Act
Waterfowl Habitat	Regional land acquisition targets set to meet goals of the Migrating Bird Conservation Act	U.S. Fish and Wildlife Service priority list for land acquisition
Examples of Quality of Life Goals		
Shoreline Access	Substantially expand recreational beach access	South Carolina's State Comprehensive Outdoor Recreation Plan
Park and Recreation Area	Increase urban wildlife programs and public use of opportunities, particularly watchable wildlife programs	U.S. Fish and Wildlife Service "Vision for the Future"

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Watershed Characteristics

In addition to identifying pollutants sources and their impacts on receiving waters, municipalities should assess other aspects of the watershed, such as land use and development patterns (e.g., general plan, zoning, subdivision requirements), physical characteristics (e.g., soils, slope, subsurface conditions, climate), and characteristics of the drainage system (e.g., physical storm drain characteristics, base flow characteristics, and water quality objectives). Again, such information should be available from existing sources, including local, State, and Federal agencies.

Institutional Considerations

Municipalities must assess their institutional capabilities for developing and implementing a storm water management program. The items to consider are existing funding mechanisms, available staffing, legal authority to carry out stormwater management program activities, and the institutional interest in marshalling joint efforts for storm water management among different municipal agencies. Municipalities should consider existing municipal programs that either affect storm water quality (e.g., road maintenance) or that may be expanded to address storm water concerns (e.g., pretreatment, fire inspections).

Community Character

To ensure the political and financial support of SWMP activities, municipalities must work in conjunction with community members to determine what issues are important to them and which programs they would be likely to support. The factors to consider include municipal demographics; types of community organizations; environmental, land use, and aesthetic issues; and the local business climate.

Existing Programs and Controls

Many cities and counties already have programs that, to one degree or another, address storm water management. The SWMP will be more cost-effective if municipalities can incorporate these existing programmatic measures or controls into those now envisioned for an expanded comprehensive SWMP. The existing programs to consider include those that currently manage pollutant sources and those that currently manage other activities of parties responsible for pollutant sources. Examples of such programs may be found on page 1-16.

Preparation of a Watershed Description

Once municipalities have gathered together available data about sources of pollution and the status of receiving waters, these data need to be organized to facilitate decisionmaking for storm water management activities. As discussed in EPA's Part 2 guidance manual, municipalities are required to prepare a map-based watershed description to obtain a visual sense of the topography in their city, drainage areas, locations of industries, and existing control measures and to pinpoint major sources of pollution. Much of the data listed in Table 1-3, which municipalities are required to collect under Parts 1 and 2 of the permit application, can be plotted on a base map to form a watershed description.

TABLE 1-3. TYPES OF DATA TYPICALLY INCLUDED IN A WATERSHED PROFILE

Environmental	Potential Sources/Existing Structural Controls
• Topography • Land use • Recreational areas (beaches, boating areas) • Designated water uses • Soils and surface/bedrock geology • Vegetation • Natural resources • Temperature • Precipitation • Hydrology	• Landfills • Illicit connections • Waste handling areas • Salt storage facilities • Underground tanks • NPDES industrial activities • Pollution control facilities • Retention/detention ponds • Flood control structures
Infrastructure	**Municipal**
• Roads and highways • Storm drainage systems • Sanitary sewer systems • Treatment facilities • Other utilities (water, electric, gas)	• Population density and projected growth • Zoning • Land ownership • Regulations • Ordinances • Municipal source controls (e.g., street sweeping, catch basin cleaning)

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA CERI, 1993.

Preparation of a Receiving Water Description

In addition to preparing a watershed description, municipalities are encouraged to assess receiving water conditions. Effective identification and use of existing water resources data will reduce the schedule program and cost, in some cases by reducing the need for additional sampling and analysis. Municipalities should work closely with States and Regional EPA offices to obtain available data on receiving waters in various States. States must collect receiving water data as required by CWA sections 304(1), 305(b), and 319 reports. Data should be available from various local departments (e.g., planning, public works, parks and recreation) as well as State and Federal departments (U.S. EPA, United States Geological Survey [USGS], Fish and Wildlife Service, U.S. Department of Agriculture). In some cases, State and Federal agencies may have conducted intensive surveys of a particular watershed or sub-watershed. Municipalities should contact these agencies prior to initiating any data collection efforts on their own. Table 1-4 identifies the data that should be collected to prepare a receiving water description.

Step 3: Assess Pollutant Sources and Their Impacts on Receiving Waters; Rank Problems

Once municipalities have gathered data to determine existing conditions within their jurisdictions, they must determine the most critical problems. During this step, municipalities should consider the following issues: (1) the types of storm water runoff pollution (and their sources) in the watershed, (2) the extent to which these pollution sources affect the receiving water resources, (3) institutional needs and constraints in solving problems, and (4) the degree to which program goals

TABLE 1-4. TYPES OF DATA TYPICALLY INCLUDED IN A RECEIVING WATER PROFILE

Source Input	Chemical
• CSO data • Storm water data • Other NPS data	• Water quality data • Sediment data • Bioconcentration
Physical/Hydrologic	**Biological**
• Physiographic and bathymetric data • Flow characteristics • Tidal elevation in coastal areas • Sediment data	• Fisheries • Benthos data • Biomonitoring data
	Water Quality Standards
	• State water quality standards

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA CERI, 1993.

are being met. Finally, municipalities should take steps to rank their problems using the decisionmaking and analysis methods presented in Chapter 2, which provides additional information on this step.

Step 4: Screen, Rank, and Select Controls (BMPs)

After municipalities have ranked and targeted storm water runoff problems (i.e., particular areas, sources, and waterbodies of concern), efforts can then be focused on solving those problems in a cost-effective manner. First, the municipality should compile readily available lists of pollution prevention and treatment practices to assess their relative effectiveness. In most cases, more than one set of BMPs will be identified as feasible to address a particular problem. From the list of feasible alternatives, the municipality will then rank and select its final list of BMPs. Chapter 2 discusses this process of screening, ranking, and finally selecting appropriate BMPs.

Step 5: Implement SWMP

Once priorities have been articulated and a list of BMPs drawn up, the program team is responsible for moving from planning to implementation. During this step, near- and long-term program responsibilities must be clearly delineated. All involved persons must be familiar with, and accept their role in, implementing and enforcing the plan. Some of the most important aspects of implementing a storm water management program include completing administrative requirements (discussed in Chapter 3), developing a program to detect and remove illicit discharges (discussed in Chapter 4), and knowing exactly when certain BMPs would be effective/appropriate (discussed in Chapter 5).

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Step 6: Collect Storm Water Quality Data

Although the municipality may already have existing data, additional data will need to be gathered as part of the NPDES permit application process and throughout the life of the SWMP. When proposing their monitoring programs under the SWMP, municipalities will have to make important decisions about when, where, and how often to monitor their storm water. Ultimately, the permit writer will establish monitoring conditions for each municipality's permit. Chapter 7 presents detailed guidance for developing municipal in-stream water quality monitoring programs.

Step 7: Evaluate Effectiveness of SWMP

The final step, evaluating the effectiveness of the storm water management program, encourages municipalities to reassess decisions previously made and, if necessary, to make alterations in the program plan. As part of this process, the NPDES regulations require that municipalities complete an annual report outlining the effectiveness of their programs on an yearly basis (discussed in Chapter 3).

DISCUSSION OF RELATED REGULATIONS/STATUTES AND PROGRAMS THAT ADDRESS MUNICIPAL STORM WATER RUNOFF

While this manual focuses on providing guidance for NPDES storm water program implementation, municipalities should carefully consider other related watershed protection programs. By integrating these programs into the storm water programs, municipalities will enhance the overall effectiveness of the SWMP. A knowledge of such programs can save startup costs (e.g., by minimizing the need to collect data that may have previously been collected for other purposes) and long-term costs (e.g., by piggybacking BMP planning and implementation activities with other watershed protection efforts). Furthermore, by working in conjunction with other runoff management programs, municipalities can more efficiently address a broad range of watersheds problems concurrently. Listed below (Table 1-5) and identified in the following paragraphs are related Federal statutes, regulations, and programs that address municipal storm water runoff, pollution prevention, and control.

Combined Sewer Overflow Policy

Combined sewer systems are designed to carry both storm water and sanitary sewage. When wet weather flows exceed the carrying capacity of the system, these combined systems discharge the excess flow through designated overflow points. This event is known as a combined sewer overflow (CSO). Such combined sewer discharges, if not treated before overflowing into receiving waters, can cause significant water resource effects and threaten human health. NPDES permits for CSOs include prohibition of CSOs

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TABLE 1-5. RELATED FEDERAL STATUTES, REGULATIONS, AND PROGRAMS ADDRESSING MUNICIPAL STORM WATER RUNOFF

- Combined Sewer Overflow Policy
- Nonpoint Source Program (CWA §319)
- Coastal Zone Nonpoint Source Pollution Control (CZARA §6217)
- Safe Drinking Water Act
- Clean Lakes Program (CWA 314)
- 404 Regulations/Wetlands Program
- National Estuary Program
- Federal Emergency Management Agency Regulations
- Pollution Prevention Act of 1990

Chapter 8, Appendix B, presents a summary fact sheet for each of these statutes, regulations, and programs, along with a list of contact telephone numbers. Given below are brief descriptions of programs that have components related to the NPDES municipal storm water program.

during dry-weather flow conditions, compliance of all wet-weather CSOs with the technology-based requirements of the CWA and applicable State water quality standards, and minimization of water quality impacts from wet-weather generated overflows.

Relationship to SWMP Implementation

Municipalities that own/operate both storm sewer systems and combined sanitary/storm sewer systems are required to comply with many of the same NPDES permit program requirements, including the following:

- Receiving water quality assessment
- Monitoring
- Public education programs
- Enforcement.

SOURCE: *Combined Sewer Overflow Control Policy*, 4/19/94

Nonpoint Source (NPS) Program (CWA §319)

This program requires States to perform nonpoint source assessments of navigable waters of the United States. They must identify impaired and threatened waters, the activities causing impairment, and controls and programs necessary to address impairments. In addition, States must develop Nonpoint Source Assessment Reports and Nonpoint Source Management Plans that include an inventory of BMPs, a schedule containing annual milestones for program implementation, certification of adequate legal authority, and available Federal and State funding sources to be used. Under this program, many States

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have also developed State Priority Ranking Systems and undertaken monitoring programs to track progress.

Relationship to SWMP Implementation

Program information may be used by municipalities completing their storm water management programs for the following purposes:

- Assessing wetland boundaries
- Assessing the water quality of receiving waters
- Identifying major sources of impairment of receiving waters
- Identifying and implementing effective controls
- Prioritizing implementation of SWMP components
- Identify Total Maximum Daily Loads (TMDLs).

SOURCE: *Selecting Priority Nonpoint Source Projects*, EPA 506/2-89/003, pp. vi, 1, and *NATIONAL GUIDANCE, Wetlands and Nonpoint Source Control Programs*, U.S. EPA Office of Water Regulations and Standards, Office of Wetlands Protection, June 1990.

Coastal Zone Nonpoint Source Pollution Control (CZARA §6217)

The Coastal Zone Act Reauthorization Amendments of 1990 require States with existing coastal zone management programs to establish coastal NPS programs that must be approved by the National Oceanic and Atmospheric Administration (NOAA) and U.S. EPA. This program is limited to NPS pollution control in coastal areas and the contribution of inland sources of pollution to degraded coastal water quality. To secure an approved coastal nonpoint program, States are required to do the following:

- Coordinate with existing State programs, including State and local water quality plans and programs under sections 208, 303, 319, and 320 of the CWA
- Submit State coastal zone boundaries and section 6217 management areas to NOAA for review and modification, if necessary
- Implement management measures in conformity with section 621 7(g) of the guidance (referenced below) and additional measures where coastal water quality remains impaired.
- Provide technical and other assistance to local governments and the public for implementing additional management measures

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- Provide opportunities for public participation in all aspects of the programs and ensure that there will be administrative coordination among various State, regional, and local agencies
- Develop enforceable policies and mechanisms to implement the Coastal Nonpoint Pollution Control Program.

Relationship to SWMP Implementation

There are many similarities between nonpoint source program goals (under 319 and CZARA 6217) and NPDES program goals. Both programs address storm water runoff from areas of industrial activity, as well as new development, pollution prevention, and watershed management. However, these programs target different classes of discharges. For example, municipalities subject to NPDES permit application requirements are not subject to requirements under nonpoint source control programs, including CZARA §6217; small municipalities (under population 100,000) are currently covered under CZARA §6217. However, pursuant to §122.26(b)(4)(iii), the permitting authority is authorized to require an NPDES permit for any city under 100,000 that may currently be covered by CZARA §6217.

The distinction between point and nonpoint source programs becomes more problematic in relationship to industrial activities. While certain industrial activities are covered under the NPDES program (40 CFR 122.26(b)(14), many other activities fall under the purview of CZARA §6217. For example, construction activity that disturbs five or more acres or that is part of a larger common plan of development or sale is covered under the NPDES program, whereas construction disturbing fewer than five acres is covered under CZARA.

SOURCE: *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, U.S. EPA, January 1993.

__Safe Drinking Water Act__

The Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA) outlines requirements for watershed protection of surface drinking water supplies from urban runoff and nonpoint source pollutants. Municipalities using surface waters for drinking water supplies are required by U.S. EPA or the approved State agency to develop a watershed protection plan for such surface waters that includes the following: a watershed description, identification of physical watershed characteristics and

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a description of activities potentially affecting water quality, a program to control pollutant sources (including implementation of appropriate BMPs), and an ongoing program to conduct monitoring.

Relationship to SWMP Implementation

The NPDES storm water management program and the Safe Drinking Water Act have many overlapping requirements, and municipalities are urged to share information between these two programs. Activities common to both include:

- Identifying critical areas and watersheds
- Determining watershed characteristics
- Identifying activities detrimental to surface water quality
- Implementation of control practices to address pollution sources.

SOURCE: *Surface Water Treatment Rule*, EPA 570/9-91-300, June 1991, and *Safe Drinking Water Act 1986 Amendments*, EPA 570/9-86-002.

Clean Lakes Program

The Clean Lakes Program sets goals for defining the cause and extent of pollution problems in the lakes of each State. Emphasis is placed on developing watershed assessments and effective technology that considers all point and nonpoint sources that affect lake quality.

Relationship to SWMP Implementation

Information developed under this program that may be useful to municipalities implementing SWMPs include:

- Identification of environmental conditions
- Description of the lake's sources of pollution and abatement actions to reduce the pollution caused by these sources

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- Monitoring data on receiving waters
- Alternative BMPs for pollution control.

SOURCE: *A Commitment to Watershed Protection, A Review of the Clean Lakes Program*, EPA 841-R-93-001.

404 Regulations/Wetlands Program

The Army Corps of Engineers and EPA jointly implement section 404 of the Clean Water Act, which regulates the discharge of dredged and fill material into waters of the United States, including most wetlands, and establishes a permit program to ensure that such discharges comply with environmental requirements.

Relationship to SWMP Implementation

Information available through this regulation may assist the municipality by helping to:

- Identify wetlands and delineate boundaries *(Corps of Engineers Wetland Delineation Manual*, 1987)
- Enforce SWMP restrictions on discharging fill materials
- Develop water quality standards specifically for wetlands.

SOURCE: *EPA WETLANDS FACT SHEETS #7, #9, #13, and #24* and *HIGHLIGHTS OF SECTION 404, FEDERAL REGULATORY PROGRAM TO PROTECT WATERS OF THE UNITED STATES*, EPA Office of Wetland Protection, October 1989, and *THE SECTION 404 PROGRAM*, EPA Office of Wetland Protection, 6-9/89.

National Estuary Program (NEP)

The National Estuary Program (NEP) focuses on point and nonpoint pollution in geographically targeted, high-priority, estuarine watersheds. Under this program, EPA assists State, regional, and local governments in developing estuary-specific comprehensive conservation and management plans that recommend corrective actions to restore and maintain estuarine water quality and to protect fish populations and other designated uses of these targeted waters.

Relationship to SWMP Implementation

Information obtained under the NEP may be helpful to the municipalities in their efforts to:

- Assess pollutant sources/loadings in particular watersheds
- Monitor trends in receiving water quality
- Implement public outreach elements of the program.

SOURCE: *The National Estuary Program After Four Years, A Report to Congress*, pp. 2-4, EPA 502/9-92/007, April 1992.

Federal Emergency Management Agency Regulations (FEMA)

FEMA works closely with local communities to identify flood hazard areas and flooding risks. Flood plain maps are also available through the agency.

Relationship to SWMP Implementation

Municipalities developing storm water management programs may use this information to:

- Effectively place structural controls
- Determine floodplains boundaries.

SOURCE: *Disaster Assistance Programs - A Guide to Federal Aid in Disasters*, Federal Emergency Management Agency, DAP 19/July March 1993, and *Answers to Questions About The National Flood Insurance Program*, Federal Emergency Management Agency, FIA-2/March 1992.

Pollution Prevention Act of 1990

The Pollution Prevention Act of 1990 established a national policy specifying that pollution prevention should be emphasized over pollution control or treatment. With this policy, Congress defined a pollution prevention hierarchy to be followed by all pollution reduction programs:

- Prevent or reduce at the source whenever feasible

- Where prevention is unfeasible, recycle in an environmentally safe manner

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- Where prevention or recycling is not feasible, treat in an environmentally safe manner
- As a last resort, dispose of (or otherwise release to the environment) materials in an environmentally safe manner.

Relationship to SWMP Implementation

Management practices set forth in EPA's pollution prevention policy include public education, household hazardous waste collection, location and elimination of illicit connections to separate storm systems, reduction of roadway sanding and salting, and reduction of pesticide, herbicide, and fertilizer use. Many of these measures are required or suggested elements of the storm water management program and can, therefore, be implemented in conjunction with one another.

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SUMMARY

Chapter 1 provided an overview of the NPDES storm water program and briefly summarized the remaining chapters. In particular, this chapter introduced the storm water management program planning, a seven-step process that involves establishing goals, collecting data, establishing priorities, and implementing the program. This planning process incorporates the requirements of Parts 1 and 2 of the NPDES municipal storm water permit application. Finally, this chapter examined the relationship between the NPDES program and programs addressing urban runoff management.

Chapter 2 will provide guidance for municipalities as they attempt to establish priorities for storm water management activities. The chapter will describe methods for ranking "problems" (i.e., pollutant sources and receiving waters) and ranking appropriate controls.

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CHAPTER 2

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CHAPTER 2

ASSESSING STORM WATER RUNOFF PROBLEMS AND DEVELOPING SOLUTIONS: HOW TO SET PRIORITIES

Step 3: Assess Pollutant Sources and Impacts on Receiving Waters: Rank Problems
- A. Problem Assessment Criteria and Methods
- B. How to Rank Problems

Step 4: Screen, Rank, and Select Controls (BMPs)
- A. How to Screen BMPs
- B. How to Rank and Select BMPs

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INTRODUCTION

The NPDES regulations require that municipalities develop storm water management programs to control storm sewer system discharges to the maximum extent practicable. But how do municipalities know what their biggest storm water runoff problems are? How do they know which solutions are most cost effective?

This chapter[1] is designed to help municipalities answer these questions by identifying sources of information to recognize the existing conditions of a watershed, suggesting ways to identify and prioritize sources of water quality problems, and evaluating the effectiveness of potential control measures. Municipalities have already complied some of this information as part of the application requirements. However, other watershed information was not included in the applications and will involve additional data collection activities. Using information available on watershed conditions will enable municipalities to set priorities for conducting storm water management activities. As information is gathered and analyzed, a municipality may find it will need to modify SWMP planning and implementation activities. This chapter also emphasizes the use of water quality models to determine this information. However, there are non-computer based methods for determining the benefits and impacts of different pollution prevention alternatives.

[1]Chapter 2 has been adapted in part from U.S. EPA, Office of Research and Development. *Urban Runoff Pollution Prevention and Control Planning*. September 1993.

ORGANIZATION OF THE CHAPTER

This chapter consists of 3 primary sections. The first section addresses methods for assessing problems and ranking them in order of importance. The second section of the chapter offers methods for evaluating and selecting controls to solve these problems. The criteria used to assess problems (e.g., consideration of public opinion, costs, goals) will often be similar, if not identical, to those used for selecting control measures. The third section includes case studies of municipalities assessing storm water runoff problems and evaluating/selecting appropriate BMPs.

As mentioned in Chapter 1, Steps 1 and 2 (setting goals and assessing existing conditions) are not extensively discussed in this manual because they were covered in the application guidance manuals; *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges From Municipal Separate Storm Sewer Systems* (November 1992). Readers should refer to these manuals for detail on Steps 1 and 2. This chapter addresses Steps 3 and 4. Step 3, assessing receiving waters and sources of any impaired conditions, is described below. Step 4 is discussed later in this chapter. Step 6, which addresses data collection programs, is discussed in Chapter 7.

STEP 3: ASSESS POLLUTANT SOURCES AND IMPACTS ON RECEIVING WATERS: RANK PROBLEMS

To determine the need for, and appropriate level of, pollution prevention and control measures under their SWMPs, municipalities need to assess and rank existing watershed conditions. To assess watershed conditions, a municipality must gather information concerning the physical, chemical, and biological integrity of the water bodies in its jurisdiction. This type of information can be accessed through numerous sources, including Federal, State, and local sources. Some of these sources are a biennial report (known as the 305(b) report) on water quality conditions; the State's listing of impaired water bodies (known as 304(l) listings) prepared by the State for submittal to EPA; State Nonpoint Source Assessments; Fish and Wildlife Service biological surveys; United States Geological Survey (USGS) sources, including maps, water quality and quantity data, and aerial photographs; water quality data compiled by State environmental agencies; Geographic Information System (GIS) data compiled by State or Federal agencies (e.g., EPA, Department of Agriculture, and Department of the Interior); as well as

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information available by local park departments, health departments, public works departments, and local universities.

Information concerning watershed conditions that may have been collected as part of the application requirements includes the following:

Part 1

- Major outfalls and industrial contributions to the MS4
- Topographic map
- Rain and snowfall data
- List of receiving water bodies, with a description of water quality impacts
- Results of field screening analysis
- Existing storm water management activities.

Part 2

- Runoff sampling results
- Estimate of annual and seasonal pollutant loadings and event mean concentrations
- Estimate of expected reduction in pollutant loadings.

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Using the information collected from the sources listed above, a municipality must identify the watershed conditions in its jurisdiction. When identifying the problems, a municipality must consider the chemical, physical, and biological conditions of a water body and determine the degree to which flow volumes and/or associated pollutants led to impaired conditions. For example, when eutrophication occurs in a lake, excess nutrients are of concern. The municipality, in turn, needs to assess the problem, which in this case may be too much fertilizer reaching the water body through runoff. Another example may involve storm water flow resulting in bank erosion and/or changing the strata of the streambed. In large part, the traditional water quality program has focused on chemical impairments. However, in developing a storm water program, municipalities will also need to consider physical impairments.

Once the problems have been identified, they need to be assessed. While many different types of problem assessments may be conducted as part of the storm water management program, to simplify the process this chapter focuses on four major types:

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- Resource Assessments: Evaluating the extent to which these pollution sources adversely affect water resources
- Pollutant Source Assessments: Assessing the sources of urban runoff pollution in the watershed
- Institutional Assessments: Assessing existing BMPs, costs, public opinion, and technical feasibility
- Goals and Objectives Assessments: Evaluating whether program goals and objectives are being met.

Municipalities may establish criteria (such as those presented in Table 2-1) for assessing problems. Methods for assessing the problems can also be explored. A discussion of the most commonly used methods of problem assessment is presented under each of the four headings. Finally, methods for ranking problems using both quantitative and qualitative measures are explained.

Once storm water runoff problems have been fully assessed and ordered, municipalities will begin to screen and select BMPs (discussed in the second section of this chapter).

Resource Assessments

The critical element for ranking storm water runoff problems is assessing storm water effects on receiving water physical, chemical, and biological integrity and determining locations where preventive and corrective measures are needed.

Criteria To Consider

In assessing receiving waters, municipalities need consider the importance or value of a resource (with respect to such issues as aquatic habitat, recreational use, and public water supplies), the current and desired uses of a resource, and the degree to which a resource is impaired. Water resource values are reflected in a State's water quality standards. Municipalities should consider the following when evaluating which receiving waters need to be addressed by storm water control activities:

- Extent to which the waterbody is meeting its designated use
- Level of waterbody impairment due to pollution (chemical integrity), loss of aquatic habitat, or riparian or terrestrial area modification (physical integrity)

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TABLE 2-1. CRITERIA FOR ASSESSING POLLUTION PROBLEMS

<u>Resource</u>
- Existing use of the affected resource (type, status, and level of use)
- Designated use of receiving water
- Type and severity of impairment
- Relative value of resource affected

<u>Pollutant Source</u>
- Type of pollutant
- Pollutants typically associated with the source
- Source magnitude/pollutant loading
- Transport mechanisms to water resource (direct pipe, overland flow, or ground water)

<u>Institutional</u>
- Available resources and technologies
- Problems and opportunities
- Potential for solving identified problems
- Implementability of controls
- Applicable regulations
- Multi-agency responsibilities
- Costs of controls
- Funding sources and limitations
- Public perception

<u>Goals and Objectives</u>
- Water resource goals (water use objectives)
- Technology-based goals
- Land use objectives

Adapted in part from U.S. EPA, 1987.

- Relative value of resource from functional perspective, for instance, for aquatic habitat (biological integrity), recreation, and water supply

- Threat of waterbody impairment, habitat destruction, or terrestrial area destruction if no action is taken (i.e., new impairments are anticipated)

- Feasibility of implementing corrective or protective (e.g., pollution preventative) measures and achieving demonstrable results in the watershed

- Availability of information necessary to target waterbodies and watersheds and to develop and implement effective management strategies.

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Methods for Assessing Water Resources and Receiving Waters

Water resource assessments address the effect of storm water flow and associated pollutants on the water bodies of interest. Water resource assessments frequently involve taking the results of the pollutant source assessments described in the following part of this chapter and determining the effect of these pollutant sources on water resources. Water resource assessments may include chemical water quality assessments, as well as aquatic life assessments, sediment quality evaluations, and assessments of any other relevant conditions, such as streambed strata. The methods to perform water quality assessments can range from simple evaluations, involving the comparison of measured concentrations to water quality standards, to detection modeling, to more complex, mathematically based computer models. It is more than likely that sufficient State and local data exist to assess the chemical quality of the waters. It is less likely that State and Federal agencies have data on the physical and biological integrity of the water body of concern. Nonetheless, the municipality should work with the permit writer to access any available information. If necessary, municipal staff, perhaps with the assistance of local universities, can conduct biological assessments. EPA has issued a valuable guide to biological assessments entitled, *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA/444/4-89-001) 1989.

Some municipalities may choose to use receiving water models to assess existing water quality conditions and to simulate future conditions of the water resource under various pollution prevention and control scenarios. These models can also be used to differentiate the impacts of sources from one another, thereby enabling the decisionmaker to make informal decisions concerning control options. Receiving water models can also be used to assess the impacts of alternative BMPs. These models receive input from runoff model results, field-measured parameters, and the values of parameters found in the literature. The level of complexity of the receiving water model chosen should parallel that of the model used to assess urban runoff flows and loads. Some commonly used receiving water models include the following:

- The Enhanced Stream Water Quality Model (QUAL2E)
- The Water Quality Analysis Simulation Program (WASP4)
- The Exposure Analysis Modeling System II (EXAMSII).

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These models are available from U.S. EPA's Center for Exposure Assessment Modeling, Environmental Research Laboratory, in Athens, Georgia. For further information, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA, 1993.

<u>Pollutant Source Assessments</u>

Using the Federal, Regional, State, or local sources discussed above, it can be determined which physical and chemical conditions are threatening the water bodies and/or their designated uses. Previous studies on water quality have indicated that certain pollutants are associated with a discrete number of sources. Some of these sources are more easily controlled at a local level than others. For example, controlling runoff from gas stations can be more practically controlled at the local level than can atmospheric deposition.

This section presupposes that municipalities are already aware, or can gain ready access to, information identifying the pollutants of concern. In still other cases, municipalities may be able to anticipate pollutants that may be of concern in the years ahead based on, for example, a knowledge of growth patterns. The purpose of this section is to help municipalities determine which sources they want to control based on impacts to water bodies. In heavily industrialized watersheds, for example, municipalities may want to control industrial sources by using detention ponds to filter runoff. In residential areas, municipalities may want to focus on non-structural measures, such as public education campaigns encouraging used oil recycling. In choosing a source to focus on, municipalities need to consider pollutant loading estimates for storm water runoff and to calculate such estimates on a sub-watershed basis.

Criteria To Consider

To evaluate which sources should be addressed first, municipalities will want to consider the range of pollutant characteristics and sources, the size of each source, the distance between the source and the receiving water, and the mode of pollutant transport. In keeping with the watershed approach, impacts should not be confined to exceedances of chemical criteria. Rather, flow impacts on the physical regime and biological community structure need also be considered. "High-tech" tools useful in evaluating criteria for assessing pollutant sources include geographic information systems (GIS) and urban runoff models. However, high-tech technologies are not essential to step 3. Hand-drawn maps and desk top calculators can be just as effective in problem assessment and solution identification. The criteria a municipality would consider when determining which sources to address include an estimate of pollutant loadings from the source and an estimated impact of that source on water quality conditions. Sources can be identified in an incremental fashion by targeting areas of the watershed first, then by further focusing on individual sources or source categories (e.g., large parking lots, service stations) within the sub-watershed. Other important criteria to consider include the use of environmental indicators. The discussion below relates the goals of storm water management programs to the use of environmental indicators to meet the goals.

Environmental Goals and Indicators for Storm Water Management Programs

The "seven-step" planning process for storm water management programs must identify both the overall and project-specific environmental goals for the program. Overall environmental goals include those identified in local watershed strategies, basin-wide plans, local ordinances, community local master plans, and State water quality standards, especially the narrative statements. Project-specific goals include specific actions that will be taken to ensure that the environmental goals will be met. Such specific actions can involve pollutant loadings reductions, bank stabilization, elimination of hydraulic disturbances, increasing the effectiveness of buffers, and other common activities. Environmental indicators are used to measure the progress in meeting the overall environmental goals. Tracking of the completion of the project-specific goals must also be done.

EPA has identified four overall environmental goals and specific objectives for the nation's surface and ground waters (Table 2-2). The two ultimate overall environmental goals are to (1) Protect and Enhance Human Health, and (2) Conserve and Enhance Ecosystems. These goals will be achieved by Improving Ambient Conditions and Reducing Pollutant Loadings (Table 2-2). There are a variety of types of indicators to consider which apply to all water management programs, including storm water, traditional point sources, CSOs, and nonpoint sources. A source to assist municipalities in targeting the use of indicators for specific management actions is the *Guidance for Specifying Management Measures for Sources of Non Point Pollution in Coastal Waters* (EPA 1993). Despite its title, this document broadly addresses specific actions for all types of storm water management in freshwater.

The following discussion provides a summary of the types of indicators available to meet the overall environmental goals and the specific objectives. We are not suggesting that all of these indicators must

TABLE 2-2. EPA's ENVIRONMENTAL GOALS, OBJECTIVES, AND INDICATORS

Environmental Goal	Objective	Indicator Type
Protect and Enhance Public Health	Safe Drinking Water	Meet Public Water Supply Designated Use
	Safe Aquatic Recreation	•Beach Closures
		Meet Swimming and Secondary Contact Designated Uses
	Safe Fish and Shellfish Consumption	Tissue Concentrations
		Fish Advisories
Conserve and Enhance Ecosystems	Biologically Healthy Water Resources	Biological Diversity
		Biological Criteria
Improve Ambient Conditions	Ground Water Protection	Ground Water Quality
	Improved Ambient Pollutant Concentrations	Water Quality Standards
		Selected Parameters
	Reduce Contaminated Sediments	Extent of Contaminated Sediment
	No Net Loss of Wetlands	Loss or Gain of Wetland Acreage
Reduce Pollutant Loadings	Reduce Conventional Pollutant Loadings	Water/Effluent Chemistry
	Reduce Toxic Pollutant Loadings	Water/Effluent Chemistry

be measured. Indicators should be selected based upon the overall and specific goals of the project. For example, if contaminated sediments is not suspected to be a problem, then there is no need to routinely sample for sediment toxicity or chemistry. However, sediment toxicity and chemistry may need to be sampled in the future to help diagnose a problem. The Intergovernmental Task Force for Monitoring Water Quality is recommending a core set of parameters be measured in all water management programs followed by more detailed parameters to meet specific needs. Among those core parameters include basic water chemistry and physical measurements (temperature, pH, nutrients, solids), biological community measurements (benthic macroinvertebrates, fish, and/or algae), and physical habitat.

Human Health Indicators

Indicators for human health protection are fairly straightforward. These would include the measures used by the State to determine whether the designated use for public water supplies are met, as well as the designated uses for swimming and secondary contact use. These would typically include beach closures, if applicable.

Ecosystem Health Indicators

Determining the biological health, or integrity, of the communities inhabiting the surface waters requires more than just chemical and physical sampling. Even toxicological measures usually only account for a portion of the community effects due to other potential impacts such as habitat degradation, cumulative and synergistic effects of toxicants, and the conventional and other non-toxic pollutants. Two categories of indicators should be examined to measure progress towards meeting this goal: biological diversity and biological criteria or condition. Biological diversity measures usually are limited to determining the presence of threatened/endangered or rare species that may appear on State or Federal lists. Consultation with the State regulatory and natural resource agencies, The Nature Conservancy, and the National Biological Survey should reveal whether any "special status" species have been encountered in the area. Correction of storm water impacts could bridge important gaps in the natural range of special status species and reintroduce them into the management area.

Biological criteria, or condition, is monitored and assessed by most State regulatory, or natural resource, agencies. This process requires the collection of at least two assemblages, such as fish and benthic macroinvertebrates (and/or algae) and the results are compared with reference conditions developed by sampling least-impacted conditions within specific ecoregions, or by other means available to State biologists. States are working towards adoption of numeric biological criteria into their State water quality standard similar to that done by the State of Ohio, so measurements of the biological health of the waters should be a standard part of the program.

Ambient Condition Indicators

Improvement of ambient conditions can be measured in a number of ways. Table 2-2 shows the types of pollutants that could be monitored associated with various types of storm water management activities. This table summarizes the information in EPA's coastal zone guidance (EPA 1993), but for more detailed information not in this text, we encourage you to refer to the original document. The traditional approach for determining the improvement in ambient conditions is to compare the receiving water chemistry with State water quality standards or national criteria. However, this does not provide much information for determining the reduction in the extent of contaminated sediments. Conducting sediment toxicity testing is an effective screening tool for determining whether additional sampling and measurement of sediment chemistry is needed.

Pollutant Loading Indicators

This chapter addresses methods for assessing pollutant sources. It is important to document the reductions in pollutant loadings due to management activities to be sure that these activities resulted in measurable progress towards meeting the ultimate environmental goals. The success or failure of these activities can help us learn more about the effectiveness of best management practices.

Methods for Assessing Pollutant Sources

Once criteria have been developed to evaluate pollutant sources—including consideration of the type, magnitude, and transport mode of the pollutants (existing or potential)—the municipality can assess these sources. Pollutant assessments are frequently aimed at quantifying the source flows and pollutant loads under various conditions. Many municipalities may have already completed this step under their municipal permit application. Described below is one widely used assessment method for pollutants source.

Source Determination and Data Evaluation

Urban runoff pollution sources can be defined by completing a comprehensive watershed description that includes the following: the type(s) of pollution affecting a water resource, the pollutant transport mechanisms, the characteristics of drainage patterns and drainage structures, and the land uses in the program area. (Refer to Chapter 1 and the EPA Part 2 NPDES Guidance Manual.)

Those activities or land uses within a watershed that are, or potentially could be, causing pollution problems need to be identified. Both point source and nonpoint source discharges should be considered. Pollutant types found in the watershed can provide some clues regarding the source(s) of the problems. To isolate sources of pollution, it is helpful to divide the watershed into smaller areas so that individual pollution sources can be identified. Depending on the size of the watershed, a drainage basin can first

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be divided into subbasins. If necessary, subbasins can then be divided into individual tributaries, pipe systems, or drainage channels. Table 2-3 lists pollutant types typically associated with certain activities or land uses. This information can be used to identify potential sources. Problem sources can also be identified according to water resource conditions, such as eutrophication of a water body resulting from excessive nutrients, or closures of shellfish beds because of high concentrations of bacteria. In addition, sediments from aquatic systems and storm sewers can provide useful information for tracing and identifying potential sources (Livingston, 1991).

Computer modeling is valuable in quantifying the flows and loads of pollutant sources needed for pollution source assessments. Available models range from simple screening tools to numerical models with varying levels of complexity based on the number of processes incorporated and the level of detail provided. The level of application of a given model may also vary depending on the objectives of the analysis and available resources. Municipalities must keep in mind that modeling can be quite expensive and should only be used when the potential benefits justify their use.

In addition to the magnitude of a pollutant load and the location of a pollution source with respect to its receiving waters, the mode of transport to the receiving water and the degradation of the pollutant should also be considered. Sources with a clear path to a waterway, such as pipes, ditches, and gullies, often cause more adverse effects in a receiving water than similar sources that must travel through natural filters, such as forested or grassy areas, before entering a surface water body. Changes in loads, from the initial source discharge to the point where they affect the receptor, occur because of such factors as travel time, dilution, and decay. The fate and transport of pollutants can be modeled using hydrologic and pollutant buildup-washoff models that account for these factors. The more simple modeling methods (i.e., unit load or statistical) can only empirically estimate these factors, and, thus, the level of uncertainty and error is likely to be higher.

Models available for urban runoff assessments vary widely in their levels of complexity, ranging from simple estimation techniques to sophisticated and expensive computer models. Simple methods are compilations of expert judgement and empirical relationships between physiological characteristics of the watershed and pollutant export that can be solved by a spreadsheet program or hand-held calculator. These methods are often used when data limitations, budget, and time constraints preclude the use of more detailed models. Simple models frequently include information on land use, percent impervious factors, runoff coefficients, size of the drainage area, pollutant loading values, and rainfall data. The

TABLE 2-3. TYPES OF ACTIVITIES AND ASSOCIATED POLLUTANTS

Categories and Subcategories	Nutrients	pH	Sediment	Organic Enrichment	Bacteria	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Agriculture												
Cropland	✓		✓		✓							✓
Pasture Land Animal Holding Areas Animal Waste Storage Areas	✓		✓	✓	✓							
Hayland	✓			✓	✓							
Wash & Processing Water	✓	✓	✓	✓	✓			✓				✓
Waste Application Areas	✓		✓	✓	✓		✓					
Construction												
Highways, Bridges, Roads	✓		✓		✓	✓		✓	✓	✓	✓	
Land Development	✓		✓		✓			✓		✓	✓	
Urban Land												
Storm Water Sewers, Combined Sewers, Surface Runoff-Pavement	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Surface Runoff Turf Areas	✓		✓		✓					✓		✓
Infiltration Wells & Basins	✓				✓	✓	✓	✓	✓	✓		
Land Disposal												
Wastes-Sludge-Septage	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Landfills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
In-Situ Wastewater System	✓				✓	✓	✓	✓				✓
Hazardous Waste Areas	✓	✓			✓	✓	✓	✓	✓			✓

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TABLE 2-3. TYPES OF ACTIVITIES AND ASSOCIATED POLLUTANTS (Continued)

Categories and Subcategories	Nutrients	pH	Sediment	Organic Enrichment	Bacteria	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Hydrologic Modifications												
Earth Fills, Channelization			✓							✓	✓	
Dam Construction/ Reconstruction	✓	✓	✓	✓						✓	✓	
Other Sources												
Atmospheric Deposition	✓	✓				✓	✓					
Underground Storage Tank Leaks						✓	✓	✓				✓
Illegal Disposals/ Dumping, Release of Contaminants from in-place deposits	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Highway/Bridge Maintenance	✓		✓			✓	✓	✓	✓			✓
Auto Salvage			✓			✓	✓	✓				
Washing & Processing Areas	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Snow Dumping Areas	✓		✓	✓	✓	✓	✓	✓	✓			
Utility R.O.W.S			✓							✓	✓	✓
Surface Runoff from Gasoline Station						✓	✓	✓				
In-place sediments	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Sewer System Leaks, Domestic	✓			✓	✓	✓	✓					
Wild Birds and Mammals	✓			✓	✓	✓	✓					
Natural Vegetation (Leaves, Fallen Trees)	✓	✓	✓	✓						✓		
Marinas & Boat Moorings, Boat Maintenance & Boat Washing	✓		✓	✓	✓	✓	✓	✓				

Source: Morehouse, 1988.

Federal Highway Administration (FHWA) has made great strides in researching pollutant loadings from highway storm water discharges. FHWA has a number of models and statistical methods that municipalities may find useful in determining the benefits and impacts of various pollution prevention alternatives.

Mid-range models, on the other hand, attempt to compromise between the empiricism of the simpler methods and the complexity of detailed models. Detailed models use storm event or continuous simulation to develop historic time series of stormwater runoff and pollutant loadings and concentrations. These models often consider, among other factors, soil type and percent imperviousness factors. To select the model that will best achieve the project objectives, analysts need to consider the available required input data, watershed pollutant characteristics, and time and resources available (*Compendium of Watershed-Scale Models for TMDL Development*, June 1992).

Several models are available from EPA's Center for Exposure Assessment Modeling in Athens, GA. For more detailed information on urban and nonurban models, refer to the following publications:

- U.S. EPA, Office of Water. *Compendium of Watershed-Scale Models for TMDL Development*. EPA841-R-92-002. June 1992.
- U.S. EPA, Office of Research and Development. *Urban Runoff Pollution Prevention Planning and Development*. EPA/625/R-93/004. March 1993.
- U.S. EPA. *Guide to Nonpoint Source Pollution Control*. 1987b.

Example Models

The following discussion highlights a number of commonly used methods and focuses on models used to predict pollution characteristics in an urban environment. The methods include constant concentration or unit load estimates, preliminary screening procedure, statistical method, rating curve or regression approaches, and hydrologic and pollutant buildup-washoff models.

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Constant Event Mean Concentration or Unit Load Estimates

Constant event mean concentrations or unit pollutant loads can be used to estimate pollutant source loads. They can be obtained from available data or estimated according to the types and sizes of land uses in the watershed. Constant event mean concentrations can be coupled with runoff volume estimates to calculate runoff loads or can be used in hydrologic models to calculate time variable flows and loads. The constant event mean concentration or unit load method is easy to use and can be helpful in identifying which areas within a watershed contribute the largest pollutant loads. Constant event mean concentrations or unit loads can also be estimated using a spreadsheet. Where local resources allow, these calculations can be facilitated using a GIS to keep track of such information as pollutant concentrations from different sources, land use or source boundaries, and quantities of flow produced in individual areas. However, a GIS system is not necessary to prepare load estimates, and municipalities without access to such systems should use other methods.

Where actual measurements are not available, input data can be taken from the literature. For example, the U.S. EPA's Nationwide Urban Runoff Program provides a comprehensive study of storm water runoff from residential, commercial, and light industrial areas throughout the United States and contains a large data base of pollutant concentrations and loads measured during various storm events from 1978 through 1983 (U.S. EPA, *Results of the Nationwide Urban Runoff Program*, 1983). The Metropolitan Washington Council of Governments has published a manual entitled *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs* (1987). It recommends a simple method for calculating pollutant export from urban development sites. Included in this manual are recommended concentration values for phosphorus, nitrogen, COD, BOD_5, lead, zinc, and copper from new suburban sites, older urban areas, and a central business district.

Other data bases of storm water pollutant concentrations and loads include Driver and Tasker (1990), Tasker and Driver (1988). These data can be used as inputs to source load estimation techniques, such as the constant concentration or unit load method.

Preliminary Screening Procedure

Simple equations can be used to estimate annual average loading contributions of urban runoff for BOD, suspended solids, volatile solids, total phosphate phosphorus, and total nitrogen. Pollutant loadings can be estimated based on the relative contribution of pollutants from each land use; however, the equations are not location-specific and are only useful for screening purposes.

Statistical Method

The statistical method of modeling urban runoff assumes that event mean concentrations (EMC) are distributed log-normally and characterizes EMCs by their median values and their coefficients of variation. The U.S. EPA's statistical method (Driscoll et al., 1989) includes statistical properties of rainfall, area, runoff coefficients, median EMCs, and coefficients of variation of EMCs of various pollutants. The FHWA has implemented U.S. EPA's statistical method for various locations in the United States (Driscoll, 1989, and Woodward-Clyde Consultants, 1990).

Regression-Rating Curve Approaches

Rating curve or regression models, such as the 31 storm-runoff-load models developed by the USGS for metropolitan areas throughout the United States (Driver and Tasker, 1990, and Tasker and Driver, 1988), use site-specific rainfall, runoff, and water quality data, such as the data collected for U.S. EPA's Nationwide Urban Runoff Program and similar studies, to relate concentrations and loads of pollutants to flow rates and volumes (see Driver and Tasker, 1990).

Hydrologic and Pollutant Buildup-Washoff Models

Hydrologic and pollutant buildup-washoff models address the accumulation of pollutants during dry-weather periods and runoff of these pollutants during rainfall events. Of the many models available, some of the more widely used models that use a buildup-washoff mechanism include:

- Hydrological Simulation Program-Fortran (HSPF) (U.S. EPA, 1981); also described in (U.S. EPA 1991)
- Storm Water Management Model (SWMM) (U.S. EPA, 1988); also described in (U.S. EPA 1991)
- Source Loading and Management Model (SLAMM) (Pitt, 1989).

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Institutional Assessments

In ranking urban runoff related problems, it is also essential to assess institutional constraints/capabilities for the regulators, owners, and the public.

Criteria To Consider

To assess institutional constraints/capabilities, municipalities may want to consider the following: applicable regulations, preferences of the local authorities and regulatory agencies, funding sources and limitations, multi-agency responsibilities and overlaps, and public acceptance of the program. The criteria a municipality would consider when considering which sources to target or which receiving waters to address include:

- Potential for solving the identified problem
- Degree to which existing resources, technology, or (municipal, State, Federal) programs could be used
- Potential for adverse effects due to a particular action
- Willingness of municipal agencies to take steps (use their tools and resources) to help address this problem
- Potential for combined action (involving government agencies, citizens, interest groups, or nongovernmental organizations) in conducting storm water management activities
- Extent to which there are existing programs/activities to support measures required under the SWMP
- Implementability of controls in a particular area
- Level of public support for a) protecting a given resource, b) developing a particular program measure, or c) funding recommended controls
- Availability of funds to undertake a particular project
- Extent to which regulatory/permit requirements are satisfied.

Methods for Assessing Institutional Constraints/Capabilities

The institutional issues of a program are assessed by evaluating the program's potential and limitations and by reviewing the requirements of involved agencies and the public. One major institutional issue that must be addressed by an urban runoff program is determining the responsibilities of each involved party. This is especially true for programs involving multiple agencies. Interviews and meetings with all interested parties can be conducted to help develop institutional criteria. Questionnaires can be prepared and distributed to help identify concerns. Complaints, either filed with local authorities or available through public interaction programs, can help develop urban runoff pollution prevention and control programs to be implemented later.

Issues related to the control of the program, such as enforcement, maintenance, permitting, and funding, can affect the program's emphasis and the selection of its corrective measures. Another institutional issue involves the limitations of available technology. Implementability of controls may also be considered, particularly in areas involving limited access to private properties. In addition, the potential for eliminating or reducing an urban runoff problem or improving affected water resources can be considered. Public questions and concerns can be influential during the decision-making processes. Applicable regulations and permit conditions may force the sequencing of corrective measures so that those addressing compliance with the regulations or permit conditions are implemented first.

<u>Goals and Objectives Assessments</u>

Finally, municipalities should evaluate storm water runoff problems with respect to current and future goals.

Criteria To Consider

Municipalities will generally want to focus on those problems where preventive or corrective measures would provide the greatest benefit. One goal, for example, might be to increase the use of public beaches by decreasing bacteria counts and aesthetic nuisances associated with storm water events. Application of goals and objectives criteria could identify where corrective measures would provide the greatest benefit, perhaps at beaches only slightly degraded and needing only minimal cleanup before they are restored, or at beaches in heavily populated areas where many people could benefit from restoration of the water body. Criteria a municipality may consider when considering which sources to target or which receiving waters to address include:

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- Potential for achieving water resource goals as described in the water quality standard
- Potential for realizing short-term benefits, thereby building good will and commitment to long-term objectives
- Consistency with other land use objectives
- Consistency with programmatic goals of SWMP
- Opportunity to maximize efforts by coordinating activities with other agencies.

Methods for Assessing Attainment of Goals and Objectives

The relative importance of an urban runoff problem may be assessed by comparing that problem to the program's water resource and technology-based goals and objectives. By considering pollution problems in connection with the program's goals and objectives, the program team can identify and focus on the urban runoff problems most important in attaining the overall aims of the program. The assessments conducted on pollutant sources, water resources, and institutional aspects provide input to these determinations.

How to Rank Storm Water Runoff Problems

Municipal storm water pollution problems can be numerous, and funding to correct these problems is usually limited. It is desirable, therefore, that a priority list of sources or impacts be developed to allow for targeting of limited resources. Ranking is a subjective process that requires the judgement of decision-makers. A ranking methodology can range from simple, descriptive methods (qualitative) to numerically complex (quantitative) methods, depending on the requirements of the urban runoff program objectives and the constraints of program funding. Ranking methods can be applied to a variety of geographic areas, ranging from counties or communities with multiple watersheds or individual water bodies or pollution sources.

A ranking methodology is developed for a specific study area to encourage a phased approach and to ensure the optimal allocation of available resources. Several methodologies can be used to rank pollution problems for control, depending on the complexity of the watershed, water resources, and their problems.

Criteria such as those presented in Table 2-1 can be used in problem ranking. Ranking should be conducted following consultation with involved parties, including local, State, and Federal agencies, local environmental groups, and concerned citizens.

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Qualitative Rankings

The simplest approach is to use qualitative rankings, such as high, moderate, or low, to prioritize pollution problems. Table 2-4 provides an example of such a ranking system. The assigned ratings must then be interpreted to determine which areas should receive the highest priority as appropriate controls are developed. The use of rating points or categories can allow all the criteria to be evaluated on an equivalent basis. For each problem, the ranking criteria can be assigned relative ratings of 1 to 10, with a higher rating indicating a higher priority. In Table 2-4, the criteria used to gauge which area should receive highest priority for storm water management include imperviousness of the site, land use, runoff coefficient, annual runoff volume.

Quantitative Rankings

To perform numerical ranking, a rating is assigned to each ranking criterion for each problem. The assigned ranking for a criterion can then be multiplied by its relative weight for each pollution problem. All of the products (Criterion Ranking × Relative Weight) should be summed for a given problem. This procedure is then repeated for all problems being evaluated. The sums thus assigned should be compared, and the problems with the highest sums should receive the highest priority during implementation of urban runoff controls. An example of numerical ranking is given on page 2-23.

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An important point for municipalities to consider when using the rankings is that the ultimate goal is to address their specific water quality problems. For example, in a given municipality, stream scouring may be a bigger problem than eutrophication. In this case, the municipality would weigh runoff volume heavier than nutrients in runoff.

STEP 4: SCREEN, RANK, AND SELECT CONTROLS

Once particular waterbodies and sources have been targeted for action (based on the criteria discussed in Step 3), the municipality's task is to determine the most cost-effective solutions to solve the identified problems. This section discusses the tools needed to prioritize and rank solutions or control measures in relationship to program goals.

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TABLE 2-4. ESTIMATED NONPOINT SOURCE LOADINGS USING CONSTANT CONCENTRATIONS

Source Area	Description and Location	Area (acres)	% Impervious	Land Use	Runoff Coeff.	Annual Runoff Volume (MG)	Annual FCOL Loading org x 10^{12} (rank)	Annual NO_3-N Loading lbs (rank)	Qualitative Ranking
A	Main St and Freeport Outlet Stores	3.3	85	Commercial[a]	0.73	2.7	1.7 (12)	14 (11)	Low
B	Commercial development at I-95 Interchange, Main St, and Pine St	30.6	50	Commercial	0.45	15.7	9.8 (1)	82 (1)	High
C	A portion of Freeport Crossing Outlets, Main St, Varney Rd, and Kar Klean	13.9	60	Commercial	0.61	9.7	6.0 (3)	51 (4)	High
D	Main St, Varney Rd, a portion of Linwood Rd, and adjacent residential development	21.0	10	Multifamily Residential[b]	0.13	3.1	2.0 (10)	24 (8)	Low
E1	South LL Bean parking lot	6.5	85	Industrial[c]	0.73	5.4	2.8 (7)	28 (7)	Medium
E2	Northern LL Bean parking lot	5.5	80	Industrial	0.69	4.3	2.2 (8)	23 (9)	Medium
F	Independence Way, Eastland Shoe warehouse, Horsefeathers Restaurant, and Main St	14.1	20	Commercial	0.21	3.4	2.1 (9)	18 (10)	Low
G	Somerset Condominiums, Summer St, Upper West St, and Freeport Place Condominiums	38.0	20	Single[d] and Multifamily Residential	0.21	9.1	5.9 (4)	73 (3)	High
H	Municipal Garage, Main St, and town office parking lot	15.0	60	Industrial Commercial	0.53	9.1	4.7 (5)	48 (5)	High
I	Downtown Village area along Main St, between Morse and West St, including Oak	19.2	75	Commercial	0.65	14.2	8.8 (2)	75 (2)	High

Source: Metcalf & Eddy, 1992

[a] FCOL Conc. = 16,000 org/100 ml, NO_3-N Conc. = 0.63 mg/l
[b] FCOL Conc. = 17,000 org/100 ml, NO_3-N Conc. = 0.96 mg/l
[c] FCOL Conc. = 14,000 org/100 ml, NO_3-N Conc. = 0.63 mg/l
[d] FCOL Conc. = 37,000 org/100 ml, NO_3-N Conc. = 0.96 mg/l

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EXAMPLE: NUMERICAL RANKING SYSTEM

The following is an example of a numerical ranking system for prioritizing pollution sources. A hypothetical application of this weighted ranking methodology uses the following criteria: water body importance (as reflected by stream or lake size), type of use (ranging from urban drainage to recreational contact), status of use (impaired versus denied), level of use (low, moderate, or high), pollutant loads (not actual loads but estimates for comparative purposes), and implementability of controls (based on institutional factors, existing ordinances, or technical considerations). The criteria used for this example are similar to those identified in Table 2-1. Other criteria may be just as valid. The relative importance of the ranking criteria is designated by assigning each criterion a weight appropriate for the site-specific conditions of the watershed under consideration. The sum of all weights used to rank the problems equal 100. Next, for each problem, the criteria are ranked using a suggested range of 1 to 9, with a higher numerical ranking indicating a higher need for corrective action. This listing allows relative comparisons to be made among problems with respect to a single criterion.

This numerical ranking method for prioritizing pollution problems is illustrated in the hypothetical urban watershed (below) which consists of three streams and several types of land use (Figure 2-1). Information describing the system is presented in Tables 2-5 and 2-6. Typical sources for these data include site-specific pollutant loading data, model results, and literature values from such projects as the NURP study. For this example, the three "use" criteria are clustered together as subcriteria of a "beneficial use" criterion. There are, thus, four prioritization criteria of equal weight: stream size, beneficial use, pollutant load, and ability to implement (Table 2-7).

Ranking for "stream size" is determined according to the total drainage area of each of the three streams. Consistent with the goals for the hypothetical watershed, Stream C is ranked highest with respect to "type of use" because of its recreational uses in the city park, Stream B receives the lowest ranking because it is used mainly as an urban drain, and Stream A is ranked between the other two streams because it is used to support aquatic life. With respect to "status of use," Stream A ranks highest because although somewhat impaired, it has the potential to be improved by control of pollution sources. Stream B receives a low ranking for use status because its water quality is poor and its function as part of an urban drainage system has long been accepted. Stream C also receives a low ranking for use status since the water is of high quality. Rankings for "level of use" reflect the number of people using or affected by each stream.

Mass pollutant loadings are calculated based on runoff coefficients (functions of the amount of impervious area), runoff concentrations of pollutants, and the amount of land use type in each stream's drainage area. Each stream is ranked based on the proportion of pollutant load from its watershed (in this example, total suspended solids is used). The watershed of Stream B is judged to be easiest to implement controls because it is predominantly industrial. Based on the method presented in this example, the watershed of Stream C should receive priority during implementation of controls, followed by the watershed of Stream A and then that of Stream B.

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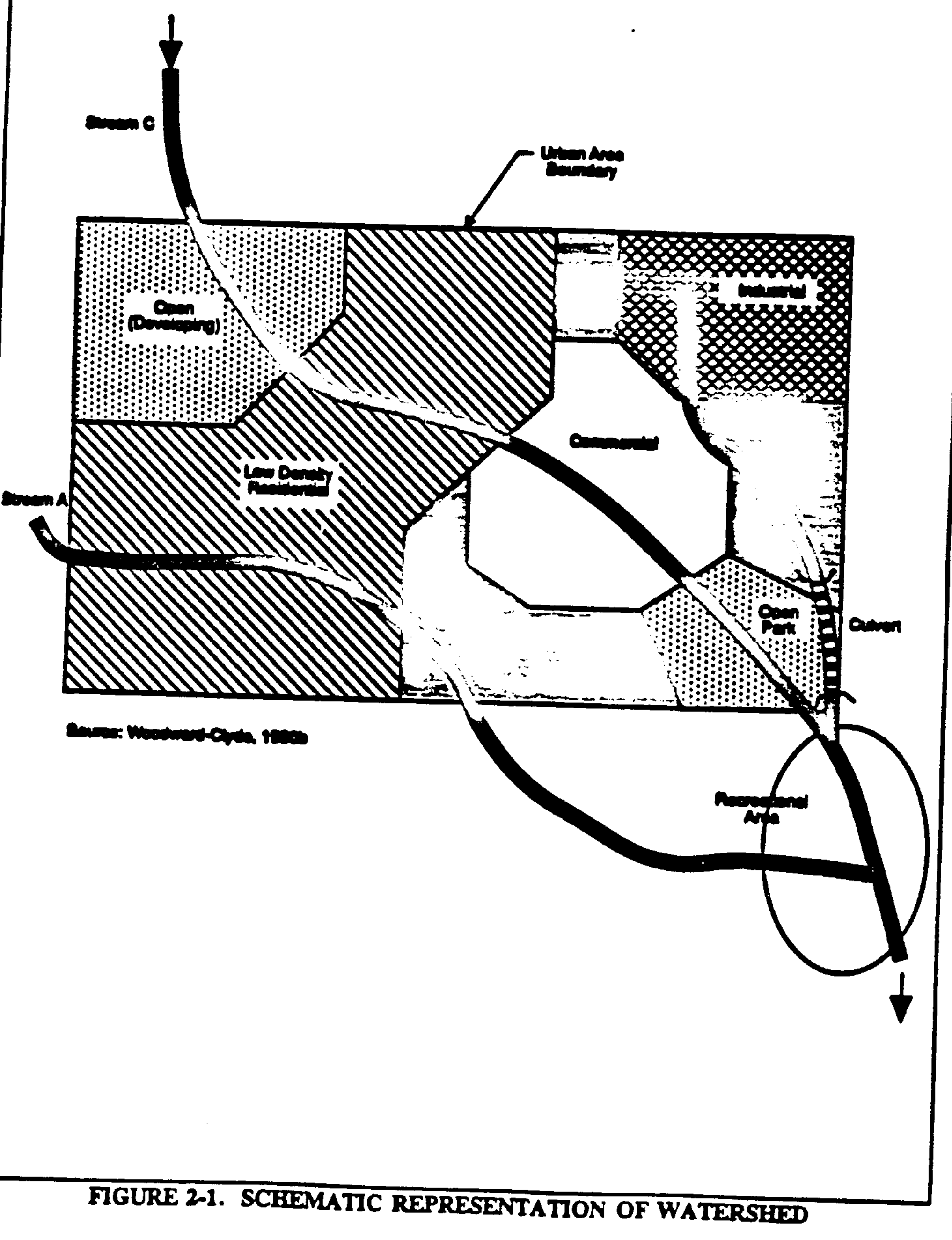

FIGURE 2-1. SCHEMATIC REPRESENTATION OF WATERSHED

TABLE 2-5. CHARACTERISTICS OF THE TARGETED AREAS AND ESTIMATED CONCENTRATION LOADS

Land Use Category	Runoff Coefficient	Average Concentration in Runoff (mg/l)				Drainage Area (acres)			
		Total Suspended Solids	Oil and Grease	Total Phosphorus	Copper	Stream A	Stream B	Stream C	Urban Total
Industrial	0.6	120	20	0.20	0.05	0	150	0	150
Commercial	0.8	80	15	0.20	0.05	10	80	110	200
Residential (High Density)	0.4	90	10	0.40	0.04	100	100	50	250
Residential (Low Density)	0.2	100	5	0.60	0.03	200	0	200	400
Open - Developing	0.1	150	0	0.80	0.01	0	0	150	150
Open - Urban Park	0.1	50	0	0.80	0.01	0	0	50	50
Total Urban Area						310	330	580	1,200
Upstream Drainage Area						600	0	20,000	20,600
Total Drainage Area						910	330	20,560	21,800

Source: Woodward & Clyde, 1990

TABLE 2-6. ESTIMATED TOTAL SUSPENDED SOLID LOADS FOR TARGETED AREAS

Land Use Category	Total Suspended Solids Load (lbs per inch of rain)			
	Stream A	Stream B	Stream C	Urban Total
Industrial	0	150	0	2,452
Commercial	10	80	1,598	2,906
Residential (High Density)	100	100	409	2,043
Residential (Low Density)	200	0	908	1,816
Open - Developing	0	0	511	511
Open - Urban Park	0	0	57	57
Watershed Total	1,870	4,431	3,482	9,784
Watershed Rank Value	1.7	4.1	3.2	9.0

Source: Woodward & Clyde, 1990

TABLE 2-7. PRIORITIZATION ANALYSIS FOR URBAN AREA TARGETING

Urban Watershed	Stream Size	Beneficial Use			Pollutant Load (TSS)	Ability to Implement	Target Score
		Type	Status	Level			
Weights	25	10	10	5	25	25	100
Watershed A	4	5	7	4	1.7	5	4.08
Watershed B	2	2	2	1	4.1	7	3.73
Watershed C	8	8	2	6	3.2	3	4.85
Total Urban Watershed	8	8	5	8	9.0	2	6.45

Target Score = Weighted Average of Rank Points = Sum(Rank Score * Weight)/Sum(Weights)
TSS: Total Suspended Solids

Source: Woodward & Clyde, 1990

Selecting BMPs for preventing and controlling storm water runoff pollution is a two-step process. First, a comprehensive list of BMPs should be compiled and screened to eliminate those that are inappropriate for the program. The appropriate BMPs are then assessed to select those that will ultimately be implemented in the SWMP.

The construction of facilities to collect and treat urban runoff may be prohibitively expensive. Therefore, the emphasis of storm water pollution control should be on developing a cost-effective approach that includes nonstructural controls and low-cost structural controls. Nonstructural controls include both regulatory controls (e.g., pollution prevention measures and land use controls) and source controls (e.g., controls that reduce pollutant buildup or lessen its availability for wash-off during rainfall). Low-cost structural controls include the use of facilities that reduce pollutant loads through infiltration or biological degradation. Given below is a list of the types of controls and BMPs available to municipalities for managing their storm water runoff (discussed in detail in Chapter 5).

EXAMPLES OF SOURCE CONTROL AND TREATMENT BMPs
Regulatory Controls • Land use regulations • Comprehensive runoff control regulations • Land acquisition
Source Controls • New development controls • Illicit discharge controls • Illegal dumping controls • Materials management controls (fertilizers, chemical storage and use) • Street/storm sewer maintenance controls • Spill prevention and cleanup • Public education/pollution prevention
Treatment Controls • Detention facilities • Infiltration practices • Vegetative practices • Filtration practices • Water quality inlets • Retrofitting existing flood control facilities

How to Screen BMPs

The goal of the BMP screening process is to reduce the list of BMPs to a more manageable number to be considered for implementation. Because this is an initial step, the methods used are generally qualitative and require that good engineering judgement be exercised.

For the purposes of screening, BMPs are divided into two general categories: structural and nonstructural. Structural BMPs, such as detention ponds and infiltration practices, are designed to address specific pollutants from known sources. In contrast, nonstructural BMPs, which include regulatory practices (such as those that limit impervious areas or protect natural resources) and source controls (such as street sweeping or solid waste management) are typically implemented throughout an entire community, watershed, or special area to be protected. Municipal storm water management programs will, in most cases, rely on a combination of both structural and nonstructural practices. Methods for screening these

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two types of BMPs are outlined below. Chapters 5 and 6 present detailed guidance on implementing structural and nonstructural BMPs.

Nonstructural Practices

Nonstructural BMPs are a good solution when limited funds are available. In addition, these BMPs can perform an auxiliary role to a structural BMP. Many low-cost techniques can lead to significant improvements in water quality. Urban storm water management programs typically include a number of nonstructural BMPs. For example, an urban runoff management plan for the Santa Clara Valley identified more than 100 separate potential nonstructural BMPs used throughout the county (Woodward-Clyde, 1989). To reduce the large number of available BMPs, municipalities must screen these regulatory and source control BMPs for their appropriateness to the watershed. The case study at the end of Chapter 2 discusses the Santa Clara Valley program and the BMP screening and selection method.

One screening method involves applying screening criteria to each nonstructural practice to determine its applicability to the conditions in the watershed. The screening criteria will be specific to the watershed and will depend on the goals of the program. Typical criteria include:

- Pollutant Removal: Different regulations and source control practices are designed to address different pollutants and, therefore, the program team should ensure that the screened list of controls includes those practices designed to address the pollutants of primary concern. Certain source control measures (e.g., development of a public information program) may not be measured in terms of reduction in pollutants loads. Therefore, municipalities may want to use alternate measures, such as the level of public participation in recycling programs or the number of community outreach activities completed.

- Existing Government Structure: Some practices implemented throughout the country require a specific government structure. For example, a strong county government may be important for implementing a specific regulatory control. However, the role of county governments can vary from one section of the country to another. Practices requiring specific government structures that do not exist in the area of concern could, therefore, be eliminated from the list.

- Legal Authority: For regulatory controls to be effective, municipalities must have the legal authority to implement and enforce regulations. Municipal boards and officials may lack this authority and may be required to obtain it through local action.

- Public or Municipal Acceptance: It may be difficult to implement some practices because of resistance from the public or an involved municipal agency. An improved communications strategy or other appropriate measures may improve the perception of these practices.

- Technical Feasibility: Some of the municipal BMPs described may require large expenditures, extensive efforts, and long-term operation and maintenance costs. Therefore, they may not be suitable for implementation in small municipalities that lack the required resources.

Additional screening criteria may also be used, as shown in the Santa Clara Valley case study at the end of Chapter 2.

Another method of screening involves the use of a comparative summary matrix, an example of which is presented in Figure 2-2. This matrix was developed for screening nonstructural control practices in coastal areas; however, it is at least in part applicable to inland areas as well. In this matrix, various regulatory and source control practices are listed and compared for their ability to meet various criteria. The criteria listed generally include ability to remove specific pollutants, such as nutrients and sediments, maintenance requirement, longevity, community acceptance, secondary environmental impacts, costs, and site requirements. Other criteria are also listed, and some of these are only applicable in coastal areas. For each practice and criterion, an assessment of effectiveness is indicated, with the solid circle indicating high effectiveness and the open circles indicating low effectiveness. This type of matrix may provide a basis for making an initial assessment of practices and their applicability to the program.

Structural Practices

Because structural practices generally are more site-specific and have more restrictions on their use than nonstructural practices, the initial screening step for these practices can be more precise than the initial screening step for nonstructural practices. Table 2-8 outlines some of the more important criteria for screening structural BMPs, including their pollutant removal efficiencies, land requirements, the drainage area that each BMP can effectively treat, the desired soil conditions (e.g., soils favorable for infiltration), ground water elevation, and costs. By using these criteria and the information obtained in the data collection and analysis and problem identification and ranking steps, the program team can narrow the choice of BMPs to a list that can be further assessed in the BMP selection step.

The initial screening criteria for structural practices include the following:

- Pollutant Removal: It is important for the municipality to ensure that the BMPs selected address the primary pollutants of concern to the level of removal desired.

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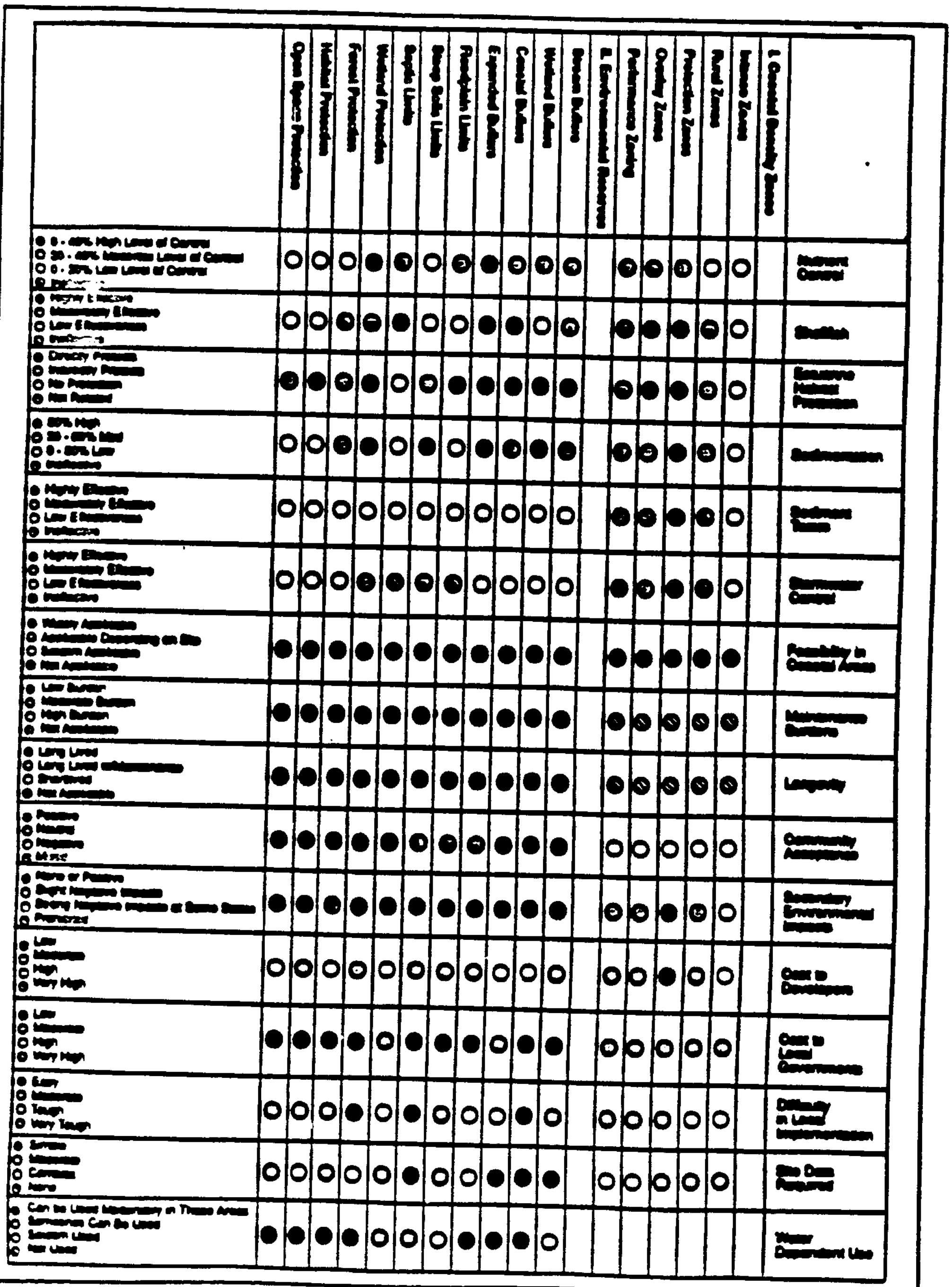

FIGURE 2-2. SAMPLE NONSTRUCTURAL CONTROL SCREENING MATRIX

Criterion	Key	III. Site Planning	Cluster	Performance Criteria	Minimize Imperviousness	IV. Erosion & Sediment Control	Time/Area Disturbance	V. Post Development	Urban Housekeeping	Fertilizer Control	Septic Maintenance	Household Hazardous Waste
Nutrient Control	● [illegible] High Level of Control; ◐ 20 - 40% Moderate Level of Control; ○ 0 - 20% Low Level of Control; ○ Ineffective		○	●	○		●		○	◐	◐	○
Shellfish	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ○ Ineffective		◐	●	○		○		○	○	●	◐
Enhance Habitat Protection	● Directly Protects; ◐ Indirectly Protects; ○ No Protection; ○ [illegible]		○	●	○		●		○	◐	○	○
Sedimentation	● 80% High; ◐ 20 - 80% Mod; ○ 0 - 20% Low; ○ Ineffective		○	●	○		●		●	◐	●	●
Sediment Toxics	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ○ Ineffective		○	●	○		●		◐	◐	●	●
Stormwater Control	● Highly Effective; ◐ Moderately Effective; ○ Low Effectiveness; ○ Ineffective		○	●	●		○		◐	◐	◐	◐
Feasibility in Coastal Areas	● [illegible]; ◐ [illegible]; ○ [illegible]; ○ Not Applicable		●	●	●		●		●	◐	●	●
Maintenance Burden	● Low Burden; ◐ Moderate Burden; ○ High Burden; ○ Not Applicable		●	○			●		●	○	○	○
Longevity	● Long Lived; ◐ Long Lived w/maintenance; ○ Short Lived; ○ Not Applicable		●	○			●		○	○	◐	○
Community Acceptance	● Positive; ◐ Neutral; ○ Negative; ○ Mixed		●	○			●		◐	◐	◐	●
Secondary Environmental Impacts	● None or Positive; ◐ Slight Negative Impacts; ○ Strong Negative Impacts at Some Sites; ○ [illegible]		●	○			●		◐	●	◐	●
Cost to Developers	● Low; ◐ Moderate; ○ High; ○ Very High		●	○			●					
Cost to Local Governments	● Low; ◐ Moderate; ○ High; ○ Very High		●	○			◐		●	◐	◐	●
Difficulty in Local Implementation	● Easy; ◐ Moderate; ○ Tough; ○ Very Tough		○	○			●		●	◐	◐	●
Site Data Required	● Simple; ◐ Moderate; ○ Complex; ○ None		●	○			◐		●	◐	○	○
Water Dependent Use	● Can be Used Moderately in These Areas; ◐ Sometimes Can Be Used; ○ Seldom Used; ○ Not Used		●	●			●		●	◐	◐	◐

FIGURE 2-2. SAMPLE NONSTRUCTURAL CONTROL SCREENING MATRIX
(Continued)

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TABLE 2-8. STRUCTURAL BMP INITIAL SCREENING CRITERIA

Structural BMPs	Pollutant Removal (1)					Land Requirements	Drainage Area (2)	Desired Soil Conditions	Ground Water Elevation
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals				
Detention Facilities									
Extended Detention Basins	Medium-High	Low-Medium	Low-Medium	--	Low-Medium	Large	Medium-Large	Permeable	Below Facility
Wet Ponds	Medium-High	Low-Medium	Low-Medium	--	Low-Medium	Large	Medium-Large	Impermeable	Near Surface
Constructed Wetlands	Medium-High	Low	Low-Medium	--	Medium-High	Large	Large	Impermeable	Near Surface
Infiltration Facilities									
Infiltration Basins*	Medium-High	Medium-High	Medium-High	High	Medium-High	Large	Small-Medium	Permeable	Below Facility
Infiltration Trenches/ Dry Wells*	Medium-High	Medium-High	Low-Medium	High	Medium-High	Small	Small	Permeable	Below Facility
Porous Pavement	High	High	Medium	High	High	N/A	Small-Medium	Permeable	Below Facility
Vegetative Practices									
Grassed Swales	Medium	Low	Low	--	Low-Medium	Small	Small	N/A	N/A
Filter Strips	Medium-High	Medium-High	Medium-High	--	Medium	Varies	Small	N/A	N/A
Filtration Practices									
Filtration Basins	Medium-High	Low	Medium	--	Medium-High	Large	Medium-Large	Permeable	Below Facility
Sand Filters	High	Low	--	--	Medium-High	N/A	Small-Medium	N/A	N/A
Water Quality Inlets	Low-Medium	Low	Low	--	Low	N/A	Small	N/A	N/A

(1) Low = 0-30%; Medium = 30-65%; High = 65-100%
(2) Small = 0-10 acres; Medium = 10-40 acres; Large = >40 acres
N/A = Not applicable
* Potential for failure high, especially when not designed and installed properly.

Sources: Schueler, 1987; Woodward-Clyde, 1991.

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- Land Requirements: Large land requirements for some of the above-ground structural BMPs can often restrict their use in highly developed urban areas.

- Drainage Area: The structural BMPs listed in Table 2-8 are used primarily to treat runoff from watersheds extending to 50 or 60 acres. Drainage areas above this size might have to be treated by locating BMPs in sub-watersheds.

- Soil Characteristics: Structural BMPs have differing requirements for soil conditions. Infiltration facilities generally require permeable soils, while detention BMPs generally require impermeable soils. The municipality must become familiar with soil conditions in the watershed.

- Ground Water Elevation: The ground water elevation in the watershed can be a limiting factor in siting and implementing structural BMPs. Generally, high ground water elevation can restrict the use of infiltration facilities.

- Public Acceptance: It may be difficult for a municipality to implement a structural BMP that meets with general public approval. Public acceptance of the BMP is an important consideration in the screening step.

- Technical Feasibility: Some of the municipal BMPs described may require large expenditures, extensive efforts, and long-term operation and maintenance costs. Therefore, they may not be suitable for implementation in small municipalities that lack the required resources.

Of the screening criteria listed, the pollutant removal, land requirements, and drainage area served are usually absolute restrictions. Soil condition and ground water elevation, on the other hand, impose restrictions that can potentially be overcome by importing needed soil or constructing facilities with clay liners to restrict ground water inflow. These modifications, however, can add significantly to BMP costs.

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BMP Selection Process

Having screened the initial list of BMPs, municipalities can now rank and select a final set of BMPs using the decision-making process (Figure 2-3) described below. This process evaluates the relative merits of each BMP or group of BMPs. Because of the complexity of urban runoff control problems, a number of factors must be taken into account in assessing alternative plans. These are presented in Figure 2-3 as inputs to the decision process and include analysis tools and decision factors. The analysis tools are those used to assess and rank the existing pollution problems (see beginning of Chapter 2). The decision factors are the criteria used to compare the alternatives. All of these inputs are then used to evaluate the alternatives using one or more decision analysis methods. The following discussion discusses each input

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to the decision analysis, then describes the various decision analysis methodologies that may be used to select BMPs for ultimate inclusion in the SWMP.

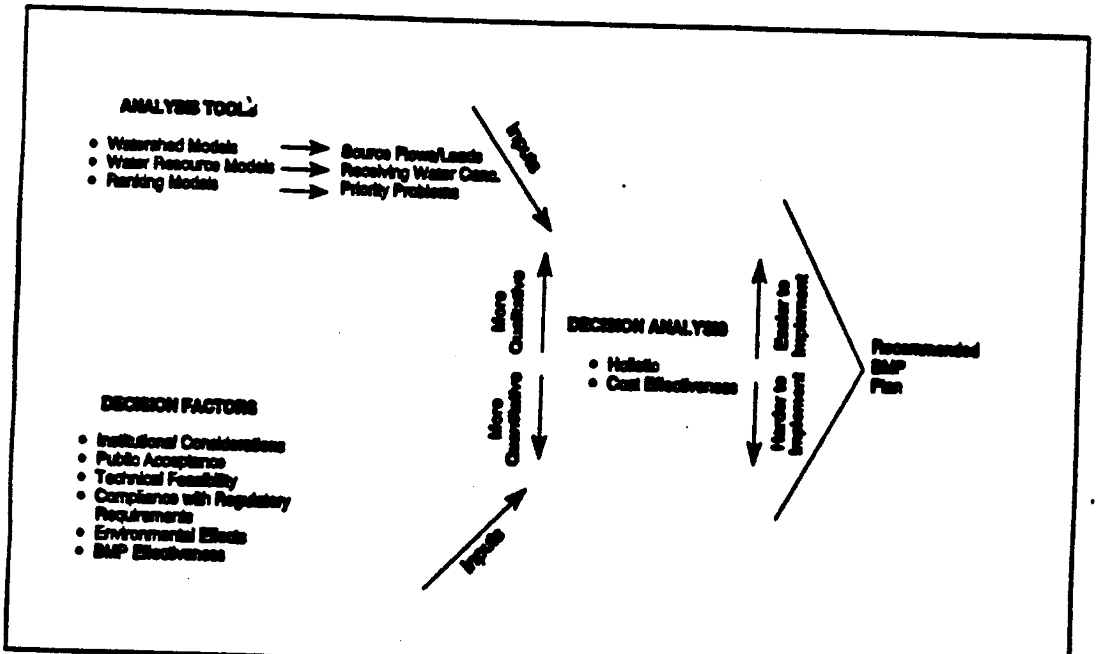

FIGURE 2-3. CONCEPTUAL DIAGRAM OF BMP SELECTION METHOD

Analysis Tools

These tools were described in detail during the discussion of Step 3. They can consist of watershed models, receiving water models, and ranking models. The analysis tools are used to project future conditions, given the alternatives being investigated. For example, the total pollutant loads for each alternative may be calculated (whether using a unit load method or complex models, such as SWMM). This will serve as one item of input information as the alternatives are being compared. Similarly, the impacts to receiving waters may be assessed using these tools, so that the impacts can be compared when making a decision.

Criteria for Decisionmaking

An important step in BMP plan selection is to determine the decision factors of importance. The selection of these criteria is site-specific and needs to be determined by the program team based on the characteristics of the watershed and the financial and personnel resources available. Typical decisionmaking criteria are discussed below. Note that they are similar to the problem assessment criteria use in Step 3.

Institutional Considerations

To evaluate and select appropriate BMPs, municipalities may want to consider a number of institutional factors, including existing governmental structures, legal authority, and implementation responsibilities. If the proper legal authority does not exist, an analysis for attaining this authority must be undertaken (as required under Part 2 of the application). In addition to these considerations, the team should investigate existing urban runoff programs in the community, region, or State. Often, cost savings are realized and total program efforts reduced by taking advantage of material and data compiled from existing programs. It should be noted that these decision factors are similar to the assessment criteria used to rank pollution problems. Factors to consider when ranking BMPs are:

- Degree to which existing technologies or programs (municipal, State, Federal) could be used
- Availability of tools (technical methods and measures) to address adverse side effects of a particular action
- Extent to which legal authority exists to implement the BMP.

Public Acceptance

In many instances, the public will be responsible for at least a portion of the funding required to implement the recommended plan. Public reaction to aspects of the storm water management program should, therefore, be assessed through the use of public meetings. Measuring public acceptance can be difficult, but is often important to the overall success of a program. The main factors to consider are:

- Level of public support to address problems
- Level of public support for implementing a particular BMP
- Public perception of the value of the resource.

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Technical Feasibility

Cost is one of the most important factors to consider when selecting BMPs. Municipalities should consider the costs associated with both the development and implementation of nonstructural BMPs and the construction and operation of structural BMPs. Total costs should be reflected in addition to capital and operation and maintenance costs for each alternative. The benefits associated with the implementation of a control plan are usually more difficult to determine. For example, if an urban runoff control plan is designed to reduce the discharge of fecal coliform to a closed shellfish area, there will be monetary benefits when these beds are reopened. These benefits are difficult to quantify but should not be neglected when selecting BMPs. The factors to consider are:

- Relative costs for a particular BMP
- Availability of funds (capital) to initiate the project
- Availability of funds to operate and maintain BMPs over time.

Construction Issues

In evaluating and selecting BMPs (particularly structural BMPs), municipalities should consider various aspects of construction, including site requirements, the extent of disruption, and the degree of construction difficulty. When relying on complex structural controls, there are difficulties inherent in construction and future maintenance that need to be overcome. Construction issues are not as important when assessing source control and regulatory control practices. However, for structural controls, they can often be very important. The factors to consider include:

- Land requirements
- Soil requirements
- Ground water elevation.

Compliance With Regulatory Requirements of the SWMP

BMPs should also be assessed on their capacity to meet the regulatory requirements of the SWMP. For example, as part of the SWMP, municipalities must prevent illicit discharges from entering the storm sewer system. In addition, they must control discharges into their storm sewer systems from industries. BMPs that work toward achieving these programmatic requirements would be assigned higher priority

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than those that do not. Priority considerations and pollution sources should be the focus of the selected alternative. The factors to consider are:

- Extent to which regulatory requirements are satisfied
- Extent to which specific programmatic measures of the SWMP are satisfied.

Environmental Effects

The implementation of pollution control measures for storm water runoff can affect the environment in a number of ways. When evaluating various BMPs, municipalities should consider the potential effects—both positive and negative—that may result from their implementation. The many resources that can be positively affected include water resources, aquatic animal and plant life, wildlife, and wetlands. The negative environmental effects, which can include aesthetic problems, cross-media contamination, the loss of useable land, and wetlands impacts, may also be considered.

The importance of considering BMP side effects is becoming more widely recognized. Indeed, there is a shift away from viewing BMPs simply in terms of their pollution control ability. Incorporating structures into new developments or retrofitting them in existing areas can gain wider acceptance if aesthetic qualities are considered. For example, unvegetated above-ground infiltration basins or extended detention basins are generally not attractive elements of the environment and may serve as insect breeding grounds. However, natural-looking wet ponds or vegetated wetlands can be incorporated into the environment and even improve aesthetics. These are issues that can greatly affect public acceptance. The main factors to consider are:

- Potential for positive effects of BMP on the community (e.g., property value, aesthetics), water resources, aquatic animal and plant life, wildlife, or wetlands
- Potential for negative effects due to BMP, such as aesthetic problems, cross-media contamination, the loss of useable land, wetlands impacts, operation and maintenance costs to the community (taxes).

Secondary environmental impacts from municipal BMPs most often affect wetlands because of the role they play in storm water management. Wetlands are used in the treatment of urban storm water discharges within a storm water management program. The impacts of urban storm water discharges on

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wetlands include degradation of wetland hydrology, wetland water quality, wetland soils, and wetland plants and animals. As a result of urbanization, wetland hydrology is affected by the increased quantity and poor quality of the storm water discharges. The impacts to wetland hydrology include lower wetland response time, change in water levels in the wetland, and a change in the wetland's detention time. The changes in wetland water quality that result from urban storm water runoff are physical and chemical. The physical changes occur in temperature, conductivity, and the level of suspended solids. The chemical changes result from the increased levels of toxics, metals, and nutrients contained in the storm water runoff. Impacts to wetland soils include changes in the pH and redox potential. The combined results of the above impacts negatively affect plants and animals in the wetland. The increased levels of storm water runoff can flood plants and the feeding and breeding grounds of many animals. Also, the toxicity levels in storm water runoff may kill plants and other food for animals within the wetland habitat.

BMP Effectiveness

Estimating the effectiveness of a BMP is one of the most important factors a municipality will consider as part of the BMP selection process. In most cases, determining BMP effectiveness for structural controls is easier than for nonstructural controls. Structural controls (e.g., detention facilities and infiltration basins) may be assessed in terms of their demonstrated capacities to remove pollutants (see Chapter 5), whereas nonstructural controls (e.g., street sweeping, land use regulations, and solid waste management) may be evaluated according to indirect measures, such as the degree to which public awareness is heightened or the number of community outreach programs that are implemented.

Some municipalities may choose quantitative, decision analysis techniques to assess BMPs, whereas others may prefer to use more basic qualitative assessments backed by basic statistics, such as cost-effective data. While qualitative factors may be subjective by their very nature, the need for more quantitative, decision analysis models may be unnecessary during the early steps of BMP selection.

One type of qualitative analysis involves a holistic approach, which relies on the use of certain basic facts, intuition, and professional judgment. One key deciding factor (cost, for example) can guide the process. Given the inherent complexity of assessing alternative urban runoff control plans and the large number of available inputs to the decision, this approach is usually over-simplified. The selection of an appropriate plan from the developed alternatives will generally require an assessment of multiple factors and should be done in as quantitative a manner as is reasonably possible.

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Quantitative approaches include such measures as cost-effectiveness analyses. A cost-effectiveness analysis helps the municipality attain a predetermined goal with the least expensive method possible.

SUMMARY

The process of targeting storm water runoff problems and selecting BMPs to control those problems is difficult and can best be performed by undertaking a systematic assessment process. Because of the qualitative nature of some inputs to these assessments and decisions, subjective comparisons among the alternative plans will likely be necessary. Where cost-benefit issues need to be addressed, or where technically complex cases are encountered, more quantitatively based, analytical tools may be necessary. The process outlined in this chapter acts as a guide for decision making and cannot account for all of the circumstances that might be encountered. Professional judgment and care is needed at each step along the way. Once these choices have been made and BMPs have been selected, the storm water management program is ready to be implemented.

WORKSHEETS

The next two pages contain worksheets developed for the *State of California Storm Water Best Management Practice Handbook (Municipal)*. These worksheets may be useful in setting priorities for selecting municipal source and treatment controls.

WORKSHEET 1
SOURCE CONTROL BMP

PROGRAM ACTIVITIES:

PROGRAM ELEMENTS:

BMPs	Meets Regulatory Requirements (1 - 5)	Effectivenes s of Pollutant Removal (1 - 5)	Public Acceptance (1 - 5)	Implementable (1 - 5)	Institutional Constraints (1 - 5)	Costs (1 - 5)	Total (30 MAX)

WORKSHEET 2
TREATMENT CONTROL BMP

Pollutants of Concern	BMPs	Area of Application (Ac)	Annual Pollutants Removed (Lb/Yr)	Annual Capital Costs[1] ($/Yr)	Annual O&M Cost[2] ($/Yr)	Annual Admin. Costs ($/Yr)	Total Annual Costs ($/Yr)	Removal Cost[3] ($/Lb)

[1] Annual capital costs based on a 20-year design period.
[2] Annual administration costs are best determined by a given community once a city-wide program is established.
[3] Removal costs are in units ($/Yr)/(Lb/Yr) = $/Lb.

CASE STUDIES

The following case studies provide examples of methods for both assessing storm water runoff problems and evaluating/selecting appropriate BMPs to address those problems.

This section summarizes the Virginia Beach, Virginia, Part 2 Storm Water permit application. The example illustrates the overall program priorities considered by Virginia Beach for the initial implementation of its storm water management program.

Program priorities were developed based on a qualitative approach rather than a rigorous quantitative approach using specific evaluation criteria that are assigned values and weights. Priorities, however, were considered by evaluating each activity listed in Table 2-9 using the following guidelines:

- Level of pollution load reduction (if high, then higher priority)
- Cost (if low, then higher priority)
- Public acceptance (if high, then higher priority)
- Type of program (if ongoing program, then higher priority than enhanced ongoing program; if new program, then lower priority than existing program; if program designed to meet a minimum requirement not presently undertaken by city, then a higher priority)
- Type of development (if program for new development, then higher priority than for program for existing development).

Using these guidelines, the first priority programs and the second priority programs were selected and are presented in Table 2-9 under the heading Priorities with either a "1st" priority or a "2nd" priority indication.

<u>Schedule</u>

Figure 2-4 shows an overall schedule for the program activities listed in Table 2-9. Many of the ongoing programs (e.g., BMP Reinspection Program) and some of the new programs (e.g., implementation and enforcement of new storm sewer system ordinance) will be fully implemented during each year of the term of the permit. Other programs will require phased implementation (e.g., development of a slide show for reporting illicit discharges), and still others will be developed during the middle years of the program (e.g., evaluation of any existing major flood control structures for water quality benefits). For some programs, the schedule indicates the number of ponds, structures, and sites to be considered (e.g., ongoing field screening for up to 25 new sites a year) for each year of the permit. The frequency (e.g., once a year) of monitoring and specific inspection programs are also indicated on the schedule.

<u>Program Evaluation</u>

During the term of the permit, the city, principally through the Department of Public Works, will monitor the progress of implementing the components of the comprehensive management program and the representative monitoring program. As part of this process, the city will evaluate the pollution removal/control effectiveness of the various program activities. For commercial and residential areas, the comprehensive storm water management program will be tracked and evaluated in light of the new and existing ordinances related to storm water quality. The expanded BMP data base will be monitored to assure that new data on structural BMPs are being used by the BMP reinspection program to assist in the maintenance schedule for structural controls, including major sediment removal.

TABLE 2-9. PROPOSED MANAGEMENT PROGRAM ACTIVITIES*

Activities	Priorities
Program for Commercial and Residential Areas	
• Master Plan for New Development	
- Maintenance of Comprehensive Plan	1st
- Existing Ordinances	1st
- Owl Creek Watershed Protection Program	1st
- Design Guidelines	2nd
• Maintenance of Structural Controls	
- Maintenance of Structures	
— Retention/Detention Ponds	1st
— Ditches/Canals/Waterways	1st
— Oil/Water Separators	1st
— Volume Control BMPs	1st
— Culverts/Structures	1st
- BMP Reinspection Program	1st
- BMP Data Base Expansion	2nd
- Major Sediment Removal	2nd
• Practices for O&M for Streets, Roads, and Highways	
- Erosion and Sediment Control	1st
- Catch Basin and Ditch Cleaning	1st
- Snow and Ice Control	1st
- Litter Control	1st
- Other Programs	1st
• Flood Management Procedures Assessment	1st
• Pesticide, Herbicide, and Fertilizer Application	
- Certification and Licensing	1st
- Training	1st
- Public Education	2nd
• Storm Water Master Plan Continuation	
- Plan Maintenance	1st
- Storm Sewer System Inventory	2nd
Program for Illicit Discharges and Improper Disposal	
• Implementation and Enforcement of Ordinance	1st
• Ongoing Field Screening	
- Sites from Part 1 Investigation	1st
- New sites each year	2nd

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the City of Virginia Beach, Virginia (1992).

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TABLE 2-9. PROPOSED MANAGEMENT PROGRAM ACTIVITIES (Continued)

Activities	Priorities
Program for Illicit Discharges and Improper Disposal (Continued)	
• Storm Sewer Investigations	
- Mapping and Evaluation	
-- Part 1 sites	1st
-- New sites	2nd
- Field surveys	
-- Part 1 sites	1st
-- New sites	2nd
- Source Identification	
-- Part 1 sites	1st
-- New sites	2nd
• Spill Response and Inspection Program	1st
• Reporting of Illicit Discharges	
- Brochures, Cityline Message and Slide Show	1st
- Hotline and main-in programs	2nd
• Controls to Limit Infiltration	1st
Program for Industrial Facilities	
• Mount Trashmore (Closed Landfill)	
- Inspection/Maintenance of Park	1st
- Monitoring Program for Two Lakes	1st
• Landfill No. 2	
- Inspection	1st
- Monitoring at One Site	2nd
• Other Facilities Data Evaluations	2nd
Program for Construction Sites	
• Site Plan Review	1st
• Inspection/Enforcement	1st
• Training Site Operators	2nd

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ACTIVITIES	YEAR OF PERMIT				
	1	2	3	4	- 5
COMMERCIAL AND RESIDENTIAL AREAS					
Master Plan for New Development					
Comprehensive Plan					
Existing Ordinances					
Owl Creek Watershed Protection Program					
Design Guidelines					
Maintenance Plan for New Development					
Maintenance of Structures					
BMP Reinspection Program					
Data Base Expansion					
Major Sediment Removal	2 ponds	2 ponds	2 ponds	2 ponds	2 ponds
Practices for O&M for Streets, Roads, and Highways					
Flood Management Procedure Assessment					
Pesticides, Herbicides, and Fertilizer					
Certification/Licensing					
Training (O = developed)	O				
Public Education (O = developed)	O				
Storm Water Master Plan					
Water Quality Model					
Plan Maintenance					
Storm Sewer System Inventory (continuing after 5 years)					
ILLICIT DISCHARGES AND IMPROPER DISPOSAL					
Implementation and Enforcement of Ordinance					
Ongoing Field Screening					
Sites from Part 1 Investigation	30 sites				
New Sites Each Year	25 sites	25 sites	25 sites	25 sites	25 sites
Storm Sewer System Investigations					
Mapping and Evaluation					
Part 1 Sites	30 sites				
New Sites	25 sites	25 sites	25 sites	25 sites	25 sites
Field Surveys					
Part 1 Sites		30 sites	25 sites	25 sites	25 sites
New Sites		25 sites	25 sites	25 sites	25 sites

FIGURE 2-4. CITY OF VIRGINIA BEACH, VIRGINIA
PROPOSED STORM WATER MANAGEMENT PROGRAM SCHEDULE*

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the City of Virginia Beach, Virginia (1992)

ACTIVITIES	YEAR OF PERMIT				
	1	2	3	4	5
Source Identification					
Part 1 Sites		30 sites			
New Sites		25 sites	25 sites	25 sites	25 sites
Spill Response and Inspection Program					
Reporting of Illicit Discharges					
Brochure, Cityline Message, and Slide Shows (O = developed)	O				
Call-in and Mail-in (O = developed)	O				
Proper Management and Disposal of Toxic Materials					
Support for Ongoing Programs					
Brochure, Cityline Message, and Slide Show (O = developed)	O				
Controls to Limit Infiltration					
INDUSTRIAL FACILITIES					
Mount Trashmore					
Inspection/Maintenance of Park					
Monitoring Program for Two Lakes	twice	twice	twice	twice	twice
Landfill No. 2					
Inspection	4 times	4 times	4 times	4 times	4 times
Monitoring at a Site	once	once	once	once	once
Other Facilities Evaluations					
Evaluate Data					
Site Inspection of Each Site	once	once	once	once	once
CONSTRUCTION SITES					
Site Plan Review					
Inspection/Enforcement					
Training Site Operators (O = developed)	O	once	once	once	once

FIGURE 4-2. CITY OF VIRGINIA BEACH, VIRGINIA
PROPOSED STORM WATER MANAGEMENT PROGRAM SCHEDULE (Continued)

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Criteria for Prioritizing Basins

The primary objective of King County's watershed approach is to protect and maintain the integrity of County stream systems and to prevent their degradation to the degree possible.

King County's philosophy is that stream protection must be accomplished through the evaluation and management of land and water within the entire watershed; that erosion cannot be managed without controlling the high flows that cause erosion; that water pollution cannot be adequately reduced without controlling the runoff and sediment, by which pollutants are transported; and that aquatic habitat cannot be managed without considering all of the chemical, physical, and hydrological elements that define each habitat.

Accordingly, criteria for prioritizing watersheds were developed to give planning urgency to those basins where hazardous conditions, such as landslides and flooding, were most frequent/severe and where water quality and habitat have not been severely affected (and could yet be preserved through proactive planning).

The initial basin planning prioritization was based on a significant body of knowledge gained from the 1987 Basin Reconnaissance program, a field inventory of problems and potential solutions conducted during the rainy seasons of 1985-1986 and 1986-1987. Multidisciplinary teams noted existing problems and features in portions of 29 service area basins. These data were used directly to determine ratings for each basin in four major categories: Existing Problems, Future Problems, Existing Resources, and Urgency/Timeliness. Rating criteria were associated with each major category, as listed in Table 2-10 below.

TABLE 2-10. BASIN PLANNING PRIORITIZATION CATEGORIES AND CRITERIA*

Category	Criteria
Existing Problems	- Landslides - Erosion/Sediment - Flooding
Future Problems	- Land in Unincorporated King County - Subdivision/Plat Activity - Population Growth - Permitted Residential Units
Existing Resources	- Stream Habitat - In-Stream Resources - Wetland Value - Wetland Storage Potential - Water Quality Potential
Urgency/Timeliness	- Other Agency Interest - Opportunity to Integrate with Other Programs

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

Problem counts for each category were generated from the Technical Appendix of each Basin Reconnaissance report (included with the Part 1 permit application). For example, for the Landslides, Erosion/Sedimentation, and Flooding categories, the following ratings were applied: "0" - low (few problems), "1" - moderate (some problems), and "2" - high (many problems). For other criteria, such as Water Quality and Stream Habitat, opposite

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scores were assigned: "0" - low quality (many problems), "1" - moderate (some problems), and "2" - high quality (few problems).

Tables 2-11 through 2-14 show the final scores of each basin for each major category. Table 2-15 shows the ranking of basins according to total scores. These rankings form the basis of the proposed basin planning schedule shown in Table 2-16.

By the end of 1992, the County will have completed, or will be substantially underway, with basin plans for 12 of the 37 basins in the surface water management service area. As expected from the ranking criteria, the first basins selected for planning services were predominately rural watersheds. More recently, the Surface Water Management Division has begun the basin planning process in urban or urbanizing basins, such as Miller Creek, Seola Creek, and Salmon Creek. The planning process for these basins will incorporate many of the same management strategies applied to rural basins and will be complemented with new programs being developed and implemented as part of the NPDES program (e.g., drainage mapping, illicit discharge surveys, and source control best management practices).

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TABLE 2-11. BASIN PRIORITIZATION*

1. Existing Problems (from Basin Reconnaissance)				
	Criteria			
Drainage Basin	Landslide	Erosion/ Sediment	Flooding	Sheet 1 Total
McAleer	1	1	2	4
Lyons	0	1	2	3
Swamp	0	1	2	3
Sammamish	2	2	1	5
North	0	0	0	0
Little Bear	0	1	1	2
Big Bear	0	2	1	3
Thornton	0	0	1	1
Lk Washington	0	2	1	3
Juanita	1	2	2	5
Forbes	0	1	1	2
Evans	1	2	1	4
W Lk Sammamish	1	2	1	4
E Lk Sammamish	1	2	1	4
Coal	1	1	1	3
Tibbetts	2	1	1	4
May	1	2	2	5
N Fk Issaquah	0	1	1	2
E Fk Issaquah	0	1	1	2
Issaquah	1	2	0	3
Lower Cedar	2	2	2	6
Duwamish	0	1	2	3
Black	1	2	0	3
Mill	0	2	2	4
Lower Green	1	2	1	4
Soos	0	1	2	3
Jenkins	0	1	2	3
Covington	0	0	0	0
Middle Green	2	1	1	4
Boeing	2	2	1	5
Middle Puget	1	1	1	3
Lower Puget	2	2	1	5
Salmon	1	1	1	3
Miller	0	1	1	2
Des Moines	0	1	2	3
Hylebos	0	2	2	4
White	0	1	1	2

Note: See narrative for explanation of rating criteria.

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-12. BASIN PRIORITIZATION*

II. Future Problems					
	Criteria				
Drainage Basin	Land in Unincorp. King Co.	1982-1987 Subdivision/ Plat Activ.	Population Growth	Permitted Residential Units	Sheet 2 Total
McAleer	1	1	0	1	3
Lyons	0	1	0	2	3
Swamp	0	1	1	2	4
Sammamish	1	2	2	1	6
North	0	2	1	2	5
Little Bear	0	1	2	0	3
Big Bear	1	1	2	2	6
Thornton	1	0	0	0	1
Lk Washington	0	2	1	1	4
Juanita	2	2	2	2	8
Forbes	1	2	1	2	6
Evans	2	2	2	1	7
W Lk Sammamish	0	2	1	2	5
E Lk Sammamish	2	2	2	2	8
Coal	1	1	2	0	4
Tibbetts	1	1	1	0	3
May	1	0	1	1	3
N Fk Issaquah	2	0	1	0	3
E Fk Issaquah	1	0	0	0	1
Issaquah	2	0	0	0	2
Lower Cedar	0	1	1	1	3
Duwamish	0	0	0	1	1
Black	0	1	1	2	4
Mill	1	0	1	0	2
Lower Green	1	2	1	2	6
Soos	2	2	2	1	7
Jenkins	2	1	1	1	5
Covington	1	0	0	0	1
Middle Green	0	0	0	1	1
Boeing	2	1	0	2	5
Middle Puget	0	0	0	0	0
Lower Puget	1	2	2	2	7
Salmon	2	0	0	2	4
Miller	2	0	0	1	3
Des Moines	2	0	0	0	2
Hylebos	2	1	2	1	6
White	0	1	0	0	1

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

TABLE 2-13. BASIN PRIORITIZATION*

III. Existing Resources

Drainage Basin	Stream Habitat	In-Stream Resources	Wetland Value	Wetland Strg. Pot.	Water Quality	Sheet 3 Total
	Criteria					
McAleer	0	0	0	0	1	1
Lyons	0	0	0	0	0	0
Swamp	1	1	1	0	1	4
Sammamish	0	2	1	1	1	5
North	1	2	0	0	2	5
Little Bear	1	2	0	0	2	5
Big Bear	1	2	2	2	2	9
Thornton	0	0	0	0	0	0
Lk Washington	0	0	1	1	0	2
Juanita	1	1	1	0	1	4
Forbes	1	1	1	1	1	5
Evans	1	1	2	2	1	5
W Lk Sammamish	0	1	0	0	1	7
E Lk Sammamish	1	1	2	2	1	2
Coal	0	1	1	0	1	7
Tibbetts	1	2	0	0	1	3
May	1	1	2	1	1	4
N Fk Issaquah	1	1	1	1	1	6
E Fk Issaquah	1	1	1	1	1	5
Issaquah	2	2	2	1	1	5
Lower Cedar	1	1	2	2	2	9
Duwamish	1	1	0	0	1	7
Black	0	2	1	0	0	2
Mill	0	1	1	0	0	3
Lower Green	0	1	2	1	0	2
Soos	1	2	2	2	1	5
Jenkins	2	2	2	2	1	8
Covington	2	2	2	2	2	10
Middle Green	1	2	2	1	1	9
Boeing	0	0	0	0	1	7
Middle Puget	0	0	0	0	0	0
Lower Puget	0	0	2	1	0	0
Salmon	1	1	1	0	0	3
Miller	1	1	1	0	1	4
Des Moines	1	0	1	0	0	3
Hylebos	1	2	2	1	0	2
White	1	2	2	1	1	7

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

TABLE 2-14. BASIN PRIORITIZATION*

IV. Urgency/Timeliness

Drainage Basin	Criteria: Other Agency Interest	Opp. to Integrate with Other Programs	Sheet 4 Total
McAleer	1	0	1
Lyons	1	1	2
Swamp	1	0	1
Sammamish	0	1	1
North	0	0	0
Little Bear	0	0	0
Big Bear	2	2	4
Thornton	1	0	1
Lk Washington	0	0	0
Juanita	0	0	0
Forbes	0	0	0
Evans	2	1	3
W Lk Sammamish	1	1	2
E Lk Sammamish	1	1	2
Coal	1	0	1
Tibbetts	2	1	3
May	0	0	0
N Fk Issaquah	2	2	4
E Fk Issaquah	2	2	4
Issaquah	2	2	4
Lower Cedar	0	1	1
Duwamish	2	1	3
Black	0	1	1
Mill	2	2	4
Lower Green	0	2	2
Soos	2	2	4
Jenkins	2	2	4
Covington	2	2	4
Middle Green	0	2	2
Boeing	0	0	0
Middle Puget	0	0	0
Lower Puget	1	1	2
Salmon	0	0	0
Miller	0	1	1
Des Moines	2	1	3
Hylebos	1	1	2
White	0	1	1

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-15. BASIN PRIORITIZATION*

Summation Sheet
Ranked According to Total Score

Drainage Basin	Existing Problems	Future Problems	Existing Resources	Urgency/ Timeliness	Total Sum
Big Bear	3	6	9	4	22
Jenkins	3	5	10	4	22
Soos	3	7	8	4	22
E Lk Sammamish	4	8	7	2	21
Evans	4	7	7	3	21
Hylebos	4	6	7	2	19
Issaquah	3	2	9	4	18
Juanita	5	8	4	0	17
Lower Cedar	6	3	7	1	17
Lower Green	4	6	5	2	17
Lower Puget	5	7	3	2	17
Sammamish	5	6	5	1	17
Covington	0	1	9	4	14
May	5	3	6	0	14
Middle Green	4	1	7	2	14
N Fk Issaquah	2	3	5	4	14
Tibbetts	4	3	4	3	14
Forbes	2	6	5	0	13
W Lk Sammamish	4	5	2	2	13
E Fk Issaquah	2	1	5	4	12
Mill	4	2	2	4	12
Swamp	3	4	4	1	12
Black	3	4	3	1	11
Coal	3	4	3	1	11
Salmon	3	4	4	0	11
White	2	1	7	1	11
Boeing	5	5	0	0	10
Des Moines	3	2	2	3	10
Little Bear	2	3	5	0	10
North	0	5	5	0	10
Duwamish	3	1	2	3	9
Lk Washington	3	4	2	0	9
McAleer	4	3	1	1	9
Miller	2	3	3	1	9
Lyons	3	3	0	2	8
Middle Puget	3	0	0	0	3
Thornton	1	1	0	1	3

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-16. PROPOSED BASIN PLANNING SCHEDULE 1992 - 1997*

Basin/Start Year	Current and Future Conditions Report	Draft Basin Plan	WMC Proposed Basin Plan	WMC-approved or Executive Proposed	Expected Adoption
Soos/87	—	Nov 89		July 90	*Jan 92*
Bear/87	—	*Dec 89*		May 91	Oct 92
Hylebos-LPS/88	*July 90*	*Feb 91*		July 91	Jan 93
ELS/88	*Sept 90*	*May 92*	Nov 92	June 93	Sept 93
Issaquah/89	*Oct 91*	Nov 92	Apr 93	Sept 93	Jan 94
Cedar/91	Jan 93	July 93	Jan 94	Sept 94	Jan 95
May 2/92	Aug 93	April 94		Nov 94	May 95
Miller-Salmon-Seola/92	Oct 93	July 94		Feb 95	Aug 95
Green/94	May 95	Feb 96		Dec 96	Jun 97
Duwamish-Black-Mill/94	Feb 95	Oct 95		May 96	Nov 96
Sammamish 94	Dec 95	Sept 96		Apr 97	Oct 97
Boeing-McAleer-Lyon-Thornton/95	Feb 96	Oct 96		May 97	Dec 97
Juanita, E LK Wa. 96	Apr 97	Dec 97		Jul 98	Dec 98
W. Lk. WA, W. Lk. Samm 96	May 97	Dec 97		Jul 98	Dec 98

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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This section summarizes the Part 2 storm water permit application prepared by Charlotte, North Carolina. The discussion does not mirror the planning process described in this manual, but rather presents a variation for municipalities to consider.

Step 1 — Develop Criteria to Evaluate Objective Attainment and Planning

The table below, taken verbatim from the Charlotte, North Carolina, Part 2 storm water permit application, summarizes the factors considered in each of the Charlotte Storm Water Quality Management Program (SWQMP) elements. The purpose of the table was to force full consideration of both the pros and cons of each program element and to assist the city in determining the practicability of each measure in formulation of its MEP.

TABLE 2-17. BEST MANAGEMENT PRACTICE SCREENING CRITERIA*

BMP:					
	Criteria Description	+	0	-	**Comments**
1.	Human Risk, Public Safety and Potential Liability				
2.	Environmental Risk and Implications				
3.	Ability to Control Key Targeted Pollutants				
4.	Costs to Implement and Continuing Costs				
5.	Acceptability to the Public, Stakeholders, Staff and Political Leadership				
6.	Equitability to Impacted Persons				
7.	Reliability and Consistency Over Time				
8.	Sustainability in Terms of Maintenance or Program Management				
9.	Ability to be Applied Universally Throughout the Jurisdiction or, on a Specific Watershed Basis				
10.	"Fit with other Charlotte Operations and Programs				
11.	Relationship to other Federal, State, or Local Regulatory Requirements				
12.	Amenity or Multi-use Value				
Totals					

*Excerpted verbatim from the Part 2 Storm Water Permit Application prepared by Charlotte, North Carolina (1992)

Step 2 — Develop List of Possible Control Measures (BMP's)

There are almost an infinite number of variations on programmatic, structural, and nonstructural BMPs. A candidate set of nearly 100 control measures, program elements, and other activities was developed through brainstorming sessions. A preliminary screening was done of these based on engineering judgement and knowledge of what measures were not remotely feasible. Candidate control measures and programs surviving this initial screen were subjected to a more formal consideration using the table in step 1.

Step 3 — Apply the Criteria to Screen the Measures

The criteria were generally applied (along with engineering judgement) to spotlight potential problems with the application of program elements. It was considered too premature to require the use of certain structural BMPs,

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though a more formal technical consideration of specific design standards and incorporation into Charlotte design criteria was adopted as a program element.

Step 4 — Preliminarily Analyze a Practical Set of Control Measures

This shortened list was organized and analyzed to determine how each measure will function singularly and in conjunction with other program elements and how and by whom these elements will be implemented. Another part of this analysis is to determine ranges of BMP application to allow for development of alternative programs and to get a feel for cost sensitivity where appropriate.

Step 5 — Estimate Overall Program Costs and Pollution Reduction Effectiveness

In most cases, particularly for nonstructural BMPs, it was very difficult to assign pollution reduction numbers without better data and information. In many cases it was inappropriate. Great care and engineering judgment must then be exercised. The steps generally were to:

- Define such factors as the control measures, phases of implementation, ranges of implementation, equipment, and locations as necessary to define the program as fully as possible; consider pilot applications and data monitoring feedback loops
- Make first order estimates of program costs in each implementation stage or phase.
- Realistically allocate budgets to these programs, over the first 5-year permit period and at ultimate development as appropriate.
- Make first order estimates of the program's effectiveness by relying on the experience of other cities.

Step 6 — Obtain Feedback and Revise Program Scope to Maximize Program Cost Effectiveness

There is a need in any comprehensive program development to go back and look at the whole assembled puzzle after suitable examination of each of the pieces and after preliminary coordination with the permit writer. Adjustments were made to the program scope and schedule.

Step 7 — Describe Roles and Responsibilities to Implement the Program

After a preliminary SWQMP strategy was formulated, preliminary roles or responsibilities for each program element were identified. The local organizational structure and current program responsibilities were considered.

Step 8 — Develop Schedule for Implementation Control Program Including Management and Feedback Loops

The end result of this step is the schedule and budget for program implementation. It was considered important to evaluate the success of the programs at every step and build into each program ways to measure that success. This may be through specially designed feedback from the persons implementing the program, through data collection and monitoring, public awareness polls, or other means.

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EXAMPLE METHOD FOR SELECTING SOURCE CONTROL BMPs

This section summarizes the *State of California Storm Water Best Management Practice Handbook (Municipal)*, Storm Water Quality Task Force, March 1993. The discussion provides a step-by-step planning example on how to select potential source control BMPs for inclusion in a municipal Storm Water Management Program. It assumes that program goals and priorities and existing conditions (Steps 1-3) have been identified. This example illustrates how source control BMPs may be selected using the Source Control Worksheet #1.

Selection Process

The selection criteria and the scoring system below are similar to other selection processes developed around California. It is recommended, however, that the criteria and/or the scoring be modified to suit the particular community. Modification of the following selection process attributes may be considered:

- **Criteria** — Redefine some of the criteria or add/subtract criteria.
- **Scores** — Modify the scoring to a simple +,0, and -, or 1, 2, and 3.
- **Weighting** — Group the criteria into tiers reflecting their relative importance to specific SWMP goals. By multiplying the scores of the highest tier by some factor (e.g., x2), the first tier scores could be weighted more heavily than the others to reflect this importance.
- **Fatal flaw** — Provide for some fatal flaw in scoring the BMPs (e.g., the BMP is illegal or its implementation is completely unacceptable to the public) that would make implementation impossible. Scoring a fatal flaw as a 0 is one way of highlighting the flaw. Any BMP scoring a 0 against a criterion would be eliminated from consideration, regardless of its overall ranking.

Example

In the following example, municipality Anytown, California, is developing a Storm Water Management Program that includes an element for Residential/Commercial Activities. By following the steps below, the community uses Worksheet 1 to rank the BMPs according to their ability to meet the selection criteria. The worksheet shows the initial results of this hypothetical ranking.

1. The selection process involves consideration of following:
   - Table 2-18, Application of BMPs to SWMP Program Elements
   - Discussion of selection criteria
   - Worksheet 1
   - Source Control BMPs.
2. A review of Table 2-18 shows that for Residential/Commercial Activities, the storm water regulations require the SWMP to have an element addressing Roadway and Drainage Facility Maintenance. The program activity and element are listed at the top of Worksheet 1.
3. Looking across the Roadway and Drainage Facility Maintenance row in Table 2-18, two categories of source control BMPs apply, Material Use Control and Street/Storm Drain Maintenance.
4. The Material Use Control category includes two types of BMPs, Housekeeping Practices and Safer Alternative Products. These are listed on Worksheet 1.
5. Several BMPs are described within each fact sheet. These are also listed on Worksheet 1.

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WORKSHEET 1*
SOURCE CONTROL BMP

PROGRAM ACTIVITIES: ***Residential/Commercial***

PROGRAM ELEMENTS: ***Roadway and Drainable Facility Maintenance***

BMPs	Meets Regulatory Requirements (1 - 5)	Effectiveness of Pollutant Removal (1 - 5)	Public Acceptance (1 - 5)	Implementable (1 - 5)	Institutional Constraints (1 - 5)	Costs (1 - 5)	Total (30 MAX)
MATERIAL USE CONTROL:							
Housekeeping Practices							
• Distribute Public Education Material	3	2	5	5	4	5	24
• Train City Employees Regarding Chemical Use	3	3	5	4	4	5	24
Safer Alternative Products							
• Use Organic Soil Amendments	3	5	5	3	5	2	23
• Train City Employees Regarding IPM	3	3	5	4	4	5	24
• Substitute IPM for Pesticides	3	5	5	2	5	5	25
STREET/STORM DRAIN MAINTENANCE:							
Street Cleaning							
• Replace Mechanical Sweepers with Vacuum	3	3	5	3	3	1	18
• Increase Frequency Two Times a Week	3	2	5	3	4	2	19
• Maintain Equipment	3	2	5	5	5	4	24
• Maintain Operation Log	3	1	5	5	5	5	24
Storm Drain Flushing							
• Flushing	3	4	4	2	0	4	17*

*Taken verbatim from the *State of California Storm Water Best Management Practice Handbook*, Storm Water Quality Task Force, March 1993.

TABLE 2-18. APPLICATION OF BMPs TO SWMP PROGRAM ELEMENTS*

Required Elements of SWMP	Source Control BMPs Chapter 4							
	Planning Management	Material Use Control	Material Exposure Controls	Material Disposal & Recycling	Spill Prevention & Cleanup	Illegal Dumping Controls	Illicit Connection Controls	Street/Storm Drain Maintenance
FOR RESIDENTIAL/COMMERCIAL ACTIVITIES:								
Roadway and drainage facility maintenance		✓						
BMP planning for new development and redevelopment projects	✓							✓ ✓
Retrofitting existing or proposed floor control projects with BMPs	(See Page 3-9, Chapter 3)							
Municipal waste handling and disposal operations		✓	✓	✓	✓	✓		
Pesticide, herbicide, and fertilizer use controls		✓	✓	✓	✓	✓		
FOR IMPROPER DISCHARGE ACTIVITIES:								
Prevention, detection, and removal of illegal connection to storm drains							✓	
Spill prevention, containment, and response		✓	✓	✓	✓	✓		
Promote proper use and disposal of toxic materials		✓	✓	✓	✓	✓		
Reduce storm water contamination by leaking/overflowing separate sanitary sewers					✓	✓		
FOR INDUSTRIAL ACTIVITIES:								
Inspection and control prioritization and procedures		✓	✓	✓	✓	✓	✓	✓
Monitoring of significant industrial discharges						✓	✓	
FOR CONSTRUCTION AND LAND DEVELOPMENT ACTIVITIES:								
Water quality and BMP assessments during planning	✓	✓	✓	✓	✓	✓		✓
Site inspection and enforcement procedures	✓	✓	✓	✓	✓	✓		
Training for developers and contractors	✓							✓

*Taken verbatim from the *State of California Storm Water Best Management Practice Handbook (Municipal)*, Storm Water Quality Task Force.

6. Using the discussion of selection criteria, the BMPs are ranked against the selection criteria using the scale of 1-5.

7. For the first BMP, Distribute Public Education Materials, the following scores are recorded:
   Meets Regulatory Requirements = 3. Public education meets the intent of the storm water regulations.
   Effectiveness of Pollutant Removal = 2. Effectiveness of source control is high; however, insufficient data exist to support this claim.
   Public Acceptance = 5. Anytown believes that the public education materials are available from other municipalities and agencies to serve as models or to purchase for use as is.
   Implementable = 5. The existing department and staff may be used, and public education materials are available from other municipalities and agencies to serve as models or to purchase for use as is.
   Institutional Constraints = 4. To provide a consistent message to the public, Anytown must coordinate its public education program with the county, which already has in place a hazardous waste disposal program. The county has indicated that it will cooperate fully with Anytown to ensure that the public education material is consistent with the county's program.
   Costs = 5. Given the availability of materials to serve as models or to use directly, production should be relatively inexpensive.

8. Addition of the criteria scores across each row produces a total score, which may be compared to the other totals.

9. The process is continued for each of the source control BMP categories checked in Table 2-18.

As a result of this evaluation, Anytown, California, implemented all the BMPs in the Housekeeping Practices and Safer Alternative Products categories, as well as the maintenance BMPs in the Street/Storm Drain Maintenance category. However, the scores for the other Street/Storm Drain Maintenance BMPs indicated that further study was necessary before their implementation could be proposed. Anytown, California, also found that storm drain flushing was not allowed by the local sewer agency, so this fatal flaw removed this BMP from further consideration.

<u>A Few Points to Remember</u>

- Have several people or one of the storm water committees conduct the selection independently to get a broad perspective on the relative merits of each BMP and to help reach a consensus.
- Keep the selection system as simple as possible and use best professional judgment to interpret and to conduct a reality check on the total scores.
- Remember that differences of a few points in the total score are probably not significant.
- Use the final rankings to plan and prioritize the SWMP. For example, those BMPs with the highest scores may be implemented in the first year of the NPDES permit, while low scoring BMPs may need more time to develop, relegating their implementation to the fifth year or to further study.
- Use the exercise of working through this selection to provide the necessary data to promote the program to other departments, political leaders, regulatory agencies, and the public.

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION BMP SELECTION MATRIX

To address storm water and nonpoint source pollution control in areas of new development, the Maine Department of Environmental Protection (ME DEP) has developed a method to select BMPs. The method is based on the following information:

- Development land use type and size
- Receiving water type (e.g., estuary, wetland, river, or stream)
- Watershed priority (either priority or nonpriority)
- Erosion and sediment control target or "level to achieve"
- Storm water quality control target or "level to achieve"
- Erosion and sediment control options and "treatment level codes"
- Storm water quality control target or "treatment level codes."

To implement the BMP selection method, ME DEP has developed a series of eight matrices. There are two matrices for each receiving water type (estuary, wetland, river, and stream). One matrix is applied to development in designated priority watersheds, and the other is applied to development in nonpriority watersheds. A priority watershed list has been developed by ME DEP based on environmental sensitivity, local support for water quality, and importance of the watershed to the State. Example matrices for priority and nonpriority estuary watersheds are shown in Tables 2-19 and 2-20.

Each matrix has two major components, which are broken down by land use type. The first is an erosion and sediment control "level to achieve," and the second is a storm water quality "level to achieve." The "level to achieve" for a given combination of land use and receiving water category is a relative, qualitative measure of the impact of storm runoff pollution. It ranges from 1 to 5, with 1 being the lowest impact and 5 being the greatest impact. For example, a multi-housing development proposed for a priority estuary watershed is given an erosion and sediment "level to achieve" of 2 and a water quality "level to achieve" of 3. By comparison, a small residential development in the same priority watershed is given an erosion control "level to achieve" of 1 and a water quality "level to achieve" of 1. In all cases, the " levels to achieve" for priority watersheds are greater than or equal to those for nonpriority watersheds.

Each matrix also addresses the types of BMPs that can be implemented for pollution control. ME DEP selected a number of BMPs and assigned each a "treatment level code" based on the expected level of pollutant removal. The "treatment level code" is a relative, qualitative measure. It is designed to indicate the relative pollutant removal expected from various BMPs. "Treatment level codes" range from 1 to 3, with 1 providing the lowest level of control and 3 providing the greatest level of control. The BMPs and their treatment level codes are shown in Table 2-21. As indicated, various designs for each BMP are given different treatment level codes. For example, a 50-foot buffer is given a treatment level code of 1, a 125-foot buffer is given a treatment level code of 2, and a 200-foot buffer is given a treatment level code of 3.

For a proposed development to be approved, the sum of treatment level codes for the proposed BMPs must be greater than or equal to the "level to achieve." For example, if a multi-housing unit development is proposed for a priority estuary (erosion "level to achieve" of 2 and water quality "level to achieve" of 3, the developer could implement erosion and sediment controls (treatment level 2) and a combination of a swale (treatment level 1) and an infiltration system (treatment level 2). Additional combinations also could be implemented as long as the total "treatment level" provided is greater than or equal to the total "level to achieve." ME DEP has also recommended that at least one vegetative BMP be implemented unless the site is already 100 percent impervious. The specified vegetative BMPs are buffers, grassed swales with level spreaders, and swales.

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TABLE 2-19. PRIORITY ESTUARY STORM WATER CONTROL MATRIX*

Land Use Category	Erosion and Sediment Level to Achieve	Erosion and Sediment Controls	Water Quality Level to Achieve	Storm Water Controls
Low Density Residential >2 acres per lot	1	Erosion and Sediment 1	1	Buffer 1
High Density Residential <2 acres per lot	2	Erosion and Sediment 2	3	Buffer 1 or 2 Wet Pond 2 Infiltration 1 or 2 Created Wetland 2
Commercial <1 acre distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial 1-3 acres distributed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Infiltration 1 Swale 1
Commercial >3 acres disturbed	2	Erosion and Sediment 2	4	Buffer 1 or 2 Infiltration 1 or 2 Created Wetland 2 Wet Pond 2 or 3 Fertilizer Control 1 Shallow Impoundment 1
Intensive Use Open Space (e.g., golf courses, nurseries)	2	Erosion and Sediment 2	5	Buffer 1 or 2 Fertilizer Control 1 Pesticide Control 1 Created Wetland 2 or 3 Wet Pond 2 or 3
Multi-housing Units	2	Erosion and Sediment 2	3	Buffer 1 or 2 Fertilizer Control 1 Pesticide Control 1 Created Wetland 2 Wet Pond 2 Infiltration 1 or 2
Industrial <1 acre disturbed	1	Erosion and Sediment 1	1	Buffer 1 Swale 1
Industrial 1-3 acres disturbed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Swale 1
Industrial >3 acres disturbed	2	Erosion and Sediment 2	5	Buffer 1 or 2 Swale 1 Created Wetland 2 or 3 Wet Pond 2 or 3

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

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TABLE 2-20. NONPRIORITY ESTUARY STORM WATER CONTROL MATRIX*

Land Use Category	Erosion and Sediment Level to Achieve	Erosion and Sediment Controls	Water Quality Level to Achieve	Storm Water Controls
Low Density Residential >2 acres per lot	1	Erosion and Sediment 1	1	Buffer 1
High Density Residential <2 acres per lot	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1
Commercial <1 acre distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial 1-3 acres distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial >3 acres disturbed	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1 Swale 1 Shallow Impoundment 1
Intensive Use Open Space (e.g., golf courses, nurseries)	2	Erosion and Sediment 2	3	Buffer 1 or 2 Infiltration 1 or 2 Fertilizer Control 1 Created Wetland 2 Wet Pond 2
Multi-housing Units	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1
Industrial <1 acre disturbed	1	Erosion and Sediment 1	1	Buffer 1 Swale 1
Industrial 1-3 acres disturbed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Swale 1
Industrial >3 acres disturbed	2	Erosion and Sediment 2	4	Buffer 1 or 2 Swale 1 or 2 Created Wetland 2 or 3 Wet Pond 2 or 3

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

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TABLE 2-21. BMPs AND TREATMENT LEVEL CODES*

BMPs	Level of Treatment
Erosion and Sediment Control	
• One line of erosion control	1
• Two lines of erosion control	2
Non-grassed Buffers	
• 50 feet	1
• 125 feet	2
• 200 feet	3
Swales	1
Shallow Impoundments	1
Infiltration Systems	
• Single system	1
• Multiple systems	2
Wet Ponds	
• Single pond system holding 2.5 inches of runoff	2
• Double pond system each pond holding 2.5 inches of runoff	3
Created Wetlands	
• Single created wetland	2
• Two created wetlands	3
Street Cleaning	1
Fertilizer Application Control	1
Pesticide Use Control	1
Grassed Swales with Level Spreaders	1
Reverting Land (allowing land that is currently impervious to become a vegetative buffer)	1

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

This BMP selection system is in its early stages of implementation. Its success will depend on the ability to establish "levels to achieve" that will adequately protect the water bodies in new developments. It will also depend on the ability of treatment level codes to quantify the effectiveness of the identified control measures. Thus, the system is a technology-based approach for erosion and sediment control, as well as for storm water pollution control.

Currently, this method is outlined in a state-wide guidance document and is not a regulatory requirement. Municipal officials can incorporate this process at their discretion in subdivision regulations. This method of BMP selection requires extensive up-front work to develop the matrices and BMP levels of treatment. Once these are developed, however, this method provides a simple and direct technology-based approach to BMP selection. It has flexibility in terms of the range of BMPs that can be selected for given types of proposed development and given site constraints.

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SANTA CLARA VALLEY, CALIFORNIA, NONPOINT SOURCE CONTROL PROGRAM BMP SCREENING AND SELECTION PROCEDURE

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Background

In 1986, the San Francisco Regional Water Quality Control Board developed a Basin Plan for San Francisco Bay that involved regulatory activities to control point and nonpoint source discharges. This was the driving force behind initiating the Santa Clara Valley Nonpoint Source Control Program. This program involves a number of local governments and county agencies and is designed to address water quality problems in Lower South San Francisco Bay. In conducting this project, a 12-step process that closely follows the process outlined in this manual was used. The 12 steps are as follows:

- Initiate Program
- Determine Existing Conditions
- Conduct Field Monitoring
- Define Program Objectives
- Develop Evaluation and Planning Criteria
- Compile Inventory of Candidate Controls
- Apply Criteria to Screen Candidate Controls
- Apply Professional Judgment to Select a Practical set of Controls
- Estimate Overall Program Cost and Effectiveness
- Revise the Previously Defined Control Programs to Balance Cost, Effectiveness, and Other Factors
- Describe the Roles of Various Agencies
- Develop an Implementation Schedule.

Development of the Nonpoint Source Control Plan began in 1986 and has continued through various stages to initial implementation and preliminary assessment of effectiveness.

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Watershed Description

Santa Clara County, which incorporates the entire study area, is located at the southern end of San Francisco Bay (see Figure 2-5). The watershed is approximately 690 square miles and consists primarily of the relatively flat Santa Clara Valley. Land use in the watershed is approximately 30 percent residential, 5 percent industrial (predominantly light industry associated with high technology manufacturing), and 62 percent open space. Large cities, San Jose, Sunnyvale, and Santa Clara, account for the majority of urban areas in the watershed.

Overview of Water Quality

To characterize existing water quality in Lower South San Francisco Bay, a comprehensive monitoring program was undertaken. This program included hydrologic monitoring, wet and dry weather water quality monitoring, sediment monitoring, and biological monitoring. The monitoring was conducted primarily to determine the levels of toxic pollutants, such as heavy metals and pesticides, as well as nutrients and bacteria. Data obtained through this monitoring program were incorporated into data bases and used for developing computer models. Watershed loads were estimated using the Storm Water Management Model (SWMM), which was calibrated to the observed data gathered in the monitoring program. The data were also used to compare the relative contributions of point (e.g., waste water treatment plants) and nonpoint source pollution to the bay.

Water quality monitoring results indicated that heavy metal concentrations in receiving waters increase during wet weather due to contaminated runoff as well as resuspension of contaminated sediments. The metals primarily detected were cadmium, chromium, copper, lead, nickel, and zinc. However, copper was the primary metal regularly detected at levels greater than the EPA aquatic life toxic criterion during wet weather. The criteria were

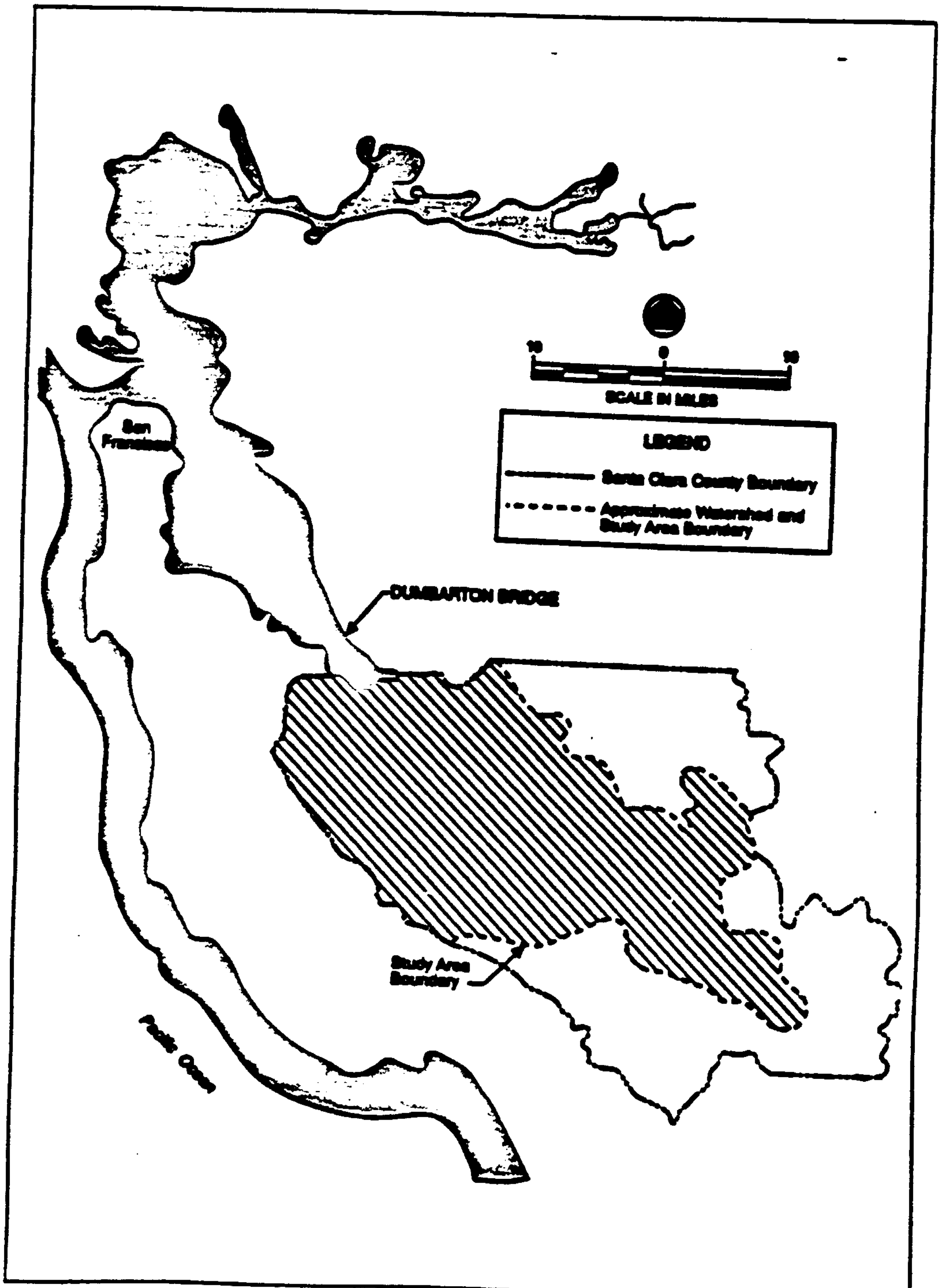

FIGURE 2-5. SANTA CLARA COUNTY

only occasionally exceeded for cadmium, lead, and zinc. Also, during wet weather, hydrocarbons and pesticides were detected in approximately 25 percent of the samples collected, while none was detected during dry weather. The limited bacteria data gathered indicated increased levels (by a factor of about 10) of fecal coliform bacteria during wet weather as compared to dry weather conditions.

In comparing point and nonpoint source contributions to water quality problems in Lower South San Francisco Bay, the monitoring results showed that point sources account for approximately 98 percent of the nutrient load. However, nonpoint sources accounted for 60 to 80 percent of the load for metals and about 98 percent of the total suspended solids on a long-term basis.

Management Practice Screening

Because of the large size of the watershed and the variety of pollutants entering the Lower South San Francisco Bay, the emphasis of the nonpoint source pollution control program was on pollution prevention measures and nonstructural controls that could be implemented across municipal boundaries. Selection of appropriate pollution controls was accomplished through a process consisting of preliminary screening followed by final control measure selection (see Figure 2-6).

To screen the extensive list of potential pollution control practices, the program team first developed a list of important criteria for the selected control measures. The criteria developed for this project were:

- **Pollutants Controlled:** Emphasis is placed on controls for metals, pesticides, oil and grease, bacteria, and sediments.
- **Effectiveness:** Each control measure should contribute enough toward the overall program pollution control to warrant its inclusion.
- **Reliability/Sustainability:** Control measures should be effective over an extended period of time and be able to be properly implemented over time.
- **Implementation Cost:** Emphasis was placed on control measures with low planning, design, land acquisition, construction, and equipment acquisition costs.
- **Continuing Costs:** Emphasis was placed on control measures with low operation, maintenance, repair, support service, and equipment replacement costs.
- **Equitability:** Controls were evaluated regarding the degree to which costs and benefits would be considered to be equitably distributed.
- **Universality:** Controls were evaluated in terms of how universally they would have to be applied to be effective.
- **Public Acceptability:** Control measures were assessed on the expected response of agencies responsible for implementation.
- **Relationship to Regulatory Requirements:** Control measures were evaluated on their consistency with existing and anticipated regulatory requirements.
- **Risk/Liability:** Control measures were evaluated in terms of the risks or liabilities that may occur in implementation.
- **Environmental Implications:** Control measures were evaluated regarding the positive and negative environmental impacts resulting from their use.

Once the control measure criteria were listed and agreed upon, the project team developed a comprehensive list of potential control measures for implementation. The inventory of potential control measures was developed through

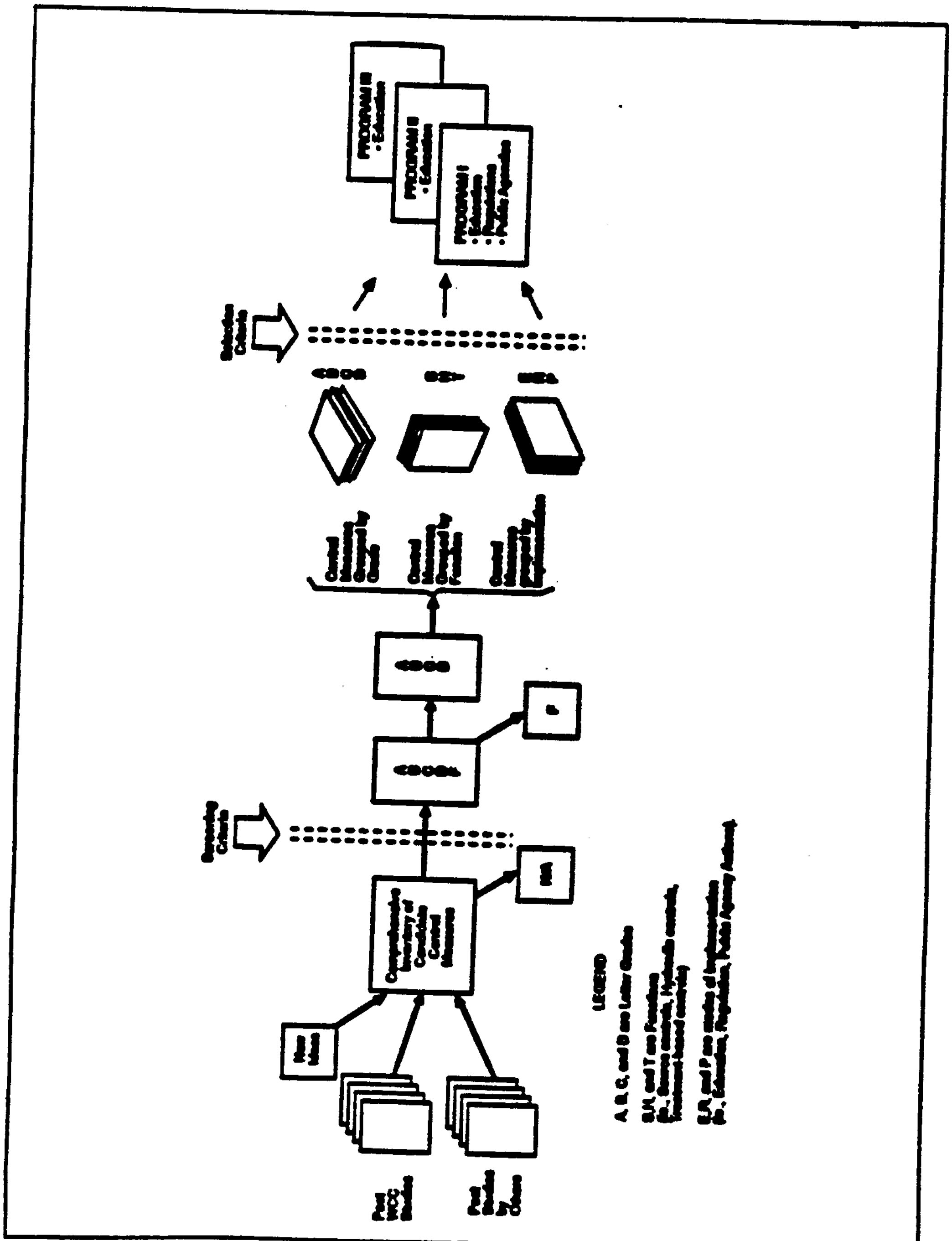

FIGURE 2-6. SELECTION OF APPROPRIATE POLLUTION CONTROLS

a review of technical literature and other nonpoint source control programs. In addition, technical and managerial personnel from other State agencies, county agencies, and city public works and planning agencies were interviewed. This review resulted in a list of more than 120 separate control measures to be screened. This initial list was developed to be comprehensive, and no consideration was given to the applicability of the measures. However, once the list had been developed, obviously inappropriate control measures were eliminated. The control measures eliminated from the list at this step were primarily those designed to address specific situations that did not exist in the watershed. This initial screening reduced the list of potential pollution controls to 92.

This list of 92 control measures was then assessed qualitatively using the criteria developed earlier in the program. This was conducted by assigning each of the control measures a letter "grade" (A through F) for its ability to meet the criteria. Those measures receiving an "A" were viewed to meet all or a large number of the assessment criteria, while those receiving an "F" were viewed to meet none or very few of the assessment criteria. In this way, each of the potential control measures was assigned to a category. The control measures that fell into the category of "F" were immediately eliminated from further consideration in the Santa Clara Valley watershed.

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The Waukegan River/Ravine system is the primary drainage for the urban areas of Waukegan. Significant point and nonpoint source discharges of storm water runoff create considerable water quality problems. Directly related to these water quality concerns are significant erosion and siltation problems occurring in various areas of the river/ravine system.

The Waukegan River/Ravine main channel and tributaries are approximately 12.5 miles. The watershed, primarily in Waukegan, is approximately 7,640 acres and receives storm water runoff from point and nonpoint discharges from an urban area with 80,000 residents. The river/ravine system has the highest population density (8.0 people per acre) of any river in Lake County. The Waukegan River discharges into Lake Michigan just east of the downtown area at a point 6,000 feet from the city's fresh water intake.

The water quality problems identified are siltation, suspended sediments, pesticides, petroleum products, and solid waste. In addition, unstable stream channels result in severe bank erosion, and damaged sewer lines along the stream channel. Stream channel instability has already broken up small sewer lines that enter the main sewer (buried in the floodplain along the stream).

In response to these problems, a number of implementation activities have occurred. The Lake County Storm Water Management Commission developed a model environmental storm water strategy and is implementing a nonpoint source pollution awareness project. This strategy is a watershed-based, multiobjective approach that considers all the environmental values associated with surface water. This comprehensive strategy includes a complete coordinated system addressing program operations, planning design, construction, finance, maintenance, and regulations. In addition, the strategy addresses prevention, remediation, and maintenance.

A specific program to restore this area includes the restoration of urban streambanks through the development of technical and legal procedures for urban stream management and training of local government employees in the bioengineering techniques of vegetative stream stabilization. Also, to improve water quality in the Waukegan River, an aerator was installed and an illicit connection program is proposed.

The purpose of the storm water pollution prevention awareness project is to increase the awareness of urban storm water pollution problems in Lake County, Illinois, through pollution prevention advertisements (e.g., messages, graphics, and photographs) on billboards, buses, and bus stops. The advertisements will address such urban runoff issues as gasoline spills on pavements, storm drains clogged by debris, sediment runoff from construction sites, erosion of urban stream banks, and runoff of phosphate detergents into storm drains. Preventive actions will include storm drain stenciling programs and recycling of motor oil.

An intensive 10-year monitoring and evaluation program has been implemented to demonstrate and evaluate the effectiveness of the storm water best management practices (BMPs) implemented in the Waukegan River watershed. This monitoring effort focuses on the impacts of the storm water pollution control program on urban fisheries and stream habitat.

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Identification of Water Quality Problems

Physical Setting

Lincoln Creek is a 9 mile high gradient warm water stream in the Milwaukee River South Watershed. The Milwaukee River drains into Lake Michigan. The creek's drainage area, the City of Milwaukee, is mostly urbanized.

Land Use

Lincoln Creek is the largest urban subwatershed in the Milwaukee River South Watershed, draining 12,600 acres. This subwatershed is entirely urban, although there are large areas of recreational and open space land, including a U.S. Army tract, the State's Havenwoods Forest Preserve and Nature Center, the Milwaukee County Lincoln Creek Parkway, and golf courses and municipal parks.

Residential lands dominate the subwatershed. High density residential areas cover 35 percent of the subwatershed and multifamily residential areas cover an additional 15 percent. Industrial areas cover 12 percent and commercial areas 7 percent of the subwatershed. Most of the subwatershed is contained within the city of Milwaukee. However, a small portion is contained within the city of Glendale and includes primarily industrial and multifamily land uses.

Project Area Size

The Lincoln Creek drainage area is about 20 square miles (12,600 acres), and the entire area is urbanized. The breakdown for some of the land uses is high density residential (35%), multifamily residential (15%), industrial (15%), and commercial (7%).

Critical Areas

Critical land uses were identified using the Source Loading and Management Model (SLAMM). Critical areas were those that had the highest annual loads of sediment and lead. Lead was considered an indicator for other toxic pollutants. High density residential, industrial, multifamily residential, and commercial land uses contributed most of the sediment and lead loads. The Lincoln Creek drainage area was the most important source of toxic pollutants in the Milwaukee South Watershed. There are 24,000 feet of eroding streambank, which produces about 430 tons of sediment each year. Construction sites are another critical source of sediments.

Water Resource Condition

The lower portion of Lincoln Creek has the potential to support a warm water sport fishery, while the upper portions have the potential to support a warm water forage fishery. All sections of the creek have the potential to support partial body contact water recreation.

However, none of the potential uses of the creek are being attained. Recent surveys of the creek have found it to be highly degraded. Only two fish species (fathead minnow and sunfish) were found in the middle portions of the creek in 1992 and both species are pollutant tolerant. Lincoln Creek should support a diverse fish community of at least 15 fish species.

Lincoln Creek is almost entirely channelized, with the channel alternating between concrete and earthen sections. Channel modifications and frequent high storm water flows contribute to the low biological activity observed in the creek.

Levels of petroleum aromatic hydrocarbons (PAHs), heavy metals, fecal coliform and suspended solids, and other pollutants increase significantly during runoff events. Some pollutants, like PAHs, reach levels high enough to exceed water quality standards. Based on EPA criteria, the bottom sediments are moderately or heavily polluted with heavy metals and PAHs.

Crayfish tissue is highly contaminated with PAHs. Mortality was observed in fathead minnows exposed to Lincoln Creek water for more than 15 days. Traditional acute and chronic bioassays did not indicate any toxicity.

Problems in the creek are caused by poor habitat, increased flows, and high levels of pollutant loading.

BMPs, such as wet detention basins, are proposed in the priority watershed plan to address these problems.

Storm water pollution control objectives for Lincoln Creek include:

1. Restore the forage and sport fish communities by improving the habitat and water quality.

2. Improve the recreational uses.

3. Reduce the loadings of pollutants to the Milwaukee River and Lake Michigan.

Watershed Plan

The implementation plan for Lincoln Creek is part of the Milwaukee River South Priority Watershed Plan, which was implemented in 1991.

One of the recommendations in the watershed plan has been implemented—the preparation of a storm water management plan. The storm water management plan provides detailed information about the management alternatives for Lincoln Creek. Critical land uses are identified by sewershed instead of the whole drainage area. A major effort is put into determining the feasibility of installing the structural practices recommended in the watershed plan and locating sites for installing the wet detention basins.

Inventory Results

Existing urban land uses, future urban land use, construction sites, and eroding streambanks were the urban sources of pollutants evaluated during the preparation of the priority watershed plan. The inventory of the urban land uses was designed to quantify the acres and the development characteristics of each land use. Existing land use categories were delineated on 1" = 400' scale, aerial photographs were digitized, quantified, and mapped by the Southeastern Wisconsin Regional Planning Commission.

Annual pollutant loadings of sediment, phosphorus, and lead were calculated for existing and planned land uses by running SLAMM. Input parameters for SLAMM included the acres of each land use and the development characteristics, such as the percent connectedness. SLAMM was also used to evaluate the effectiveness of different BMPs on the existing and future urban areas.

Lincoln Creek receives an annual lead loading of about 8,000 pounds. Major land uses contributing to the elevated lead levels are: high density residential (33%), industrial (32%), multifamily residential (14%), and commercial (14%). Future development could increase lead loads by 21 percent. These same land uses also contribute relatively large amounts of other toxicants, such as PAHs and heavy metals.

Runoff from construction sites and streambank erosion annually contribute about 6,500 tons of sediment to the stream. Sediment loads are expected to decrease as the remaining planned areas are developed.

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Storm water flows have adverse effects on the creek. High flows cause flooding, bottom scour, and streambank erosion. The Milwaukee Metropolitan Sewage District is evaluating alternative measures for reducing flows in the creek.

Pollutant Reduction Goals

Pollutant reduction goals were based on the needs of the stream. A different approach was taken to establish the reduction goals for each type of problem.

Sediment and Phosphorus

An overall 50 percent reduction in the existing sediment loading is needed to improve the habitat in the creek. Implementation of the storm water pollution control program should reduce the sediment load from construction sites by about 75 percent.

A high reduction of phosphorus (50% to 70%) is needed to reduce the excessive aquatic plant growth in the Milwaukee River and reduce the threat to Lake Michigan.

Storm Water Pollutants

Lead is being used as an indicator pollutant for the other toxic pollutants. Although the State of Wisconsin does not currently use numeric effluent limits to regulate storm water, the pollutant reduction goals for lead were based on meeting the chronic toxicity standards in the Wisconsin Administrative Code. The average annual concentration of total lead in the Milwaukee River exceeds the chronic toxicity standard by 50 percent for surface waters. The proposed pollutant load reduction goal for lead in Lincoln Creek is 50 percent.

By combining the output of SLAMM with a Probabilistic Dilution Model for the creek, the frequency with which the chronic toxicity standard for a number of pollutants is exceeded in Lincoln Creek. The models will assist in determining the amount of reduction needed to significantly lower the probability of exceeding the chronic toxicity standards. The Probabilistic Dilution Model was developed by the EPA and is a good technique for estimating the amount of pollutant reduction needed.

Stream Flow

Specific goals will be established by the Milwaukee Sewage District; however, there are three basic hydrologic goals that must be considered.

1. Maintain baseflow in the creek as much as possible.

2. Reduce stream flows to prevent streambank erosion and bottom scour.

3. Maintain peak flow discharge for 2-year 24-hour storm at predevelopment conditions.

Bottom Sediments

Bottom sediments are heavily polluted. Although a specific reduction goal has not been determined for the bottom sediments, the watershed project has a goal of reducing the levels of pollutant in the bottom sediments.

Management Practices

BMPs are those practices identified in the Wisconsin Administrative Code and are referenced in the Milwaukee River South Watershed Plan to be the most cost-effective controls for storm water pollutants. SLAMM was used

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to evaluate the effectiveness of wet detention basins, infiltration devices, street sweeping, and roof top disconnection for both existing and future urban areas. Pollution prevention measures were also suggested for controlling construction site erosion and streambank erosion.

Following is a list of BMPs proposed in the storm water management plan.

Best Management Practice	State Cost-Share Rate
Critical Area Stabilization	70%
Grade Stabilization Structure	70%
Shoreline and Streambank Stabilization	70%
Shoreline Buffers	70%
Wetland Restoration	70%
Structural Urban Practice	70%
Street Sweeping	50%

A high level of control is needed to achieve the pollutant reduction goal for lead. All of the critical land uses in established areas would have to be controlled with structural practices, such as wet detention basins or other structural practices.

About 90 one-acre wet detention basins will be needed to treat all the critical land uses in Lincoln Creek. Street sweeping could be used as an interim practice before all the structural practices are built. About 14,000 curb miles of streets would need accelerated sweeping schedules. Twelve one-acre ponds would be needed to treat all the land uses in the planned areas.

Using structural practices in the existing and planned areas would also achieve the pollutant reduction goal for sediment. However, the watershed plan also recommends the implementation of construction site erosion and streambank protection practices. These practices will provide greater than 50 percent reduction before the structural practices are completed.

The watershed plan assumes that an effective construction erosion program will be in place for the cities to obtain cost-share dollars. Erosion control practices standards and applicability criteria should be consistent with those set forth in the *Wisconsin Construction Site Best Management Practice Handbook* (DNR, 1989). Cities in the Lincoln Creek drainage area are required to effectively administer and enforce their existing ordinances.

Control of streambank erosion will require a combination of streambank protection practices. The Cities of Milwaukee and Glendale plan to control peak flows to help protect their streambanks. The Milwaukee Metropolitan Sewage District is preparing a comprehensive stream corridor management approach for Lincoln Creek. The approach will consider flow reduction, alternative approaches for stabilizing eroding streambanks, and rehabilitation of the concrete stream sections.

Construction on the stream corridor will have the most impact on the quality of Lincoln Creek in the near future. Monitoring the proposed project will document the effectiveness of improving the stream corridor. The changes should occur over the next 3 years, while other practices will take longer to bring about significant changes in the water quality of the creek. Urban education is also a practice recommended in the watershed plan.

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Institutional Roles and Responsibilities

Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) will have both administrative and monitoring responsibilities for the Lincoln Creek Evaluation Monitoring Project. The administrative role is defined as part of the Department's role in the Wisconsin Water Pollution Abatement Program.

Administration

Administration of the project began by following a selection process. After the project was selected, WDNR worked with Wisconsin Department of Agriculture Trade and Consumer Protection, the cities, and counties to prepare a watershed plan. Implementation of the plan is based on the guidance in the plan.

The Department is working with the Cities of Milwaukee and Glendale to develop cost-share agreements for the practices recommended in the plan. Grant requests will be reviewed by the Department. Interpretation of the State statutes, administrative rules, and watershed plans is provided by the Department.

Financial Support

Financial support for implementation of watershed projects is provided by local assistance agreements and a nonpoint source grant agreement. The cost of implementing all rural and urban practices in the Milwaukee River South Watershed Project is between $89,000,000 and $159,000,000. The State share is about $18,000,000. Installation of the structural practices in existing and future areas in Lincoln Creek will cost between $36,000,000 and $74,000,000. The State share of this cost is about $5,000,000. Total cost of street sweeping each year would be about $350,000. Development of storm water management plans for Lincoln Creek cost about $1,000,000. Most of the cost for the implementation of the watershed plan is for the structural practices. State funds are available to cover the State's share of the cost.

Project Evaluation

Project evaluation will involve the collection, analysis, and reporting of information needed to track the progress of the project. The categories of evaluation include administrative accomplishments, pollutant reduction, and water quality improvements. The local units of government will report annually on the progress of core and segmented program activities. Information will also be provided on financial expenditures and time spent on project activities.

Technical Assistance

The WDNR will provide technical assistance to the local units of government on the design and application of BMPs.

Monitoring Responsibilities

Fish, habitat, and macroinvertebrate sampling will be the responsibility of the Department. Field work will be done by crews supervised by the Department's Bureau of Research.

Stakeholders

Local Units of Government

Each local unit of government will have a number of responsibilities for the core and segmented programs.

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University of Wisconsin Extension

Area extension agents will provide support in developing and conducting a public information and education program.

Milwaukee Metropolitan Sewage District

Sewage districts have all the privileges and responsibilities of cities, villages, and counties when participating in the program.

Landowners and Land Operators

In some situations, private landowners will install practices on their property.

United States Geological Survey

All of the chemical and physical monitoring will be the responsibility of the U.S. Geological Survey (USGS). Peter Hughes will be the project manager for the USGS.

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CHAPTER 3

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CHAPTER 3
GUIDANCE ON COMPLETING ADMINISTRATIVE REQUIREMENTS

INTRODUCTION

Chapters 1 and 2 summarized the municipal storm water management program regulatory requirements and guidance for municipal officials to rank storm water management activities for maximum cost effectiveness. This chapter discusses the administrative requirements of a municipal storm water management plan. These requirements include public information and participation campaigns, fiscal resources, and annual assessment reports.

Public information and public participation programs are essential to the implementation of an effective municipal storm water management plan. The key points to consider in developing this component of the plan include creating appropriate goals and objectives, targeting the proper audience, explaining and selling the program to the audience, and having the necessary equipment and staff for proper program implementation. The availability of fiscal resources is another essential component of municipal storm water management plans. Several funding options are available to municipalities: local funding mechanisms, matching fund programs, and grant programs. In addition, to implement an effective plan, an assessment of the plan must be developed annually and submitted to the permitting authority. This assessment allows the permitting authority and municipality to critique the effectiveness of the plan and to make any necessary changes.

PUBLIC INFORMATION CAMPAIGNS

Developing Goals and Objectives

The program's goals and objectives will form the framework for developing public information and participation efforts. Program goals are usually general and should include the essence of a program's purpose. They should also include some measure of the expected outcome. An example goal might be "to protect our watershed by linking and supporting citizens and organizations that are working locally for protection of wetlands and water quality."

Objectives are more specific and should identify actions or activities to be taken at the program-operations level. They focus the broad vision of the goal to something that can be accomplished through organizational resources. An example of an objective is "to publish and distribute four 12 to 16-page wetland journals by June 1, 1994."

To accomplish these goals and objectives, everyone involved in the program must be given the opportunity to participate and contribute and agree on the ideas. To ensure cooperation, the benefits should be explained. Otherwise, goals and objectives will not be important to the staff and will not be considered seriously when implementing the program. Also, because people may interpret goals differently, it is essential to develop the goals and objectives jointly with the staff through a meeting or other forum that is appropriate in your organization and to make sure that everyone understands them.

Identifying the Target Audience

When developing a public education campaign, it is critical to identify the target audience and develop materials accordingly. Target audiences are groups that have common characteristics, such as age, culture, socioeconomic background, language, and the educational level of the community or watershed. Learning more about the target audience will assist the staff in developing an effective outreach program. To reach the target audience, you must know specifically who it comprises and what common traits they share. This involves breaking groups down into subgroups that exhibit similar characteristics or traits. For example, construction contractors who are likely to have projects within your municipality or residents who change their own oil can be targeted. Some likely target audiences include:

- Members of industrial categories (e.g., landfills)
- Developers
- Construction contractors
- Auto repair/gas station owners
- Environmental groups (e.g., Adopt-a-Stream, local chapters of Sierra Club, Audubon Society)
- Community groups (e.g., churches, Boy and Girl Scouts, Jaycees)
- Non-English speaking residents
- Outdoor recreation groups (fishermen, garden clubs)
- Homeowners
- Students.

Identifying and learning about target audiences allows messages and programs to be developed in a way that will reach and influence these subgroups. The following contacts can provide more information about the target audiences in your community:

- Chamber of Commerce for information on the interests of local business people and what types of materials are most useful to them
- Other government agencies that interact with groups similar to those you will target (e.g., planning department for a list of construction contractors who have received building permits or an economic development department to learn about certain industries)
- Tax records or zoning records to find industrial and commercial facilities
- Wastewater treatment plants for a list of industry types, facility sizes, and potential pollutant sources
- Board of Education to identify ongoing school programs and methods for contributing to school programs and curricula
- Libraries to find local and State magazines and newsletters directed at specific audiences (e.g., environmental and outdoor recreation topics).

"Selling" the Storm Water Program

Educating the public about a new regulatory program and getting them involved with its implementation are among the most important factors for ensuring program success. Issues such as regulatory deadlines and implementation procedures all depend on educating both the regulated community and the public at large. A key element of the municipal storm water management plan is to help communities understand the importance of the storm water program and citizens' participation in improving water quality.

When creating public outreach materials, the storm water management program goals must be clearly communicated and the importance of accomplishing these goals explained. This is especially true in cases where municipalities intend to impose a utility fee for the storm water program. Municipalities may encounter opposition to a new fee if the benefits of the program are not understood. In such cases, it is important to obtain public and political support for the program through education.

One of the biggest political obstacles that municipalities face is that the impacts of polluted storm water runoff may not be obvious. For example, a water body that has been overloaded with sediment from an

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upstream construction activity may look fine to the casual observer when, in fact, the fish and plant life has been harmed significantly. Once an awareness of both the sources and impacts of water pollution is created, educational programs can be developed to motivate the public to effect positive changes in their daily activities, thereby reducing the addition of pollutants to receiving waters.

Information intended to educate the target audience should include solutions as well as explanations of the issues. Simply providing people with information may not make them change their attitudes and rarely makes them change their behavior. People need to know more about the solutions and action that they can take. Education efforts, therefore, should present the reasons why the program is important and focus on actions that citizens and businesses can take to prevent increases in pollution of storm water. Examples of successful outreach materials that provide information and solutions are included at the end of this chapter.

Developing Outreach Materials

Specific education activities can include disseminating information through flyers included in residential utility bills; interactive methods, such as workshops; open houses at industrial facilities; school curricula materials; or talks or slide shows for schools and community groups. Whichever activities you use, communication should strive to be interactive and allow for feedback to those implementing the plan. For example, written materials become interactive when a telephone number to receive further information is provided. Keeping track of the number of callers and the questions they have also provides a way to judge the effectiveness of the materials. Some examples of communication methods that can be used to publicize public involvement are given in the following list:

- TV public service announcement
- TV news story
- Radio public service announcement
- Radio news story
- Newspaper advertisement
- Newsletter
- Fact sheet
- Pamphlet
- Storm drain stencils (e.g., "Dump No Waste, Drains To Lake")
- "Freebies (i.e., bumper stickers, magnets)
- T-shirts, hats, etc.
- Workshops
- Community meetings
- Church meetings
- School meetings
- One-on-one personal contact
- "Event" days
- Opinion leaders (i.e., community leaders, parents, teachers)

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- Magazines
- Magazine advertisement
- Magazine article
- Billboard
- Fairs
- Libraries
- Books
- Transit cards (i.e., in buses).

Table 3-1 presents positive and negative characteristics of several outreach options.

Many outreach materials already exist that you may borrow ideas from or incorporate directly into your storm water management program. One particularly good source of public education materials is a guidance manual entitled, *Urban Runoff Management Information/Education Products*, developed by EPA Region 5, Water Division, and EPA Office of Wastewater Enforcement and Compliance, February, 1993. This document describes specific materials (booklets, books, bumper stickers, catalogs, citizen action guides, computer software, fact sheets, handbooks, newsletters, pamphlets, posters, slide shows, student activities, and videos) and how to obtain them. It is available from the EPA Office of Water Resources Center, (202) 260-7186.

Outreach materials should use clear, concrete language and, where possible, incorporate graphics. The goal is to design effective materials that people pay attention to, remember, and use. Effective materials should persuade people to behave in a more environmentally friendly manner and to influence others to do the same. The ideas discussed below should help you create interesting materials that will attract public attention, encourage community action, and ultimately make a positive impact on environmental conditions in your area.

When crafting outreach materials, remember to use concrete language that helps people to understand, visualize, and remember information. Here are some tips:

- Do not use jargon or technical, scientific language.
- Use anecdotes and examples. Tell a story to draw you reader in and to add more "human interest."
- Use analogies.
- Use descriptive adjectives and adverbs.

TABLE 3-1. CHARACTERISTICS OF SELECTED MEDIA

Media Format	Channel	Pros	Cons
Newsletters	Mail, handout	Can reach a large audience	Printing/mailing is costly
		Can be more technical	Staff time
			Passive, not participatory
Videotape	Workshops	Can reach a large audience	Relatively expensive
	Mail	Visually pleasing	Must be done well
	Cable TV	More participatory	
		Can show behavior	
Public Service Announcements	TV	Free	Sometimes aired at night
	Radio	Can reach a large audience	Competition for air time
		Can target audience	Very passive
			Difficult to evaluate
Mass Media	TV	Can reach a large audience	Constrained by time, space
	Radio	Good for raising awareness	Must be "newsworthy"
	Newspapers	Usually considered credible	Cannot explain complex issues
			Bad for persuasion
Presentations	Workshops	Can be participatory	Reach smaller audience
	Conferences	Good for persuasion	Staff time
	Group meetings	Can show behavior	Can be too technical
		More personal	People may not attend
Exhibits	Libraries	Can reach a large audience	Staff time
	Malls	Visually pleasing	Must be durable
	Fairs		
Freebies (i.e., bumper stickers, buttons, magnets, hats, etc.)	Fairs	Increases awareness	Very short message
	"Event" days	Inexpensive	Weak on persuasion
	Easy to produce		

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- Use active verbs.
- Try to visualize what you are saying.
- Use graphics to illustrate and highlight what you are saying.
- Describe consequences of action (or no action) in terms of an individual, family, or business rather than using a broader term, such as "the public."

The format and layout of the materials will also influence the readers reaction to the information. Materials should be designed to help the reader find information quickly and easily. An audience that is confused or overwhelmed will be less likely to read and remember the message of the materials. Even though you may have many important points to make, try to avoid crowded pages with small type and little white space. Important information can be highlighted by using bullets, boxes, side-bars, or shading to highlight it. For example, side-bars with the following heads will capture the reader's attention: "Things You Can Do To Help" or "Where to Get More Information." An appealing layout and easy-to-read type will greatly increase the chances that your materials will be read. Special type fonts, bold, italics, or colors can be used for titles, headings, or, occasionally, extra emphasis. A medium-weight type that is large enough, usually 10 point and above, is more easily read. Selected examples of outreach materials that are easy to read are included at the end of this chapter.

Graphics can enhance the program materials by capturing attention and providing a simple visual picture of important information. A good rule of thumb is to keep graphics simple and portray images that the reader shall remember. For example, to influence people to dispose of hazardous waste properly, a person pouring oil down the storm sewer should not be used (even if the text is talking about the hazards of doing so). A picture of a person taking the waste to a proper collection site would be more effective. The following list provides further tips on using graphics effectively:

- Large illustrations are better than small ones.
- Photographs are more effective than sketches.
- If sketches are used, simple, clear, realistic ones are better than cartoons or more abstract drawings.
- A large photo at the beginning of an article draws the reader in.

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- Bright colors are useful because they attract our attention.
- Pictures grouped together have greater interest than pictures scattered throughout an article. They can also the be used to "tell a story."
- Gr:phics are especially useful for showing "how to" type information.

<u>Meeting Staffing and Equipment Needs</u>

Consider the resources allocated to your storm water management program. What kind of budget do you have to spend on production and distribution? How much time do you have? How many staff people are available and what are their skills and expertise? Is it possible to get help from citizen volunteers for development and distribution of materials? Producing your communication materials may be a major cost of your program. Make sure that you have enough resources to produce sufficient quantities of your material and to distribute them in your community.

Consider the number of people that need to be reached as a function of the amount of available money. A "cost-per-person" can be calculated by dividing the total cost of production by the number of people being targeted. This will allow comparison of different communication strategies on a cost basis.

PUBLIC PARTICIPATION PROGRAMS

Public education and participation efforts often go hand-in-hand, but public participation may require additional coordination efforts and can present unique challenges to those implementing the storm water management program. The benefits of involving the public in the implementation of the storm water program are many:

- If the public is encouraged to participate in the decisionmaking process of the program, their support for the program will likely increase.
- Large numbers of community members can watch over more of a watershed or municipality than a handful of regulators.
- The public is often the primary source of reports of illicit connections and illegal dumping to storm drains.

- Only the homeowners and residents can implement pollution prevention practices on their residential properties.

- Public volunteer efforts will save staff resources.

With proper training, citizens (e.g., community groups, local colleges, and high schools) can also be included in field screening and sampling portions of the storm water management plan. This can possibly reduce the labor required to perform a large-scale dry-weather screening program or at least locate more discharges than could be done by staff alone. In addition, dischargers would be constantly reminded that the public is watching and has access to the system, thereby encouraging compliance with the municipality's management plan. To take full advantage of the public participation watchfulness in dry-weather screening programs, municipalities can develop reporting criteria and procedures for the public to follow. The information needs to be clearly stated, public participation should be voluntary, and the city should not be liable if someone is injured in attempting to collect information. The reporting procedures can be similar to crime-watch or fraud-reporting programs and can even include a hotline for the public to report illegal dumping.

Coordination and Integration

Many water quality programs already exist at the local, State, and Federal levels. It is essential, therefore, that storm water management efforts be coordinated with these existing programs so that you are not repeating efforts. By coordinating with other agencies, non-profit groups, industry associations, chambers of commerce, and other citizen groups, you will not only save resources but will also build a coalition of supporters for the program. It may even be possible for your agency to take the lead in identifying all relevant programs and orchestrating them into an effective, comprehensive program with a focus on water quality improvement.

Resources and existing programs do not need to be strictly environmental in focus. For example, in Prince George's County, Maryland, the Police Community Relations Program will incorporate water pollution control information into their outreach program. In this way, the enforcement of water quality regulations will be enhanced through integration between police and water quality specialists.

<u>Program Components</u>

Public participation efforts contribute to the success of the storm water management program by educating other citizens and promoting responsibility for, and interest in, the preservation of water quality. This, in turn, will help generate public and political support for the storm water program. The municipality staff may save certain resources, but will have the added responsibility of communicating with other groups and programs, coordinating and training volunteers, and organizing public events. The following efforts, among others, have contributed to the success of various public participation programs:

- Partnerships with civic organizations, such as with the Boy Scouts and Girl Scouts to stencil storm drains
- Neighborhood representatives to educate their neighbors about the effects of household chemicals, such as fertilizers, herbicides, and cleaners, and alternatives homeowners can use and proper disposal methods
- Citizen watch and reporting programs
- Citizen advisory groups to help create and establish local ordinances
- Household hazardous waste collection days
- Stream and lake cleanup campaigns.

CASE STUDIES

The following pages present case studies of selected municipalities and their public information and public participation programs.

VOL 12

The overall goal of Santa Clara County's public outreach effort is to educate its target audiences about the significance of storm water pollution. The objectives of the program are to elicit public support through volunteer efforts, to encourage changes in everyday chemical usage and disposal habits, and to generate political support for the storm water management program in general. The target audiences include households, small businesses, large industries, educational institutions, private and public waste management programs and facilities, environmental groups, community/neighborhood groups, and local governmental offices. Specific education campaigns address:

- Proper disposal of pollutants that would otherwise enter storm drains and channels
- Control of leaks and spills from automobiles, trucks, and storage tanks
- The role of atmospheric emissions in generating nonpoint source pollution
- The need to promote better site runoff and sediment control.

Many of the objectives of the Santa Clara County public information and participation program will be achieved through a combination of activities that are designed to address various interest groups. A number of activities and coordination efforts have already been conducted, including the development of a public information participation plan, the establishment of a public information subcommittee, the development of program logo and stationery, and the development and distribution of a four-color general awareness brochure. Santa Clara County has also developed a storm drain stencil with instructions, a slide show, and poster and convened focus groups to coordinate a nonpoint source educational effort with existing educational programs. Specific action items include:

- Distribution of a storm drain stencil and how-to pamphlet and slide show for use with volunteer groups and general audiences
- Coordination with the Santa Clara County Household Hazardous Waste Program to develop and distribute 1) two pollutant-specific brochures to commercial and industrial audiences and 2) information guidebook for use by the jurisdictions
- Distribution a "how-to manual" explaining storm water management requirements and pollution prevention opportunities at industrial facilities
- Development of educational curriculum to teach students about the impacts of urban runoff and ways to prevent pollution
- Development of media support and advertising to promote public awareness of municipal storm water pollution and for the Santa Clara County storm water management program.

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The city of Seattle has implemented an education and outreach plan designed for each watershed to inform and educate the general public, businesses, and students about the fate of pollutants discharged to the storm drain system and what individuals can do to reduce pollution. The following paragraphs briefly describe some of the major components of the education program.

Schools Education Program

Seattle's extensive school education program includes field trips to an aquarium and a trout farm, videos and films, guest speakers, teachers guides, aquarium displays, and training and equipment for raising salmon in classrooms and releasing the fish into local receiving waters. Development of the program was enhanced by obtaining input from both students and teachers about what kinds of materials would be most interesting and educational.

Consumer Education

The city of Seattle has recruited more than three dozen businesses in the Pipers Creek watershed to display information about caring for the watershed and the proper use and disposal of household, yard, and automotive products. Information is presented in a series of brochures that are displayed in a colorful holder depicting a typical house and its connections to the water through the storm drain and sanitary sewer systems. Each business or service that is hosting a display is given a plaque that they in turn can display to the public.

Clean Water Business Partners

Businesses are mailed invitations to become clean water business partners. To qualify, businesses must earn a certain number of points based on their commitment to clean water. Points are earned by following sound management practices to help protect clean water, hosting information displays, and promoting community activities related to water quality. Each qualified business is presented with a plaque suitable for display certifying that they are a Clean Water Business Partner and honoring their commitment to the environment. The city will bring attention to these businesses through other educational promotions.

Storm Drain Stenciling

Volunteer school and community groups have been recruited to paint a pollution prevention message on a number of Seattle's 30,000 storm drain inlets. The message reads "Dump No Waste - Drains to Stream" and other variations depending on where the storm drain discharges. The program has been expanded through incorporation into the school education program and will likely expand further into a new "Adopt-A-Street" program. To date, more than 5,000 storm drain inlets have been stenciled in Seattle.

Motor Oil Recycling

Motor Oil Recycling is a joint project of the Seattle Drainage and Wastewater Utility (DWU) and the Seattle Solid Waste Utility. Waste oil collection tanks have been placed at 12 auto supply stores located throughout Seattle. The program is publicized by the auto store (Shucks) and by the two utilities. Spin-off programs have been initiated by other auto supply establishments in response to this program.

Waterfront Awareness Campaign

Seattle's downtown waterfront is a major tourist and recreation destination. Litter is a major problem along the waterfront, especially within the water itself. An association of waterfront businesses has initiated a cleanup campaign aimed at improving the appearance of the waterfront. The DWU has joined this partnership and has expanded the message to include the impact of litter and pollution on water quality. DWU recruited youth from the recreation centers around Seattle to paint trash receptacles colorfully with clean water and anti-pollution messages. Signs have been designed by Seattle Aquarium artists and placed along the waterfront reminding people about the effect of their actions on aquatic habitat. Posters similar to the signs will be displayed in waterfront businesses.

Bill Inserts and Citywide Direct Mailings

Seattle utilities include education and public awareness information in their bimonthly billings, which are sent to 188,000 customers. DWU's bill is shared with the Seattle Water Department and the Seattle Solid Waste Utility. The information is distributed on a variety of water quality subjects, including household hazardous waste, protection of Elliott Bay and the Duwamish River, and the school education program. A brochure has been distributed to every customer describing the storm water protection program and the role of the drainage and wastewater utility.

Television Public Service Announcements

Seattle has also developed four television public service announcements (PSAs) for broadcast on local television as part of the education video project in the schools program. The PSAs address the importance of watersheds, the difference between storm drains and sanitary sewers, nonpoint pollution, and pet waste.

Grand Traverse County, Michigan, developed a storm water control ordinance in response to the increase in development the county was experiencing. The primary reason for creating a new ordinance, rather than relying on the old system of Drain Commissioner review of drainage plans, was to establish clear, written guidelines for developers to follow for storm water management.

In writing the ordinance, the Grand Traverse County Drain Commissioner formed the Storm Water Management Advisory Committee. The committee comprised of area engineers, concerned citizens, and officials from the township, county, and state. The committee was split into two subcommittees: a technical committee and a policy committee. The technical committee wrote the technical guidelines for the ordinance and then submitted them to the policy committee for approval. The policy committee made all the final decisions on the ordinance and were assisted by a county-funded environmental planner.

After the ordinance was approved by the committee, the Drain Commissioner took the ordinance to each Township Planning Commission and Town Board for comments and approval. The county then held public hearings, particularly to communicate with some community members who thought the ordinance was unnecessary. The public hearings allowed the county to hear these skeptic's concerns and, in turn, to educate them about the potential impacts to the lakes and streams from soil erosion and additional storm water runoff. The county is convinced that the majority of people now understand the need for this ordinance. After the public hearings, the County Board of Commissioners approved the ordinance and it went into effect January 1992.

The ordinance went into effect with no major problems and has become acceptable practice throughout the community. Many developers are glad that there are finally written guidelines, which make project planning easier. Neighboring counties have been interested in adopting similar ordinances in their communities.

Grand Traverse County also established a program to educate landowners about pollution control on their property and the availability of conservation easements and tax-deductible land gifts through the Grand Traverse Regional Land Conservancy. A citizen committee and the Conservancy assist landowners in permanently protecting the wetlands, streamside greenbelts, and ground water upland recharge areas on their property. The county plans to contact every land owner within the critical areas of the watershed to discuss the various land protection programs offered by the Conservancy. The Conservancy has put together a Mitchell Creek Watershed Landowner's Handbook which covers creek protection issues, watershed care, land protection regulations, and a Mitchell Creek Watershed Map. There will also be a series of workshops to give property owners the chance to learn best management techniques "hands-on."

The county has also targeted areas with streams running through the property, including an elementary school and two golf courses. The county has worked with the Michigan State University Extension Service to assist the landowners in creating buffer zones around the stream and to reduce the amount of fertilizers and pesticides used. At the elementary school, students will participate in planting a buffer zone along the edge of the creek. Where possible, financial assistance is also provided either through public or private grants to cover the cost of planting additional vegetation. These programs are intended to protect the quality of the streams but they also provide education about storm water runoff and watershed protection.

The goal of the Prince George's County program is to educate the public about water quality, focusing on steps that people can take to improve water quality. The program will identify specific tasks for public participation in the management of water quality. Tailored to the specific community demographics and types of land use, the program may include an array of educational programs dealing with the following topics: lawn care (proper fertilizer and pesticide application), car care (car washing tips proper disposal of oil and antifreeze), recycling, composting of yard wastes, reporting of pollutant spills, landscaping to improve wildlife habitat and water quality, swimming pool care, septic system overflows, use/storage/disposal of household hazardous wastes and toxic material, and animal waste control.

The county has also proposed a number of public outreach programs to involve citizens and industries in watching over their local water resources. Along with public education programs, public outreach programs will be important in storm water pollution prevention efforts. To the extent possible, community groups will be identified to conduct and organize a number of volunteer activities, including tree planting, stream cleanups, road cleanups, biological monitoring, and environmental watch programs to report and stop illegal dumping activities. Environmental activists in communities, citizen groups and Citizen Advisory Committees, industrial coalitions, and schools will all be targeted for various programs, such as:

- Adopt-A-Stream and Adopt-A-Road projects
- Water Quality Hotline
- Water pollution contests and projects at area schools
- Recreational opportunities
- Recycling
- Co-op for organic fertilizers
- Wildlife sanctuary delineations
- Wildlife corridors
- Tree planting
- Cleanups
- Award programs
- Household hazardous waste collection.

In addition, communities and public meetings will be held to encourage reporting of illegal dumping into storm drains. The public will also be instructed to watch for industries or other entities that may be contributing unpermitted, non-storm water discharges to the storm sewer. A Water Quality Hotline number is planned that will enable the public to talk to local officials about violations and other water quality problems. This information may then be used in conjunction with local and State investigation and enforcement programs to control illicit discharges to the county's waterways.

Prince George's County has also planned a Community Liaison Service to assist in implementing the storm water management program. The program stresses non-enforcement methods to solve water pollution problems by empowerment and cooperation. County officials will coordinate with various organizations, such as business groups, community associations, environmental groups, Citizen Advisory Groups, schools, to enlist their help in implementing the storm water management program. This coordination will entail notification of programs (stream surveys, watershed surveys, complaints), training of all people interested in any program, and recruitment of volunteers for baseline water quality sampling.

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SAMPLE PUBLIC OUTREACH MATERIALS

The following pamphlets and booklets are examples of public education materials that attract attention, are easy to read, and provide steps that the public can take to help improve water quality.

PET WASTE and WATER QUALITY

PUBLISHED FOR THE WISCONSIN PRIORITY WATERSHEDS PROGRAM

Pet-Owners, Take Heed . . . When you clean up after your pet, do you dump the waste in the street or storm sewer? Do you leave it to decay on the sidewalk or on the grass near the street? If so, you may be causing pollution or health problems.

Are You Polluting Our Lakes and Streams?

Pollutants from improperly disposed pet waste may be washed into storm sewers by rain or melting snow. Storm sewers usually do not go to a sewage treatment plant. Instead, most storm sewers drain *directly* into our lakes and streams, carrying many pollutants along with the water.

Pollutants commonly found in urban lakes, streams and ponds include:

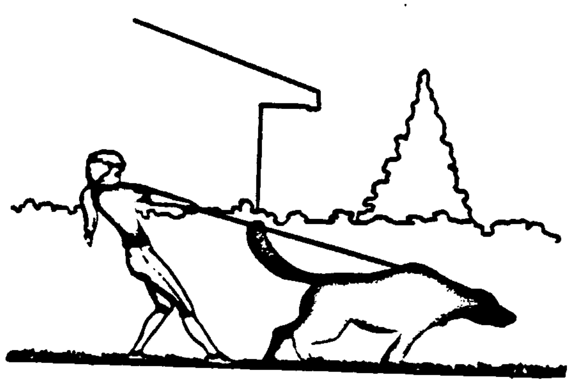
- Sediment
- Oil and antifreeze
- Pesticides and fertilizers
- Toxic chemicals
- Pet waste

When pet waste is washed into lakes or streams, the waste decays, using up oxygen and sometimes releasing ammonia. Low oxygen levels and ammonia combined with warm temperatures can kill fish.

Pet waste also contains nutrients that encourage weed and algae growth. Overly fertile water becomes cloudy and green—unattractive for swimming, boating and fishing.

Perhaps most importantly, pet waste carries diseases which make water unsafe for swimming or drinking.

About 90% of storm water samples collected recently in Wisconsin cities had very high levels of bacteria which violated water quality standards for recreational use. Common sources of bacteria include sanitary sewer overflows, pets, and urban wildlife.



Are You Risking Your Health?

When pet waste is disposed of improperly, not only water quality suffers—your health may be at risk, too. Pets, children who play outside, and adults who garden are most at risk for infection from some of the bacteria and parasites found in pet waste. Flies may also spread diseases from animal waste. Diseases that can be transmitted from pet waste to humans include:

Campylobacteriosis—A bacterial infection carried by dogs and cats that frequently causes diarrhea in humans.

Salmonellosis—The most common bacterial infection transmitted to humans by other animals. Symptoms include fever, muscle aches, headache, vomiting, and diarrhea.

Toxocariasis—Roundworms usually transmitted from dogs to humans, often without noticeable symptoms, but may cause vision loss, a rash, fever, or cough.

Toxoplasmosis—A protozoan parasite carried by cats that can cause birth defects such as mental retardation and blindness if a woman becomes infected during pregnancy; also a problem for people with depressed immune systems. Symptoms include headache, muscle aches, lymph node enlargement.

Pet waste may not be the largest or most toxic pollutant in urban waterways, but it is one of the many little sources of pollution that add up to a big problem for water quality. Fortunately, there are some simple things we can all do to help keep our water clean. See the other side for ways to keep pet waste out of local waterways.

You Can Make A Difference

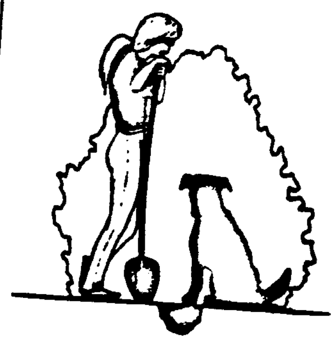
...ning up after your pet can be as simple as taking a plastic bag or pooper scooper along on your next walk. What should you do with the waste you pick up? No solution is perfect, but here are the choices:

❶ Flush it down the toilet . . .

The water from your toilet goes to a septic system or sewage treatment plant that removes most pollutants before the water reaches a lake or stream.

To prevent plumbing problems, don't try to flush debris such as rocks, stick[s] [o]r cat litter. Cat feces may be sco[oped] out and flushed down the toilet, [b]ut used litter should be put in a securely closed bag in the trash.

❷ Bury it in the yard . . .



Dig a hole or trench that is:

- About 5 inches deep;
- Away from vegetable gardens;
- Away from any lake, stream, ditch, or well.

Microorganisms in the top layer of soil will break down the waste and release nutrients to fertilize nearby plants.

Be cautious. Keep pet waste away from vegetable gardens and water supplies to prevent disease. Don't add pet waste to your compost pile. The pile won't get hot enough to kill disease organisms in pet waste.

❸ Put it in the trash . . .

This may be easy, but it is not the best solution. Waste taken to a landfill or incinerator can still cause pollution problems.

Check local ordinances. Putting pet waste in the trash is against the law in some communities.

Another option is to install an underground pet waste digester that works like a small septic tank. Before buying one from a pet store, check local laws that may restrict their use, design or location.

A Few Words of Caution

Around Your Home—If you leave pet waste to decay in your yard, be sure it does not become a problem. To prevent water pollution, clean up areas near wells, sewer inlets, ditches, and waterways. Always remove waste from areas where children play. They are the most frequent victims of diseases from pet waste. Of course, the best protection for children and adults is washing hands with soap and water.

In Your Community—Many communities have "pooper scooper" laws that govern pet waste cleanup. Some of these laws specifically require anyone who takes an animal off their property to carry a bag, shovel, or pooper scooper. Any waste left by the animal must be cleaned up immediately. Call your city or village clerk to find out more about local pet waste laws.

A publication of the University of Wisconsin–Extension, in cooperation with the Wisconsin Department of Natural Resources under funding from the Wisconsin Nonpoint Source Water Pollution Abatement Program. Jennifer A. Hill, Intern and Carolyn D. Johnson, Urban Water Quality Educator, UWEX Southeast Area.

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GWQ00[?] Pet Waste and Water Quality

This publication is available from your Wisconsin county Extension office or from Cooperative Extension Publications, Room 245, 30 N. Murray Street, Madison, Wisconsin 53715. Phone 608/262-3346.

Printed on recycled paper

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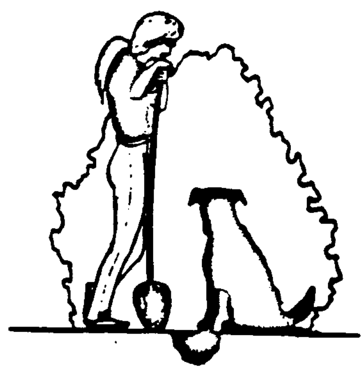

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GWQ006 Pet Waste and Water Quality

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VOL 12

5297

R0038605

YARD CARE AND THE ENVIRONMENT

VOL 12

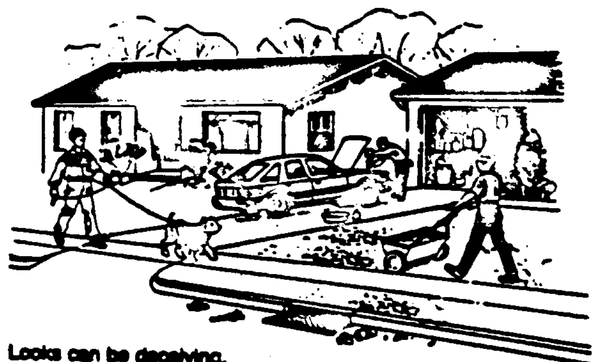
Practical Tips for Home and Yard

A SERIES OF WATER QUALITY FACT SHEETS FOR RESIDENTIAL AREAS

It's an unfortunate fact of urban life—many of our streams and lakes have been polluted. It may be a surprise, however, to learn that water pollution often starts right where you live.

In the community. Urban water pollution begins when development alters natural processes. Removing vegetation and replacing it with streets, rooftops and driveways greatly decreases the amount of water soaking into the soil. As a consequence, the amount of water running off to streams and lakes increases dramatically.

How does the water get from street to stream? Nearly every city street has storm sewer inlets, which open into a network of underground pipes. Leaves, litter, pet wastes, and other materials dumped or washed into storm sewer inlets *do not* go to a sewage treatment plant but flow *directly* to streams and lakes. Also, most storm sewer systems are designed to remove water from developed areas quickly during a storm. This allows pollutants to reach streams and lakes at a "rapid transit" pace.



Looks can be deceiving.
Fertilizing the lawn, working on the car, walking the dog and other home activities might seem far removed from water quality. But with gutters and storm sewers, it's as if we all live on a streambank.

Around the home. Our actions around home can either help or harm water quality. For example, rain can wash improperly applied lawn fertilizer and pesticides into lakes and streams. On the other hand, careful landscaping and sound lawn care practices can reduce the need for chemicals and protect water quality.

Similarly, good auto maintenance pays in the long run, but poor auto maintenance can seriously harm our waters. Anything that drips from a motor vehicle—oil, gas, antifreeze—can wash into storm sewers. These materials are toxic to aquatic life. Dumping them into a storm sewer has almost unthinkable consequences. Just five quarts of oil in a stream or lake can create a slick as large as two football fields.

Clearly, there is a need to rethink what we're doing at home if urban waters are to be clean and usable. Fortunately, by following the tips inside, we can all contribute to cleaner water while making our homes and communities more attractive and liveable.

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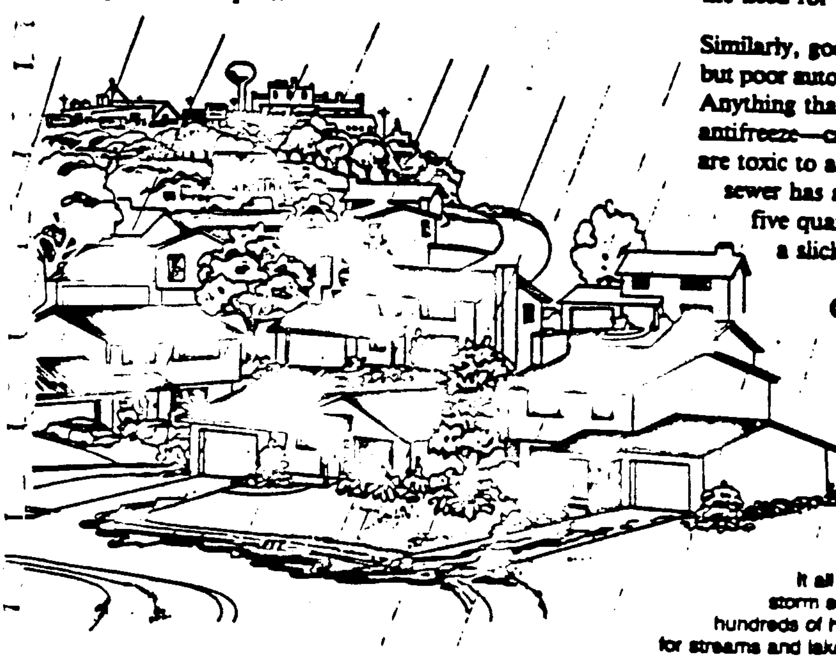


It all adds up. Pollutants washed into storm sewers from dozens of streets and hundreds of homes can become major problems for streams and lakes in a community.

SIMPLE TIPS FOR CLEANER WATER

It really doesn't matter whether you live in the city or the country . . . whether your home is large or small . . . whether you have a lot of time and money to invest in your yard or just a little. There is something you can do to improve water quality. The following suggestions are ways that you can make a contribution to clean water and a healthy environment.

Around your home

- Mow often enough to leave grass clippings on the lawn. Alternatively, use clippings as a mulch or compost them along with leaves that might otherwise "fertilize" local waters.
- Keep fallen leaves out of the streetside gutter or ditch, using them around the yard as practical. Properly place the remainder near the curb (not in the street) just before municipal collection.
- Plant an extra tree for multiple environmental benefits, especially where it becomes part of a planting bed or "naturalized" landscape area that recycles leaves, twigs, and other yard "wastes."
- Seed bare soil and cover it with a mulch as soon as possible to minimize erosion. Disturb no more ground than necessary for a project, while preserving existing vegetation.
- Direct roof downspouts away from foundations and driveways to planting beds or lawns where water can safely soak into the ground. Consider using a rain barrel if practical.
- Use lawn and garden chemicals carefully and sparingly. Pesticides, including weed killers, should be considered a last resort—other controls come first.
- Limit the use of toxic or hazardous products in general. Keep them away from storm sewers, lakes, and streams.
- Collect oil and other automotive products preferably for recycling, or tightly seal and wrap them for proper disposal.
- Wash cars on the lawn, where soapy water can't quickly run toward the nearest storm sewer, picking up other pollutants as it goes.
- Keep cars tuned up and in good operating condition. Check especially for drips and repair leaks immediately to keep nuisance oils off pavement. Better yet, walk, bike or take the bus.
- For waterfront property, grow a "buffer strip" of dense, natural vegetation along the water's edge to filter pollutants and stabilize the shoreline.
- If using a septic tank system, maintain it properly through regular inspections and licensed pumping every two to three years.
- Monitor fuel use from any underground gas and oil tanks to make sure they are not leaking.

- Plan your landscape with environmental health in mind, reducing the area that is heavily maintained.
- Clean up pet wastes, from which nutrients and bacteria could be washed toward lakes and streams.
- Conservatively use salt in winter. Use sand or chip the ice off pavement when possible.

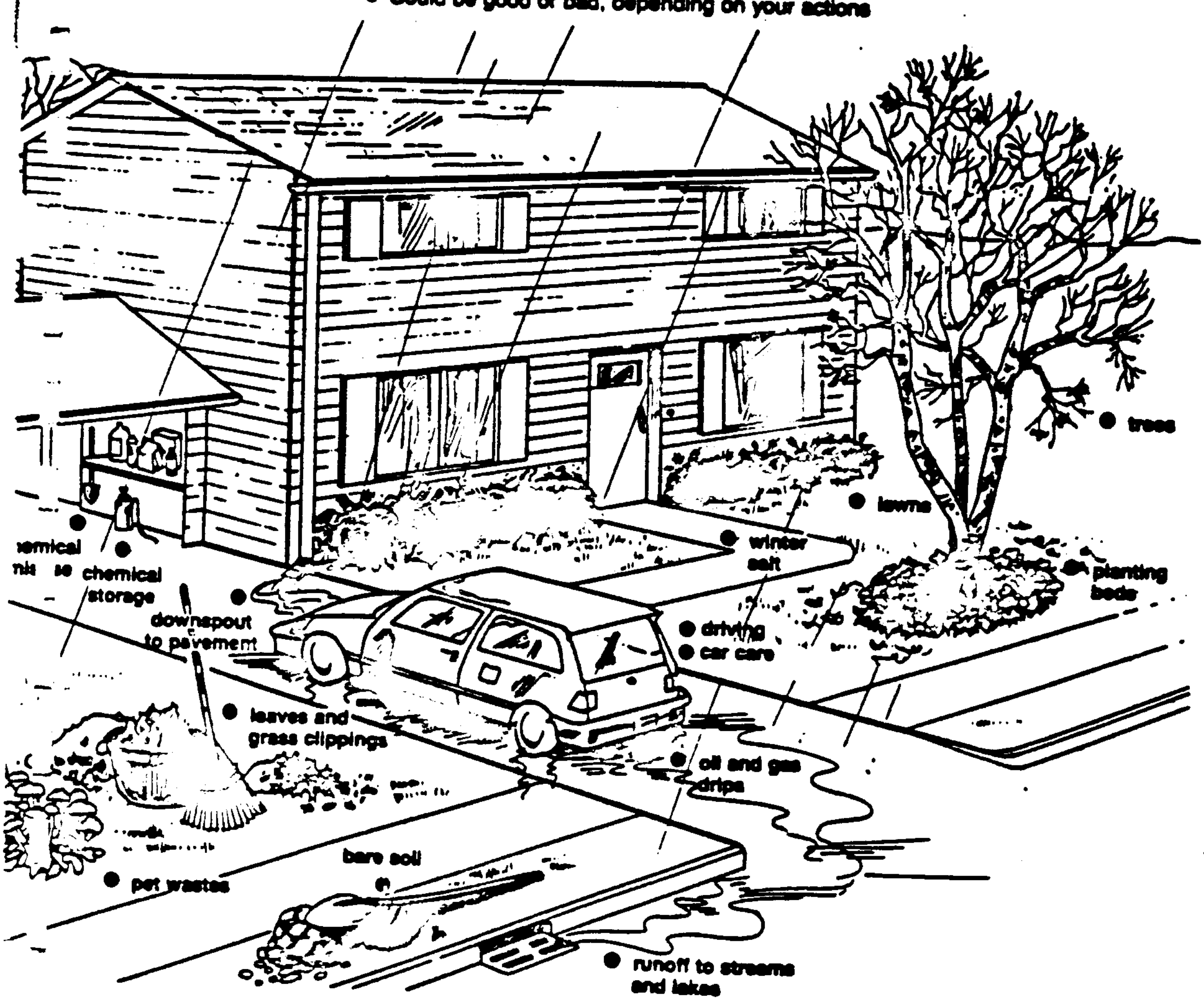
In your community

- Support and follow ordinances that limit soil erosion from construction sites.
- Encourage stormwater management practices that reduce runoff pollution by temporarily holding water in ponds or letting it soak into the ground.
- Encourage the safe but conservative use of salt on roads and limit application to critical areas.
- Tell public officials about your interest in cleaning up local waters and about their value to recreation and the economy.
- Support the preservation of wetlands as natural filters that protect water quality, prevent flooding, and provide vital open space.
- Promote "environmental or parkway corridors" adjacent to streams and waterways for water quality, wildlife, and multiple-use benefits alike.
- Participate in groups, projects, and events that promote conservation, waterfront recreation, or shoreline clean-ups.

Home Hot Spots for Water Quality

Around every yard are spots where your activities affect water quality. The illustration shows a few of them. Take a look around your own home with an eye toward water quality.

● Good for water quality ● Bad for water quality
● Could be good or bad, depending on your actions



VOL 12

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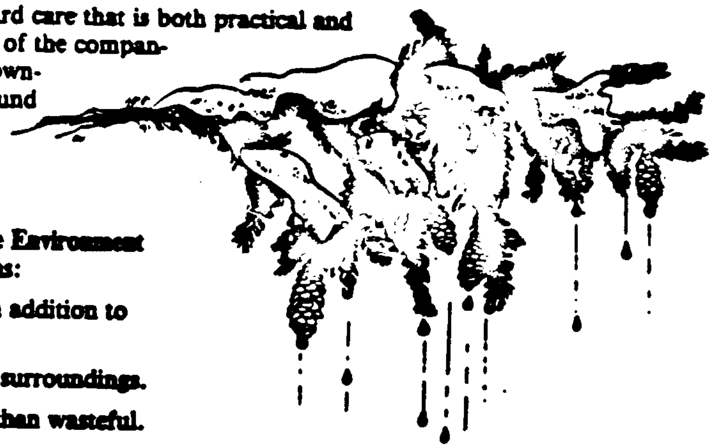
PRINCIPLES OF ENVIRONMENTALLY SOUND YARD CARE



This publication describes an approach to yard care that is both practical and environmentally sound. As a shorter version of the companion piece, *Rethinking Yard Care*, it offers down-to-earth tips for protecting water quality around your home and in your community. Look inside for information on home "hot spots" for water quality.

As stressed throughout the **Yard Care and the Environment** series, environmentally sound yard care means:

- Thinking of environmental consequences in addition to conveniences.
- Planning for greater harmony with natural surroundings.
- Being conservative and resourceful, rather than wasteful.
- Believing that small changes collectively make a big difference.
- Capitalizing on the time and cost-savings that rethinking yard care can bring.

Fact sheets in the **Yard Care and the Environment** series are designed to illustrate principles of environmentally sound yard care. They provide specific information about pesticides, fertilizers, landscaping, watering and related topics. These and other publications can be obtained from your local UW-Extension office, usually located in the county courthouse or another public building. Help is also available there regarding soil testing, pest identification, plant selection and other important items related to yard care and water quality.

VOL 12

5301

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GWQ007 Practical Tips for Home and Yard

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Please call or visit any of these offices:

LEXINGTON COUNTY

Clemson Extension Service
219 East Main Street
Lexington, SC 29072
359-4265

U.S. Soil Conservation Service
219 East Main Street
Lexington, SC 29072
359-3165

U.S. Agricultural Stabilization and Conservation Service
219 East Main Street
Lexington, SC 29072
359-3205

S.C. Forestry Commission
219 East Main Street
Lexington, SC 29072
359-2415

OTHER OFFICES

S.C. Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201
734-5228

S.C. Land Resources Conservation Commission
2221 Devine St., Suite 222
Columbia, SC 29205
734-9100

Some of these materials developed by the Tennessee Cooperative Extension Service and the alliance for the Chesapeake Bay.

Extension

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A Clear Choice for Bush River and Camping Creek

INFORMATION

Please call or visit any of these offices:

LAURENS COUNTY

Clemson Extension Service
219 Laurens Street
Laurens, SC 29360
984-2514

U.S. Soil Conservation Service
P.O. Box 348
Laurens, SC 29360
984-6921

U.S. Agricultural Stabilization and Conservation Service
221A West Laurens Street
Laurens, SC 29360
984-7741

S.C. Forestry Commission
West Main Street
Laurens, SC 29360
984-7511

NEWBERRY COUNTY

Clemson Extension Service
P.O. Box 160
Newberry, SC 29108
276-1091

U.S. Soil Conservation Service
P.O. Box 434
Newberry, SC 29108
276-0032

U.S. Agricultural Stabilization and Conservation Service
P.O. Box 638
Newberry, SC 29108
276-0000

S.C. Forestry Commission
P.O. Box 129
Newberry, SC 29108
276-3023

(List continued on back panel)

1. *Get Involved*. Each of us pollutes ground and surface water. Each of us can help save it. Our contributions may seem small, but they join with those of others on the lake. Here are nine more ways you can help keep the lake clean.

2. *Save Water*. Saving water will help water quality by reducing the volume of water going through septic tanks. A dripping faucet wastes 20 gallons of water a day and a leaking toilet wastes 200 gallons. Use water sparingly while brushing your teeth, washing dishes, or shaving. Install a water conservation shower head and take short showers instead of baths. A bath uses 30-50 gallons of water, a short shower only 10.

3. *Soil Test for Fertilizer Application.*
Many farmers apply the same fertilizer at the same rate every year. Excessive amounts of nitrogen, phosphorus, or potassium that are not used by the crop leach through the soil and contaminate groundwater. Soil testing allows farmers to determine the exact needs of their fields. This insures optimum yields, a clean groundwater supply, and helps farmers save money by using less fertilizer.

4. *Control Soil Erosion.*
Utilize conservation practices such as conservation tillage and strip cropping to reduce soil erosion. Nutrients and pesticides bond with soil particles. When these particles are eroded into streams and rivers the chemicals are carried with them. Use filter strips near surface water areas and drainage ditches to help prevent water contamination.

5. *Practice Sensible Pest and Weed Control*. Apply pesticides and herbicides at the labelled rate. Excessive amounts will leach through the soil and can cause damage to crops and beneficial insects. Make sure the pesticide is labelled for the specific weed or insect and the crop to be treated. Do not apply in windy conditions, when rain is forecast, or to other areas as a "precaution."

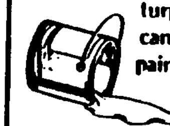
6. *Dispose of Pesticide Containers Properly*. All pesticide containers have a residue of the chemical stored in them. Triple rinsing the containers will remove over 99% of the residue. Use this rinsate in your applicator and be sure to puncture all old containers to prevent re-use. Take the rinsed containers to an approved landfill for disposal. NEVER pour rinsate on the ground!

7. *Protect Your Wellhead Area.*
Many farmers mix chemicals at or near a wellhead. Any spills near a well can easily contaminate the well water by flowing down against the well casing to the water. Always mix chemicals at least 100 feet from the well. In hilly areas make sure the mixing site is below the wellhead. A concrete pad with low curbs to catch any spills is an excellent mixing site.

8. *Manage and Utilize Animal Wastes Properly*. Concentrated animal wastes can chemically and biologically impair water supplies. Maintain lagoons and manure storage areas properly. Apply animal wastes to land to build up soil organics and lower commercial fertilizer costs. Incorporate applied wastes into the soil as soon as possible to obtain the greatest nutrient benefit. Do not apply wastes to stream banks or eroding areas.

9. *Use Equipment Service Products Wisely.*
Petroleum products, antifreeze, and battery acid contaminate water supplies just as easily as pesticides and wastes. Capture all used motor oil for disposal or re-use in lubricating chains or blades. Dispose of motor oil and antifreeze at recycling centers. Do not use gasoline as a parts cleaner or weed killer. Never pour oil or gasoline on the ground!

10. *Dispose of Household Products Carefully*. Many products under your kitchen sink or in the garbage can harm the water quality. Never pour paints, preservatives, brush cleaners, and solvents down a drain. Sewers or septic tanks do not treat these materials, and they can enter the groundwater untreated. Buy the product with the least amount of toxic material. Used turpentine and brush cleaners can be filtered and reused. Stuff paint cans and other chemical containers with newspapers before discarding.



The Lake Hartwell HUA Project is a group effort of local, state, and federal agencies. The USDA Soil Conservation Service (SCS) is assigned the overall leadership responsibility and also provides technical assistance to landowners. Financial cost sharing funds are provided by the USDA Agricultural Stabilization and Conservation Service (ASCS), and information and education assistance are coordinated by Clemson University Cooperative Extension Service.

Clean Water Begins at Home

Some household products shou[illegible] never be washed down the dr[illegible] can harm people, animals [illegible] environm[illegible]

- [illegible]
- [illegible]
- [illegible] collect and dispose of hazardous house and garden products.
- Know w[illegible] happens to your [illegible] water after it goes "away." Visit yo[illegible] local wastewater treatment pla[illegible] and learn what substances the plant can handle.

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Household alternatives for source control of heavy metals.

Often it is impossible to tell whether a product contains metals or not. Product ingredient lists are incomplete for one reason or another. Gradually this will change as the public demands "green" or environmentally sensitive products and more complete labelling information. In the meantime, research into the contents of household products is continuing, locally and nationally.

Testing conducted by the Washington Toxics Coalition of Seattle and other organizations has shown that certain products contain lower levels of metals than others. The information in this brochure is only a partial listing of products and alternatives, and will be updated and expanded from time to time.

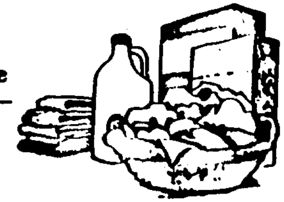
And choices don't have to be all or nothing.

Say for example that you have a favorite detergent that contains heavy metals. Try a substitute every second or fourth washload. You'll still be reducing the amount of metals by 25 to 50%—and eventually you may choose to make the substitution completely.

Garden:

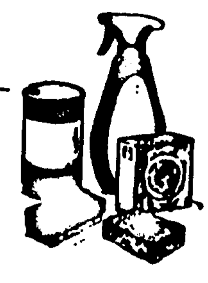
Product	Alternative
Root Killer	Crystals that are flushed down the toilet to control the growth of roots in sewer lines may contain copper. Mechanical removal may be an alternative.
Pesticides	May contain copper. Try attracting birds or introducing lady bugs or praying mantis to your garden. For small infestations, wipe leaves or use a high-pressure water sprayer and plain soap.
Weed control	Pull by hand or cover area with mulch, fabric, or plastic.
Fertilizers	Start a backyard compost bin, or use organic soil additives such as peat moss.

Laundry:



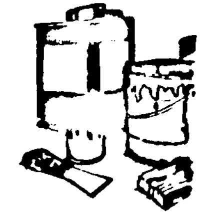
Product	Alternative
Detergents	In general, phosphate-free liquid laundry detergents contain lower levels of metals than do powdered varieties. Cheer liquid, Life Tree, Shaklee Liquid L, and White King Soap contain the lowest metals levels of products tested.
Bleach	Non-chlorine liquid bleaches are lowest in metals. Avoid bleaches containing phosphates. Try less bleach per load, with baking soda added, or presoak heavily-soiled items for 30 minutes in warm water with a half-cup washing soda.
Fabric softeners	Sheets have lower metals levels than liquids. Or add one cup vinegar or a quarter cup baking soda during final rinse.
Dishwashing Detergents	No difference between powder and liquid. An alternative is sodium hexametaphosphate, in same quantity as detergent. Hand-washing detergents have less metals than machine detergents, but do not use them as an alternative in the machines.

Household Cleaners:



Product	Alternative
Scouring Powder	Dissolve baking soda in water; or sprinkle on surface to be cleaned or on a sponge. Shaklee at Ease liquid and Soft Scrub have lowest metals levels of products tested.
General Purpose	Liquids are generally lower in metals.

Paints & Preservatives:



Product	Alternative
Paints	Avoid oil-based paints. Buy latex or water-based types. Estimate quantity carefully.
Paint removers	To remove paint from hands, massage with margarine or a few drops of baby oil. Wipe dry and then wash with soap. To strip paint, use a hook scraper, an abrasive block or sandpaper. Clean brushes right after use. Never use gasoline. Soften hard paint brushes in hot vinegar and wash with soap and water.
Preservatives	Avoid products with copper, arsenic, creosote. Use decay-resistant wood products such as redwood and cedar.
Stains	Use finishes derived from natural sources, such as shellac, tung oil, and linseed oil.

Automotive:

Product	Alternative
Used motor oil	May contain metals; never pour on land or down a sewer drain. San Jose and other cities have curbside recycling pick-up; or check with service stations/autocenters. Also, try to buy recycled oil—even for high performance autos.
Fluids	Spent antifreeze and brake fluid should be stored properly until they can be disposed of at a hazardous waste collection event.

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Cultivate Clean Water!

Fertilizer runoff, eroded sediments, septic wastes and pesticide residues are leading causes of water pollution.

★ Have your soil tested; use the right fertilizer at the right time, and don't use more than is needed.

★ Use pesticides only when other methods have failed—follow the manufacturer's instructions for use, storage and disposal. Buy only as much as you can use this season.

★ Help prevent erosion by planting slopes and resodding bare spots.

★ Keep your septic system running properly; keep the tank and leachfield areas clear.

★ Don't dispose of trash, lawn clippings, leaves or brush in drainage ditches or on flood control lands.

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FISCAL RESOURCES

The part 2 municipal permit application requires municipal permittees to demonstrate sufficient financial resources to meet the costs of implementing conditions of the permit. This section provides guidance on some sources of revenue available to permittees.

Selection of one or more revenue sources to fund a storm water management program depends on three factors: (1) type of organization that is operating the storm water management program, (2) amount of money that may be raised by various revenue options, and (3) political feasibility of the options.

The first consideration when choosing revenue options is to identify options that are legally authorized. This will depend on the type of local government organization used to implement the storm water program. Frequently, storm water programs are set up as storm water utilities and use a variety of revenue options. A storm water utility is an independent government entity established to design, construct, maintain, and operate a drainage system to control storm and surface water runoff. Utilities handle decisions concerning financing, personnel, and administration. These decisions are not delegated to another governmental department.

Once the legally authorized revenue options have been identified, the second consideration is the amount of money that may be raised and the activities that may be funded by each option. Each revenue source should be examined to determine if the funding is equitable to the consumers. It is critical that the revenue options chosen are able to finance all aspects of the program.

Third, the revenue options must be politically feasible. A successful capital improvement plan will select the revenue option, or package of options, that raises the required funding and is most politically feasible.

Revenue may be generated from the sectors of society that will benefit most from the replacement and expansion of the storm water infrastructure. Local governments may levy impact fees on developments for expansion and on redevelopments for upgrading the existing system. Impact fees should not be used for the replacement of facilities servicing current users. Likewise, current users should not be responsible for funding the expansion of an existing system. The revenue options chosen should be equitable in meeting the needs for replacement, upgrading, and expansion of the storm water system. Figure 3-1

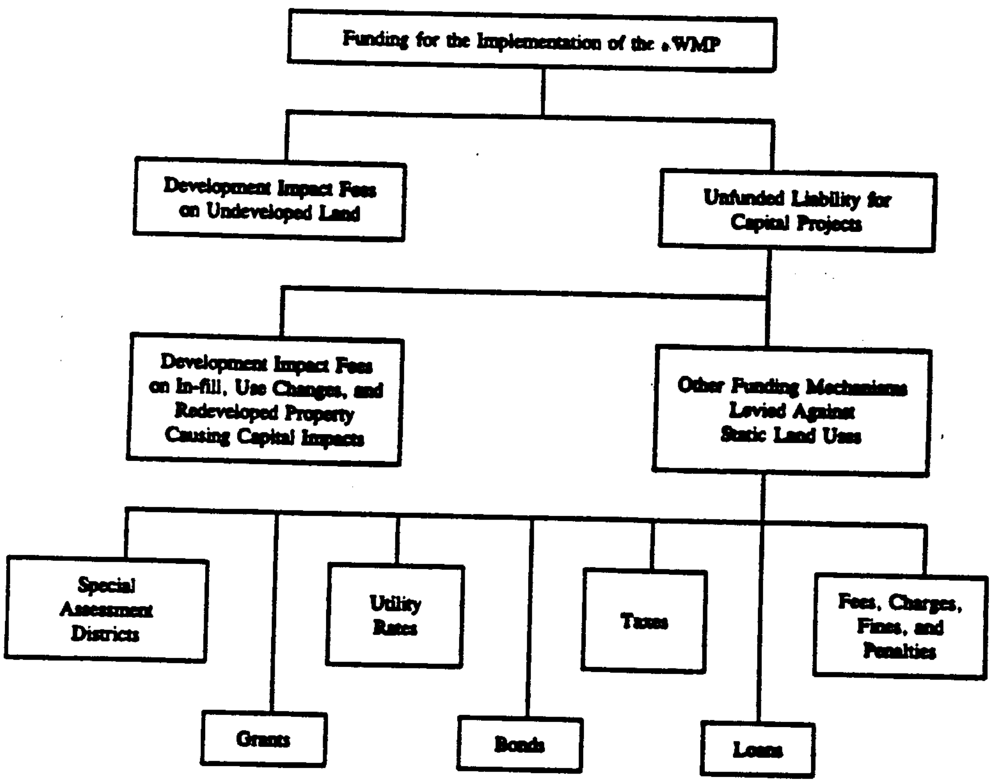

FIGURE 3-1. STORM WATER MANAGEMENT PLAN—FISCAL RESOURCES*

*This schematic is adapted from a figure in an article written by Douglas W. Ayres and Scott Thorpe titled, "Financing Capital Improvements," that was published in the *American Water Works Journal*, August 1991.

illustrates the capital and financing process. The figure shows the process by which capital projects are financed in relation to the benefits derived from the projects.

The following discussion provides an overview of the revenue options identified in Figure 3-1. In choosing a series of options to finance a storm water program, the first step is to determine whether funding is needed for replacing, upgrading, or expanding the system. If funds are needed to finance growth and expansion onto previously undeveloped land, then the authority should assess development impact fees. Development impact fees are assessed against private developers in compensation for the new capacity requirements their projects impose on public facilities.

Development Impact Fees on Undeveloped Land

A significant part of the SWMP is dictated by private development of previously undeveloped property. Additional homes and businesses require service that can only be supported by the construction of new infrastructure (including storm water BMPs). Local governments can levy development impact fees to defray the proportionate share of the infrastructure costs caused by and of benefit to the development. The capital improvement plan should contain sufficient detail to validate such fees.

Unfunded Liability for Capital Projects

Development impact fees will help finance the growth of storm water infrastructure in new developments; however, the upgrading and replacement of the system as it ages still needs to be financed. Local governments need a mechanism to finance the unfunded liabilities, other than continually drawing upon the historical funding sources. One way to help upgrade the storm water infrastructure is by including development impact fees on in-fill,[1] use changes, and property redevelopment. The funds collected can be used to help offset the cost of upgrading an existing system.

[1] In-fill is the cumulative development of single lots scattered throughout the community or the redevelopment of property that results in higher densities or increased demand on public facilities. In terms of storm water management, it includes residential to commercial use changes and an increase in the amount of impervious surface area.

Development Impact Fees on Developed Land

Levying development impact fees on properties being redeveloped, in-fill developed, or under changed use must be determined to assure current ratepayers that they are not subsidizing development. When levying development impact fees, there should be a distinct division between replacement and expansion of the system. The component of a project apportioned to replacement should be quantified. The component required for system enhancement to service new customers should be attributed to development impact fees. If the division is not made, current customers may pay for both replacing and upgrading the storm water infrastructure.

Funding of Nondevelopment-Related Project Liabilities

Portions of projects that cannot be legally or accurately charged to development should be financed by revenues paid by existing users of the capital projects. These projects may include the replacement of existing facilities or portion of an upgrade or an expanded plant that cannot be properly be apportioned to development. For example, new customers should not be expected to pay for replacing a down stream storm sewer line that has deteriorated as a result of age. Methods appropriate for use in financing storm water capital expenditures include fees, charges, fines, and penalties; taxes; utility rates; special assessment districts; debt financing (i.e., bonds and loans); and grants.

Fees, Charges, Fines, and Penalties

Municipal storm sewer operators have discovered that greater revenues may be secured with fewer complaints by separating special services and charges from general services and billing full recovery costs separately for these special operations. In addition, fines and penalties may be used to modify behavior.

Fees

Permit fees may be used to fund the portion of a storm water program that regulates activities of construction and development. Construction permits generate revenue, and they can be used to standardize the construction of new facilities and promote the use of BMPs to limit construction site runoff.

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Charges

Special services are those requested and received by a few ratepayers. Utility services for which special fees should be charged include initiation of service, restoration of discontinued service, detection and repair of household leaks, line location, and review of construction plans.

Fines and Penalties

Fines and penalties are an important part of any effective enforcement program. These revenue sources are better suited to modifying behavior than raising revenue. As enforcement improves and the number of violations decrease, revenue from fines and penalties will decline. This is a reflection of an effective program. In some cases, especially in the early years of the program, revenue from fines and penalties are sizeable and may help to finance enforcement and related efforts.

<u>Taxes</u>

Local governments may levy a variety of taxes to fund their programs. The sales tax, property tax, business and occupation tax are the principal sources of revenue for most local governments. While all these tax sources have the potential for financing storm water management programs, in reality, few dollars are available for such programs for two primary reasons: (1) many local governments have utilized all available taxing authority provided by the State and (2) it is difficult to obtain political support to raise taxes in jurisdictions that have not exercised all of their legally authorized taxing power.

Many local governments have used all of their taxing authority and still have difficulty financing their basic programs. In these cases, it is unlikely that local governments will be able to make tax dollars available to fund storm water management programs. In jurisdictions where voters have a strong preference for minimizing local taxes, raising taxes is politically difficult. Thus, while taxing authority may be available, raising taxes to fund storm water management programs may not be a viable alternative.

If taxes are involved, then a tax analysis of the community's ability-to-pay should be performed. In such cases, the jurisdiction that has the power to levy taxes must have a clear understanding of its current and future tax sources. This will help quantify the need in terms of operational, subsidy, fixed-asset

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replacement, or capital project purposes. With such information, specific tax sources may be identified to finance capital projects, relate benefits to payments, and indicate ability-to-pay.

Utility Rates

Municipalities may choose to form a storm water utility that is funded based upon values cf fees charged to users of the storm sewer system. A storm water utility's rate structure should finance the portions of the capital improvement plan that are not the responsibility of new or in-fill development. The portions of utility rates that will fund capital improvements are determined through detailed rate studies. Such studies are conducted to assess the proper payment level for operations and maintenance, fixed asset replacement, and system capital needs that cannot be attributed to development.

Rates are an appropriate mechanism for raising revenue for programs where there is a defined population being serviced. There are two types of rates: (1) unit charges and (2) service charges.

Unit Charges

Unit charges, the traditional types of rates, are calculated monthly and based on the quantity of a product consumed. For example, water and electricity rates are unit rates based on consumption. Utilities have traditionally levied rates in this form. Because it is difficult to measure the amount of storm water discharged by each user, however, storm water management programs do not lend themselves to levying rates based on unit charges. Increasingly, local governments turn to service charges to finance such programs.

Service Charges

Service charges are attractive when users cannot be charged according to their level of use, and services are difficult to price on a unit basis. Most service charges are structured to minimize administrative costs and to ensure that payments approximate the distribution of benefits received. As such, they are viewed as an equitable way to pay for services. Revenue from service charges is predictable and may be substantial.

The storm water service charge is determined through three commonly used methods, each based on the disruption of the natural drainage system. The first is an approximation of the percent impervious surface. Percent impervious surface is a measure of the property that does not allow water to penetrate the ground. This includes roofs, parking lots, and sidewalks. A second method is a flat rate based on the number of residents in a community. The third method assesses a service charge through a combination of percent impervious surface, type of business (SIC classification), and size of the property. Each business type is assigned a runoff factor that reflects the potential discharge of pollutants from the property and a development factor that reflects the percent impervious surface. The product of these two factors is then multiplied by the size of the property in 500 square foot increments. Once the rate is calculated, a fixed fee is added to cover administration costs. A municipality may use a combination of these methods or develop an entirely different method that better suits the characteristics of the community served.

An analysis of the service charge should be conducted annually to update needs, assure continued internal equity, and update cash flows and reserve projections. Computer models may be developed to provide annual rate updates. This type of operating system deflates potential political and financial problems by small annual rate increases instead of less frequent and more dramatic rate increases.

Special Assessment Districts

For services that cannot be categorized within a utility or fee schedules, a city, county, or utility district with the legal authority may create a special assessment district. Special assessments are levied for infrastructure installation or operations and maintenance. Normally, bonds are issued to finance capital construction that is backed by special assessments levied on district members.

Debt Financing

Financing of capital projects through public utility debt has three major advantages: (1) once the money is borrowed or a bond issued, a fixed interest rate and repayment schedule are established, and the debt is repaid over the years with dollars that are cumulatively deflating in value; (2) individuals who require and will use the facilities being built with the borrowed funds will pay for the facilities as they use them throughout debt repayment; and (3) debt financing provides large sums of money up-front to finance the capital expenditures.

Bond issues and loans are the two primary methods to acquire capital through debt financing. It is important to note that because borrowed funds must be repaid, the ultimate source for repayment of bonds

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and loans is either taxes or rate revenue. Bonds are not suited to fund ongoing routine expenses, such as the operation of a storm water management program.

Bonds

The two types of bonds commonly used to finance capital acquisitions are general obligation and revenue bonds. General obligation bonds are backed by the full faith, credit, and taxing power of the local government issuing the bond. While a particular revenue source may be earmarked for their repayment, guarantee for repayment of the bonds is provided by the entire stream of tax revenues paid to the local government. For this reason, general obligation bonds may be considered stronger guarantees of repayment than revenue bonds.

Revenue bonds are backed by revenue from a dedicated source as a rate revenue. Because revenue bonds have far fewer statutory constraints, they have replaced general obligation bonds as the primary form of municipal financing. In theory, because this form of debt has its own guarantee (the project revenues, if any), it should not affect a locality's credit rating. In practice, however, revenue debt represents an indirect obligation of the issuing government. Because the lender has only the project revenues to depend on for repayment, interest rates are generally higher for revenue bonds than general obligation bonds.

In most cases, established utilities issuing bonds will issue revenue bonds. New utilities may not have enough history to issue revenue bonds. In these cases, general obligation bonds are issued or, alternatively, double-barreled bonds may be issued. These bonds are backed by both a dedicated revenue source and the full faith and credit of the local government.

Many small communities are unable to enter the national bond market because of poor credit ratings, little financial expertise, and relatively small capital needs. When access to the national bond market is available, small communities usually pay very high interest rates. Some States have created bond banks that enable small communities to issue bonds through the bank. This provides the small communities access to the municipal bond market at lower interest rates and with lower issuance costs.

Loans

A common loan program available within most States is the State Revolving Fund (SRF) for water pollution control planning. SRFs are intended to create a perpetual source of low cost financing. The

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funds invested in the capitalization of SRFs assist communities in meeting their needs by providing one-time loans or grants. Below market interest rates are the single most important advantage to some communities. This reduced capital cost decreased the level of user fees required to repay the project debt. The CWA requires recipients of SRF assistance to provide a dedicated source of revenue to cover loan payments. However, SRF assistance to storm water management programs is limited. To address this concern, EPA has developed a case study guidebook that presents examples of how expanded use activities can be funded under the SRF program. For more information on expanded uses, refer to EPA, Office of Water, *Funding of Expanded Use Activities by State Revolving Fund Programs: Examples and Program Recommendations*, August 1990, (EPA 43/09-90-006).

Most States have issued SRF loans at interest rates of 2 to 5½ percent below market rates. With the current interest rate being relatively low, the difference between State SRF loans and the market rate may be minimal and, therefore, not as attractive to communities. Similar to the construction grants, some States may require communities to provide a "match" prior to granting the loan. However, economically distressed communities have indicated that they would be unable to pay back a loan even at a zero percent interest rate and must rely on grants for funding.

Grants and Matching Programs

In addition to all the financial methods mentioned previously, States provide grants to communities for their wastewater quality needs. Grants can be in many forms, with or without community matches or use restrictions. Some States, for example, may provide grants to communities to be used as the prerequisite SRF match. Grants are neither a constant or consistent revenue source and should not be seen as an integral part of financing the daily operations of the storm water program. Grants are more likely to be issued for large one-time capital expenditures to assist in reducing the financial burden on the local community.

Table 3-2 lists selected Federal grant programs that can assist in the financing of storm water management needs. The list does not include grant programs available at the State level. The *Catalog of Federal Domestic* contains a comprehensive list of Federal assistance programs.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS

Program Name	Economic Development—Grants for Public Works and Development Facilities
1992 Catalog of Federal Domestic Assistance Number	11.300
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To promote long-term economic development and assist in the construction of public works and development facilities needed to initiate and encourage the creation or retention of permanent jobs in the private sector in areas experiencing severe economic distress.
Types of Assistance	The basic grant rate may be up to 50 percent of the project cost. Severely depressed areas may receive supplementary grants to bring the Federal contribution up to 80 percent of the project cost; designated Native American Reservations may be eligible for up to 100-percent assistance. Additionally, redevelopment areas located within designated Economic Development Districts may, subject to the 80-percent maximum Federal grant limit, be eligible for a 10-percent bonus on grants for public works projects. On average, EDA grants cover 50 percent of project costs.
Uses and Use Restrictions	Grants can be used for public facilities, such as water and sewer systems, and infrastructure improvements. Qualified projects must fulfill a pressing need for the area and must (1) tend to improve the opportunities for the successful establishment or expansion of industrial or commercial plants or facilities, (2) assist in the creation of additional long-term employment opportunities, or (3) benefit the long-term unemployed and members of low-income families. In addition, proposed projects must be consistent with the currently approved Overall Economic Development Program for the area and for the Economic Development District, if any, in which it will be located and must have adequate local share of funds with evidence of firm commitment and availability.
Eligible Applicants	States, cities, counties, and other political subdivisions and private or public nonprofit organizations or associations representing a redevelopment area or a designated Economic Development Center are eligible to receive grants.
Information Contacts	Director, Public Works Division, Economic Development Administration, Room H7236, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Economic Development—Support for Planning Organizations
1992 Catalog of Federal Domestic Assistance Number	11.302
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To assist in providing administrative aid to multi-county districts and redevelopment areas economic development planning and implementation capability and thereby promote effective utilization of resources in the creation of full-time permanent jobs for the unemployed and underemployed in high distress redevelopment areas.
Types of Assistance	A minimum of 25 percent must be obtained from nonfederal sources, except for grants to Native American Tribes. This may be in the form of cash and in-kind contributions. The Secretary is authorized to fund up to 100 percent planning support grants to Native American Tribes.
Uses and Use Restrictions	Grants are used to staff salaries and other planning and administrative expenses of the economic development organization.
Eligible Applicants	(1) Public bodies and other nonprofit organizations representing groups of State-delineated adjoining counties, which include at least one area designated as a redevelopment area by the Secretary of Commerce and one or more centers of growth not over 250,000 population, (2) Native American Tribes, and (3) counties designated as redevelopment areas or nonprofit organizations representing redevelopment areas or nonprofit organizations.
Information Contacts	Director, Planning Division, Economic Development Administration, Room H7023, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Economic Development—Public Works Impact Projects
1992 Catalog of Federal Domestic Assistance Number	11.304
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To promote long-term economic development and assist in providing immediate useful work (i.e., construction jobs) to unemployed and underemployed in designated project areas.
Types of Assistance	The basic grant rate for Public Works Impact Program areas is 50 percent, except for Native American areas, where the rate can be 100 percent. Severely distressed areas may receive supplementary grant assistance to bring the Federal contribution up to 80 percent. Local matching share may be waived if appropriate entity can demonstrate that it has exhausted its effective taxing and/or borrowing capacity. On average, EDA grants more than 50 percent of project costs.
Uses and Use Restrictions	Renovation or construction of public works and development facilities to provide immediate jobs to the unemployed and underemployed in project areas.
Eligible Applicants	Eligibility is based on designation of the county or city as a redevelopment area according to the criteria under Section 401(a)(6) of the Public Works and Economic Development Act of 1965 (Public Law 89-136).
Information Contacts	Director, Public Works Division, Economic Development Administration, Room H7236, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Water Quality Management Planning 205(j)
1992 Catalog of Federal Domestic Assistance Number	66.454
Administering Office or Agency	Office of Water, U.S. Environmental Protection Agency
Legislative Authority	Clean Water Act, Section 205(j), as amended
Objectives	To assist States (including territories and the District of Columbia), Regional Public Comprehensive Planning Organizations, and Interstate Organizations in carrying out water quality management planning.
Types of Assistance	Formula Grants. Each fiscal year, the Administrator shall reserve under Section 205(j)(1) an amount not to exceed 1 percent of the amount allotted and available for obligation or $100,000, whichever is greater, for the purposes of making grants to the States to carry out water quality management planning. Forty percent of the State's annual award must be allocated to Regional Public Comprehensive Planning Organizations and Interstate Organizations, unless EPA approves a lesser amount.
Uses and Use Restrictions	Section 205(j)(1) and Section 604(b) funds are awarded under Section 205(j)(2), to the State water quality management agencies to carry out water quality management planning. States are required to allocate 40 percent of the State's annual award to Regional Public Comprehensive Planning Organizations and Interstate Organizations. EPA may approve a State's request to pass through less than 40 percent if, after consultation with its Regional Public Comprehensive Planning Organizations and Interstate Organizations, the Governor determines that pass through of at least 40 percent will not (1) result in significant participation by Regional Public Comprehensive Planning Organizations and Interstate Organizations unless in water quality management and (2) significantly assist in development and implementation of the State's water quality management plan.
Eligible Applicants	State water quality management agencies.
Information Contacts	Contact the appropriate EPA Regional Office.

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ANNUAL REPORTS: ASSESSING THE EFFECTIVENESS OF THE STORM WATER PROGRAM

Purpose of Annual Reports

On the annual anniversary of permit issuance, the municipality is required to submit an annual report discussing the progress made toward achieving the specified storm water management program goals. As stated in Section 122.42(c) of the regulation:

> 40 CFR Part 122.42(c)(1)-(7)
>
> ***The report shall include -***
>
> (1) Status of implementing components of storm water management program that are established as permit conditions;
>
> (2) Proposed changes to storm water management programs that are established as a permit condition. Such changes shall be consistent with §122.26(d)(2)(iii) of this part; and
>
> (3) Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under §122.26(d)(2)(iv) and (d)(2)(v) of this part;
>
> (4) Summary of data that is accumulated throughout the reporting year;
>
> (5) Annual expenditures and budget for the year following each annual report;
>
> (6) A summary describing the number and nature of enforcement actions, inspections and public education programs;
>
> (7) Identification of water quality improvements or degradation

In developing their Part 2 municipal permit applications, applicants should have considered their strategy for preparing annual reports. While each municipality will take a different approach, in general, strategies will include identification of measures to track the long-term progress of their storm water management program goals, discussion of the role of monitoring data in assessing program effectiveness, and discussion of how the municipality plans to provide for future adjustment to this reporting strategy.

> The annual report will be used by the municipality to provide an assessment of the program performance, and guidance in establishing longer term assessment strategies.
>
> The annual report will be used by the permitting authority to monitor program compliance, and determine if the program is achieving the goal of improved storm water quality.

Benefits for Municipality

Completing annual reports is an invaluable exercise for municipalities because it allows them to gather all relevant information from the past year's storm water management activities and to assess the effectiveness of the program to date. If program goals are being met (or are in the process of being met), then the municipality can feel confident that its storm water management program has been designed and implemented in a relatively effective manner. If program goals are not being met, however, the municipality can reassess current program measures and make alterations if necessary. This annual evaluation should help permittees gauge tangible and intangible measures of progress (e.g, pollutant loadings or public awareness).

Benefits for State

Many municipalities are still in the early stages of developing storm water management programs suitable for controlling pollutants in discharges under an NPDES permit; others have relatively sophisticated programs in place. By reviewing the annual report, the State can determine whether various municipalities are developing their programs in a timely manner and can use information gathered in these reports to assess aquatic conditions on the State level.

While the annual report may be used by the States to evaluate municipal compliance with permit conditions, it also may indicate to the permitting authority where permit conditions need to be modified to address specific problems. Access to monitoring data identifying water quality improvements or degradation is important to the State for several reasons. First, it can be used to evaluate the success or failure of a management program in reducing pollutants. Second, it provides the State with information to use in a watershed data base. Third, the State can use the data to meet the informational requirements of various Federal programs. Data drawn from the annual reports will be especially useful for programs

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such as the Coastal Nonpoint Source Pollution Control Program (CZARA), the Safe Drinking Water Act Program, the Clean Lakes Program (CWA 314), and among others, which are identified in Section 1.3 of this document.

Required Elements

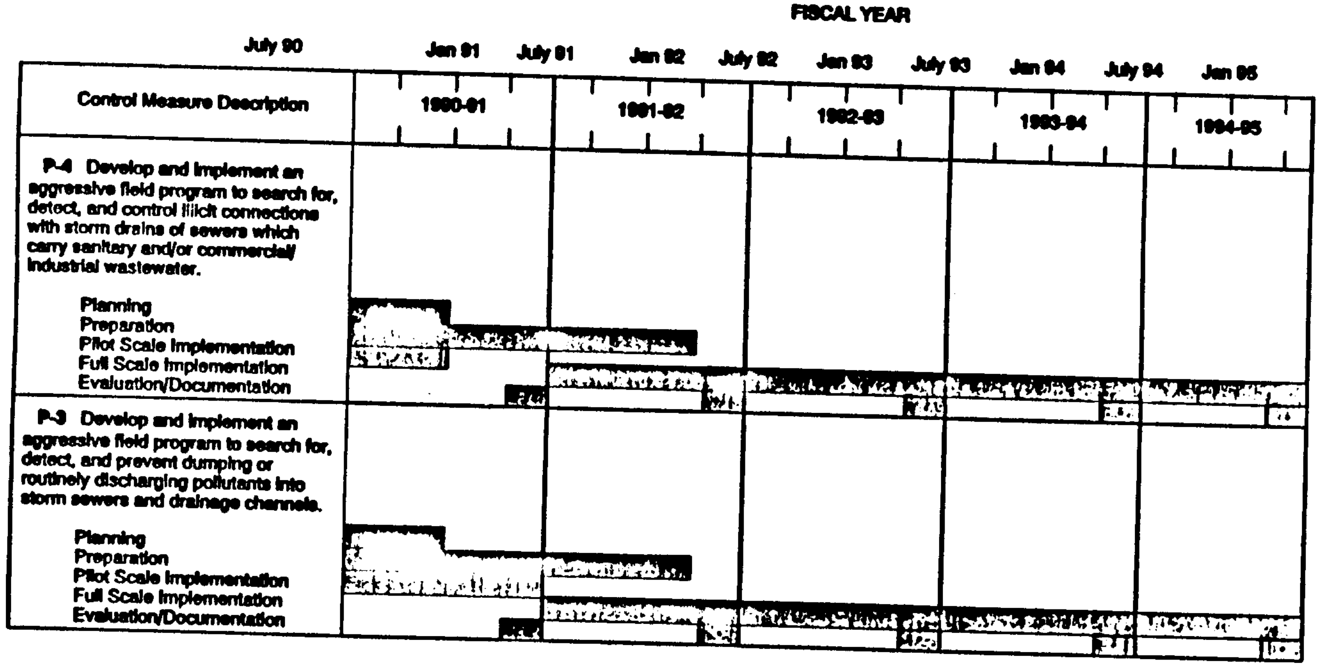
The annual report contains several requirements aimed at evaluating the accomplishments of the past year. This information can be used to evaluate the relative effectiveness of the storm water management program and to determine which elements should be continued or dropped from the plan. In some cases, the review will indicate that new methods or measures should be tried. The next several sections appear in the same order as in the permit; however, evaluating them in a slightly different order may be more productive.

Status of Implementing Components of Storm Water Management Program

This section addresses the relative degree to which storm water management program elements have been completed. Numerous approaches can be taken to accomplish this. You may want to begin by providing an overview of the program approach and history. Then, using your permit requirements as a guide, look at each component and decide whether it can be evaluated directly (e.g., pollutant removal) or indirectly (e.g., the success of a public outreach program). To complete this section, you can refer to various documents, including ordinances proposed or enacted, documentation for design or completion of structural controls, inspection reports, site assessments, and progress reports on cleanups. For components that can be directly measured, an effective way to present the information is in a matrix format, as shown in Figure 3-2.

Figure 3-2 shows activity goals versus activities accomplished. If the component you are addressing is not directly measurable, a narrative description can be given to convey its status. For example, you might describe the effectiveness of a public education program by discussing the number of meetings held to generate community awareness, the results of a post-meeting survey, any followup inquiries or letters from the meetings, or by discussing the increase in the number of citizens reporting violations.

Once you have addressed the circumstances of each program component, the status of the SWMP as a whole should be summarized.



• Submittal of annual report to RWQCB

NOTE: Schedules for tasks beyond the 1991 - 1992 fiscal year at *projected only* and will be re-evaluated and revised annually as part of the Annual Reporting Provision in the Permit. Implementation of control measures is contingent with results of planning, preparation, and pilot testing phases. Schedules for specific tasks may vary among the participants according to different conditions and considerations.

FIGURE 3-2. IMPLEMENTATION SCHEDULE FOR PROGRAM ELEMENT IV—ILLICIT CONNECTION ELIMINATION AND ILLEGAL DUMPING ELIMINATION

Proposed Changes to SWMP Established in Permit Conditions

After reviewing the effectiveness of your program components over the last year, you can determine which components require adjustments in order to meet long-term goals of water quality improvement. Among the reasons for proposing a change are:

- The existing component is not cost-effective
- The existing component has not performed as anticipated
- Physical circumstances have changed (e.g., the addition of an outfall or consolidation of existing ones)
- New technologies are available that produce better results.

When municipalities make programmatic changes, the background information used to formulate original decisions should be consulted. For example, you should be aware of the initial strategy used to develop the component, such as cost or time constraints. Consider how the initial strategy may have influenced component performance (e.g., lack of funding may have curtailed an activity before the end of the period). The next step is to explain the reason for requesting the change. A detailed description of the proposed component in terms of its impact on budget, schedule, and previously stated program goals should also be provided. For example, Santa Clara Valley's annual report included sections that described successes and shortfalls and future changes as a result of these two areas. All changes must be consistent with regulatory requirements in Section 122.26(d)(2)(iii). Requests for significant revisions to the storm water management program may require municipalities to partially resubmit their storm water permit application, as noted in Section 122.26(d)(2)(iv) and (d)(2)(v).

Revisions to the "Assessment of Controls/Fiscal Analysis" Sections of SWMP

Assessment of Controls

As part of the Storm Water Management Program, municipalities are required to provide an annual "assessment of controls," as well as a "fiscal analysis." This section should be completed only after you have reviewed and summarized the data gathered throughout the year. The municipality will compare the collected data and documented achievements of the program to the estimated data (e.g., reductions in pollutant loading and other site-specific measurements included in Parts 1 and 2 of the permit). Program components will not always meet the anticipated return value, and others may exceed

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expectations. The effectiveness of controls should be modified based on the actual values from data gathered throughout the past year.

A number of control measures cannot be evaluated in terms of direct measures, such as pollutants removed, but instead must be evaluated in terms of indirect measures. Indirect measures can often be very effective when direct measures are not appropriate or when they do not tell the whole story. For example, public education campaigns generally cannot be assessed in terms of pollutant reduction. An increase in the number of citizens participating in a cleanup program, however, would be a good indirect indicator of program effectiveness. Similarly, an increase in the rate of volunteerism within the community could indicate the relative success of a particular program. Another indirect measure might be an increase in the volume of recycling materials collected. An indirect measure of success in lowering pollutant loads would be a lowering in the number of beach closings or fishing restrictions. Be aware of the possibility of these indirect indicators as you review your records.

Table 3-3 contains control activities and possible ways to indirectly measure their effectiveness. Some of these activities may be appropriate for your situation.

TABLE 3-3. SWMP COMPONENTS AND SELECTED MEASURES

SWMP Component	Indirect Measure
Classes/art or writing contests for school aged children	Attendance records, entries received
Public hearings/discussions/seminars	Attendance records
Community cleanup programs or adopt-a-highway campaigns	Number of volunteers or truckloads of trash collected
Public education/outreach programs (e.g., print, video, audio)	Number of handouts distributed, media spots, or citizen response (e.g., phone calls or letters)
Violations reported by citizens	Number and type of violation
Public awareness	Letters, reported violations, court records indicating citizen suits against specific facilities, or a rise in recycling program participation
Household hazardous waste/used oil collection program	Number of gallons of hazardous waste or used oil collected
Industry outreach programs	Increase in the number of permit applications or articles in industry/local publications

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Fiscal Analysis

The fiscal analysis section will also be updated based on actual figures for the year past. The information to be updated will include the existing budget, estimated operation costs necessary for the storm water management program during the term of the permit, capital available to meet these costs, and the list of available sources of funding and legal restrictions on these sources. Information for this section and the section on assessment of controls can be presented in a number of ways, including graphs, pie charts, and matrices. When the projected and actual figures differ, the permittee should also include a narrative explanation. For example, if the monitoring program exceeded its budget in a particular area, the permittee may indicate in the narrative that this was caused by the addition of several outfalls that were not included in the original list.

Summary of Data Gathered Throughout the Year

This section of your annual report is used to present an overview of the data gathered during the past year and is an important step in evaluating the effectiveness of your program to date (e.g., data may indicate that efforts to reduce a particular pollutant have been successful). This section should address, at a minimum, the results of the storm water monitoring program and the seasonal pollutant load estimates for each major outfall identified in the application.

Your municipality was required to include, in the Part 2 permit application, a proposed monitoring program for data collection from the separate storm sewer system. The permit issued to your municipality should specify the required monitoring for the permit term. The amount, type, and schedule for monitoring data collection will vary, depending on the proposed plan and on the permitting authorities need to characterize the discharge from the separate storm sewer system. The annual report should summarize the monitoring activities for the previous year indicating, at a minimum, the number of outfalls or screening points sampled, the number of times each outfall was sampled, and the location of the outfalls sampled. The annual report should also summarize the data collected in the monitoring program. The monitoring data should be organized by watershed. For example, the results of all monitoring performed on discharges to Smith Creek should be listed together in the same table. The report should include the following information for each outfall sampled:

- The date the sample was collected
- The duration and depth (in inches) of the storm event that generated the discharge

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- The form of precipitation (rainfall or snow melt)
- The type of sample collected (grab, flow weighted composite, or time weighted composite)
- The results of the analysis performed on the samples (e.g., the concentrations of the pollutants).

Monitoring data are best presented in a table or matrix format. Monitoring data can also be given in line graphs, bar charts, pie charts, or other easily understood formats.

Municipalities are also required to submit in their Part 2 applications a schedule for providing estimates of the seasonal pollutant loads and event mean concentration of any parameter detected in any sample collected for the Part 2 application requirements. The proposed schedule will be reviewed by the permitting authority and should be included in the permit conditions. The annual report should present the estimates of pollutant loads and event mean concentrations in the years specified in the permit schedule. The following information should be provided:

- Location of the major outfall
- Estimates for four seasonal pollutant loads for each parameter
- Brief description of method used to estimate the pollutant load
- Estimate of the event mean concentration of each parameter for a representative event
- Brief description of the method used to estimate the event mean concentration.

The estimates of pollutant loads and event mean concentrations should be presented in tabular format by watershed. The description of the calculation methods should indicate the extent to which the monitoring data were used. You may also include a written evaluation addressing the results.

For instance, Santa Clara Valley has a 5-year monitoring plan. This plan contains 10 monitoring sites, including 5 new sites—an industrial site, two transportation corridors, and two outfalls at a detention basin. The objectives of the plan are to:

- Gather data to determine long-term water quality trends
- Assess impacts of toxicity in storm water runoff and determine the pollutants causing the toxicity

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- Evaluate the appropriateness of the WQOs in protection aquatic life
- Determine the treatment effectiveness of an existing detention basin under different hydrologic conditions
- Assess the role of stream sediments as pollutant sinks or sources
- Describe the management implications of the findings.

Annual Expenditures and Budget for the Upcoming Year

This section addresses the coming year's proposed budget and the previous year's expenditures. An analysis of last year's budget and actual expenditures is used to determine if targeted amounts in the new budget will be adequate. Note which of your program elements will be continued, which will be dropped, and whether any new ones are to be added. Compare this list of proposed program changes to your available budget to ensure adequate funding. Once you have listed the projected cost for each item, note the source of funding and its approval status. Tracking approval status of funding for planned activities is important because the program may not be able to achieve its goals or permit compliance without funding approval. For example, the Santa Clara Valley Water District (SCVWD) is the managing agency for the municipality's budget. A management committee is appointed to decide on budget matters. The committee is chaired by the SCVWD Manager of Operations and Water Quality and includes representatives from each of the 15 co-permittee municipalities. The nonpoint source division's program manager is responsible for the administration and management of the budget program.

Summary Describing the Number and Nature of Enforcement Actions, Inspections, and Public Education Programs

This section should describe each enforcement action, educational program, or inspection conducted during the past year. This may include actions initiated by citizens, private industry, or the municipality. Refer to legal notices, court records, and newspaper articles for this information. Permittees should note the number and type of each action and, where appropriate, the number of participants or the number of materials distributed (as in the case of educational programs). When addressing enforcement actions, it may be useful to indicate the types of outcome (e.g., the names of offenders published in the local newspapers, the number of fines levied and the amounts, or the number of closures or stop work orders issued). The total number of inspections, the types of facilities inspected, and the number of violations cited due to these should also be indicated. It may be helpful to note the number of in-house training programs held for inspectors and the number of attendees. Public education programs may be assessed by noting the number of meetings or classes, subject matter, attendance figures, the number and type of media spots, printed materials distributed, etc. In evaluating program success, it may also be helpful to use some indirect measures, such as a decrease in illegal storm drain dumping, which may be attributable to storm drain stenciling. The key to Santa Clara Valley's enforcement program, for example, is the ordinance regulating industrial or other polluting activities within the municipality. The ordinance to be developed by Santa Clara Valley will include language addressing the following activities: controlling non-storm water discharges to storm drains, watercourse protection, regulation of outdoor material storage, control of improper grease disposal, and storm water management requirements for new development and redevelopment. For more specific information on how the ordinance will affect these areas, various subcommittees will develop guidance manuals on storm water controls.

Identification of Water Quality Improvements and Degradation

An important measure of the program effectiveness is the extent to which water quality has improved during the past year. In particular, municipalities should examine the water quality of the receiving waters to which the system discharges. This section should include such changes in receiving water quality and cite the reasons for them.

Municipalities were required to provide information on receiving waters and watersheds in Part 1 of the permit application. This information included a discussion of water bodies cited in State reports required by CWA Sections 305(b), 304(1), and 314(a); the State Nonpoint Source Report; and other reports identifying sensitive watersheds. To complete this section, you will need to review information gathered for these State and Federal programs during the past year and data from the required monitoring program. The municipality may have also gathered receiving water data as part of its strategy for continuing program assessment. In addition, information may be available from other Federal programs, as noted in Chapter 1. Be aware that numerical data are not the only way to determine water quality. One criterion you may use when judging water quality is how well the body of water meets its designated uses (e.g., recreational or industrial uses).

Once water quality improvement has been noted, the next step is to determine the cause for these changes. For instance, if the annual monitoring data indicate that discharge water quality and receiving water quality have improved proportionally, it may be attributable to the successful implementing of the SWMP. If monitoring data indicate an improvement in discharge quality yet receiving water quality has

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degraded over the past year, you must try to find the reasons (e.g., unforeseen weather conditions, such as flooding or drought, or sources upstream). Available computer water quality modeling programs may be helpful in completing this section.

Sample Annual Reports

An excerpt from an annual report on the Santa Clara County program is given after the summary.

SUMMARY

This chapter discussed the procedures on implementing the specific administrative requirements, which include public participation and public information programs, fiscal analysis, and annual reports. Each of these components is essential to the successful implementation of a municipal storm water management plan. Public participation and public information programs solicit public support by informing individuals of the importance of good storm water management and its effect on water quality. By conducting a thorough fiscal analysis program, a municipality examines all of the available sources of funding and selects the funding option(s) according to its specific needs. The annual report assesses the effectiveness of the management plan and allows the municipality to revise the plan based on the results of the assessment. The next chapter provides procedures for implementing an effective illicit connections detection program as a key element in the municipal storm water management plan and provides examples of programs from different municipalities.

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SANTA CLARA COUNTY STORM WATER MANAGEMENT PLAN

Public Information/Participation Program

Provision 4b of Santa Clara County's NPDES permit requires the individual co-permittees to implement educational control measures to inform the public of and encourage participation in nonpoint source pollution control activities. Educational control measures are being implemented through a Public Information and Participation (PI/P) program.

Overview and Objectives

The main objective of the PI/P element is to implement educational control measures that provide information to the public and increase understanding of and participation in controlling nonpoint source pollution. The overall goals for FY 91-92 were to generate awareness of the program by defining the problem, inform individuals on ways to participate in solutions to the problem, and provide the means for participation. Specific industries were targeted for development of Best Management Practices (BMP) manuals, brochures, and posters. To aid in the development, publication, storage, and distribution of educational materials, the program established a PI/P Subcommittee in FY 90-91 to have primary responsibility for the implementation of this PI/P element.

Program Activities Completed and In Progress

The subcommittee produced nine types of educational material during FY 91-92. This included development and distribution of an Automotive Industry BMP manual and poster, a construction BMP poster, a "Recycle Your Used Motor Oil" poster, brochures describing how to decrease the use of toxic chemicals in the home, guidebooks, and stencils. The storm drain stencils developed in FY 90-91 were made available to co-permittees and volunteer groups to use during FY 91-92, and the remaining brochures developed in FY 90-91 were distributed to the co-permittees as needed. The co-permittees distribute them to the public through presentations, events, direct mailing, and billing inserts. In addition, the subcommittee distributes the materials to the public through presentations and events and to schools, teacher organizations, and specific businesses.

FY 92-93 Program Activities

The subcommittee will continue to be primarily responsible for implementation of this PI/P element, and to act as the central development and distribution point for all materials. The subcommittee will also be evaluating the effectiveness of the PI/P element activities of the past 2 fiscal years and developing recommendations for increasing the outreach effort. Activities planned for FY 92-93 include development of a program newsletter for nontechnical audiences with periodic distribution and development of a brochure for homeowners to use when dealing with contractors who offer potentially hazardous services (e.g., carpet cleaning, pest control). Other activities planned for FY 92-93 are creation and implementation of a distribution plan for program educational materials, translation of one brochure into Spanish, reprinting of existing materials to keep distribution points supplied, provision of funds to support other programs and for the purchase of educational materials produced by other programs in the Nation, development of a strategy for a recognition program for industry compliance efforts, and funding of the San Francisco Bay National Wildlife Refuge's Alviso Environmental Education Center.

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Co-Permittee Activities Completed and in Progress

The activities conducted by the subcommittee and the co-permittees for the PI/P element are summarized below. The detailed reports submitted by the subcommittee and the co-permittees are presented in the "Public Information/Participation" Program Element Report.

Infrastructure

The funding, staffing, and organizational/institutional infrastructures established by the co-permittees are summarized in Table 3-4. Of the 15 co-permittees, 6 relied wholly or partially on their general fund for funding of PI/P element activities in FY 91-92, and 10 acquired funding through related program funds, fees, or utilities. Funding for the program element was sufficient for 14 co-permittees in FY 91-92, and 1 reported that the budget was constrained. Staffing for the PI/P element was sufficient in FY 91-92 for nine co-permittees and insufficient, overextended, or limited for six co-permittees. A total of five of the six co-permittees reporting insufficient or limited staff proposed changes to resolve the problem; one indicated no changes would be made due to a hiring freeze. The 4 co-permittees who reported organizational limitations to implementation of the PI/P element identified the problems as establishment of effective communication among departments and difficulties in analysis of activities; 11 co-permittees reported that there were no organizational limitations.

Public Information and Participation Activities

The activities conducted by the co-permittees to meet the objectives of the PI/P element included storm drain stenciling; publication of articles in newspapers, community reports and newsletters, preparation of advertisements for radio and TV; direct mailing of brochures, and distribution of billing inserts (Table 3-5). Brochures and posters were distributed at presentations and special events and were made available at community centers and public office buildings. Some co-permittees provide telephone and mail service to distribute materials on request. In FY 91-92, more than 21,000 storm drains were stenciled, 76 articles and advertisements were published, 238 presentations and events were presented or attended, and more than 77,000 brochures and posters and over 82,00 billing inserts were distributed. The city of San Jose took the lead in producing bookmarks for the co-permittees to distribute to libraries for summer reading programs. Copies of San Jose's co-permittee PI/P activities are attached.

TABLE 3-4. PI/P PROGRAM ELEMENT INFRASTRUCTURE

Co-Permittee	Funding		Staffing		Organizational Limitations
	Source	Amount	Current	Proposed	
Campbell	General Fund	Sufficient	Overextended	Recruit volunteers	None
Cupertino	Environmental Bill	Sufficient	Sufficient	No changes	None
Los Altos	Sewer Enterprise Fund	Sufficient	Sufficient	No changes	None
Los Altos Hills	General Fund	Constrained	Limited	Hire 1 staff	None
Los Gatos	General Fund	Sufficient	Insufficient	Contract with WVSD	Reorganization of departments
Milpitas	Capital Improvement Program	Sufficient	Sufficient	No changes	None
Monte Sereno	General Fund	Sufficient	Limited	Recruit volunteers for stenciling	None
Mountain View	Wastewater Enterprise Fund	Sufficient	Limited	No changes due to hiring freeze	Coordination between divisions
Palo Alto	Storm Drain Utility	Sufficient	Sufficient	No changes	None
San Jose	Storm Drain User Fee	Sufficient	Sufficient	No changes	None
Santa Clara	Capital Improvement Program	Sufficient	Limited	Hire labor as needed	None
Santa Clara Co.	Existing Programs	Sufficient	Sufficient	No changes	Activity analysis difficult
SCVWD	Water Utility/Flood Control	Sufficient	Sufficient	No changes	Coordination due to physical separation of departments
Saratoga	City Budget	Sufficient	Sufficient	No changes	None
Sunnyvale	General Fund	Sufficient	Sufficient	No changes	None

Source: Santa Clara Valley Part II Municipal Permit Application

TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
CAMPBELL				
Storm drain stencils	200	200	600	Goal met
Newsletter articles	2	2	2	Goal met
Special events	No goals established	2	No goals established	Not applicable
Brochures/poster distribution	1,115	1,120	1,210	Goals met
CUPERTINO				
Storm drain stencil	All catch basins	Complete	Target businesses	Goal met
TV programs	2	2	1	Goals met
Articles in newsletters, newspapers, billings	5	7	2	Goals met
Adopt-a-creek program	Implement program	No	Implement program in 1992	Required additional research
Brochure/posters distribution	No goals established	As needed	Ongoing	Not applicable
Special programs/events	4	4	3	Goals met
LOS ALTOS				
Storm drain stencils	Ongoing (900 total)	200	Ongoing	Not reported
CATV announcements	10	6	12	Display period too long
Advertisements in newsletters, newspapers, billings	12	17	16	Goals met
New programs	1	1	1	Goals met
Brochures/poster distribution	No goals established	4,313	Ongoing	No goals established
Telephone service	500	32	Ongoing	No goals established
LOS ALTOS HILLS				
Storm drain stencils	Access activity	0	Implement alternatives	Aesthetics
Brochure mailing	8,000	8,000	800	Goal met
Brochure distribution	8,000	8,000	Ongoing	Goal met
Advertisement in newspaper	1	1	1	Goal met

Source: Santa Clara Valley Part II Municipal Permit Application

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
LOS GATOS				
Storm drain stencils	Not reported	Not reported	Not reported	Activity under consideration
News releases	6	Not reported	1+ article	Not reported
Brochure distribution	Not reported	90	0	Not reported
Brochure mailing	Not reported	Not reported	Not reported	Not reported
Brochure availability	Not reported	Not reported	Not reported	Not reported
MILPITAS				
Storm drain stencils	1,500	2,700	3,047	Goal met
Mailings	12,000	0	12,000	Scheduled for 11/92
CATV advertisement	3	3	3	Goal met
Brochure/poster distribution	No goal established	Ongoing	No goal established	Not applicable
Events/presentations	No goal established	0	3	Not applicable
MONTE SERENO				
Storm drain stencils	100%	0	100%	Volunteer program unsuccessful
Presentations	25%	0	25%	Not reported
Video presentation CATV	100%	0	100%	Program did not develop video
Article in newsletter	100%	100%	100%	Goal met
MOUNTAIN VIEW				
Storm drain stencils	1,555	1,127	600	Slowed to involve volunteer community group
Advertisements in newsletters, newspapers	7	5	6	Short reporting period
Brochure distribution	300	2,600	1,000	Goals met

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
PALO ALTO				
Storm drain stencils	100	750	2,000	Goal met
Brochures/poster distribution	4,400	4,600	6,240	Goals met
Billing inserts	27,000	54,000	54,000	Goals met
Community report	1	0	1	Report space restriction
Advertisements in newspaper, TV	3	2	5	Insufficient staff time to coordinate
Presentations/events	4	6	13	One event canceled due to budget cuts
SAN JOSE				
Storm drain stencils	19,345	15,537	3,808	Not reported
Phone/mail service	1,000	1,200	1,000	Goals met
Brochures/poster distribution	8,100	11,880	6,000	Goals met
Advertisements in radio, TV, newspaper, newsletters, transit	22	22	As needed	Goals met
Special events	14	14	As needed	Goal met
SANTA CLARA				
Storm drain stencils	100% industrial areas 100% other	70% industrial 20% other	30% industrial 80% other	No reported
Advertisements in TV, newspapers, newsletters	5	7	6	Goals met
Phone service	50	50	50% as needed	Goals met
Presentations/events	7	7	As available	Goals met
Brochures/poser distribution	No goal established	As needed	Ongoing	Not applicable

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
SANTA CLARA COUNTY				
Storm drain stencils	Conducted pilot program	50%	100%	Goal met
Presentations/events	No goals established	5	As needed	Not applicable
Brochures/poster distribution	As needed	4,975+	Ongoing	Not applicable
Advertisements in newspapers, newsletters	As needed	4	As needed	Not applicable
HHW pilot program	Complete pilot program	8,800 door hangers	Expand program	Goal met
Mailings	No goals established	Not applicable	Develop industry mailing list	Not applicable
SCVWD				
Storm drain stencils	All at district headquarters	All inlets	No goal established	Goal met
Advertisement in newsletters	No goals established	3	4	Not applicable
Presentations/events	No goals established	187	As needed	Not applicable
Calendar distribution	No goals established	1,000	1,000	Not applicable
SARATOGA				
Storm drain stencils	25	240	240	Goal met
Brochures/poster distribution	28,000	30,000	Ongoing	Goals met
Presentation/display/events	No goals established	4	As needed	Not applicable
Advertisements in TV, newspapers	3	3	3	Goals met
SUNNYVALE				
Storm drain stencils	1,000	1,129	1,000	Goal met
Brochures/poster distribution	No goal established	5,865	1,700	Not applicable
Presentations/events	12	9	6	Events rescheduled
Mailings/billing inserts	38,400	38,400	38,400	Goals met
Newsletters, quarterly reports	No goals established	1 report	1 report/as needed	Not applicable

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TABLE 3-5. PUBLIC AGENCY CONTROL MEASURES ACTIVITY SUMMARY—PART A

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
CITY OF CAMPBELL				
Street sweeping	5 events/259 miles per month	5 events/261 miles per month	13 events/326 miles per month	Goals met
Catch basin cleaning	As needed	Not reported	284	Not applicable
Conveyance cleaning	As needed	Not reported	12.5 miles	Not applicable
CITY OF CUPERTINO				
Street sweeping	6 events/628 miles per month	6 events/628 miles per month	8 events/628 miles per month	Goals met
Catch basin cleaning	1,420	2,840	2,840	Goals met
Conveyance cleaning	As needed	30 incidents	As needed	Not applicable
CITY OF LOS ALTOS				
Street sweeping	5 events/291 miles per month	7 events/332.5 miles per month	7 events/332.5 miles per month	Goals met
Catch basin cleaning	900	900	900	Goals met
Conveyance cleaning	As needed	None	As needed	Not applicable
TOWN OF LOS ALTOS HILLS				
Street sweeping	As needed	Not reported	No goals established	Not applicable
Catch basin cleaning	250	250	250	Goals met
Conveyance cleaning	5 miles	5 miles	5 miles	Goals met
TOWN OF LOS GATOS				
Street sweeping	23 days/700 miles per month	23 days/700 miles per month	23 days/700 miles per month	Goals met
Catch basin cleaning	500	325	600	Limited staff
Conveyance cleaning	20	20	20	Goals met
CITY OF MILPITAS				
Street sweeping	20 events/390 miles per month	18 events/390 miles per month	16 events/390 miles per month	Goals met
Catch basin cleaning	3000	2172	3000	Limited staff
Conveyance cleaning	85 miles	1.25 miles	4.5 miles	Limited staff

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CHAPTER 4

CHAPTER 4

PROCEDURES FOR IMPLEMENTING A PROGRAM TO IDENTIFY AND REMOVE ILLICIT AND/OR INAPPROPRIATE DISCHARGES FROM STORM SEWER SYSTEMS

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INTRODUCTION

The previous chapters presented information on municipal storm water management program regulatory requirements, guidance for municipal officials to rank storm water management activities for maximum cost effectiveness, and detailed procedures on how to implement specific administrative requirements. This chapter describes the procedures for identifying illicit discharges and implementing illicit discharge programs. Specifically, it discusses the components of an effective illicit discharge detection program, EPA's method for identifying illicit discharges, and examples of illicit discharge programs that have been or will be implemented in different municipalities.

Current interest in illicit or inappropriate connections to storm drainage systems is an outgrowth of investigations into the larger problem of determining the role of urban storm water runoff as a contributor to receiving water quality problems. Water discharge from storm water drainage systems often includes waters from many non-storm water sources. A 1987 study in Sacramento, California, found that almost half the water discharged from the storm water drainage system was not directly attributable to runoff. Illicit and/or inappropriate entries to the storm drainage system are likely sources of this discharge and can account for a significant amount of the pollutants discharged from storm drainage systems.

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Common sources of non-storm water entries include sanitary wastewater, automobile maintenance and operation waste products, laundry washwater, household toxic substances, accident and spill waste streams, runoff from excess irrigation, and industrial sources of cooling waters, rinse water, and other process wastewater. Although these sources can enter the storm drainage system various ways, they generally result from either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the storm drain system or spills collected by drain inlets). Sources can be further divided into those discharging continuously and those discharging intermittently. Table 4-1, presented in *Investigation of Inappropriate Pollutant Entries Into Storm Drainage Systems*, gives a simple overview of typical pollutant sources and their most likely characteristics. The table lists the potential sources for inappropriate pollutant entries into the storm sewer system from residential, commercial, and industrial areas.

TABLE 4-1. POTENTIAL INAPPROPRIATE ENTRIES INTO STORM DRAINAGE SYSTEMS

Potential Source	Storm Drain Entry		Flow Characteristics		Contamination Category		
	Direct	Indirect	Continuous	Intermittent	Pathogenic/ Toxic	Nuisance	Clear
Residential Areas							
Sanitary wastewater	X	x	X	x	X	x	
Septic tank effluent		X	X	x	X	x	
Household chemicals	x	X		X	X		
Laundry wastewater	X			X		X	
Excess landscaping watering		X		X	x	x	X
Leaking potable water pipes		X	X				X
Commercial Areas							
Gasoline filling station	X	x		X	X		
Vehicle maintenance/repair	X	x		X	X		
Laundry wastewater	X		X	x	x	X	
Construction site de-watering		X	X	x		X	
Sanitary wastewater	X	x	X		X		
Industrial Areas							
Leaking tanks and pipes	x	X	X	x	X		
Miscellaneous process waters	X	x	X	x	X	x	x

Note: X: most likely condition
x: may occur
blank: not very likely

REQUIRED COMPONENTS OF AN ILLICIT AND/OR INAPPROPRIATE DISCHARGE DETECTION AND REMOVAL PROGRAM

The regulations under 40 CFR 122.27 require that the Storm Water Management Plans include "a description of a program . . . to detect and remove . . . illicit discharge and improper disposal into the storm sewer." The regulations further require the following components be included in the program:

- Prohibition of illicit and/or inappropriate discharges
- Field screening of outfalls within the drainage area

- Investigation of potential illicit and/or inappropriate discharges
- Spill response and prevention
- Public awareness and reporting program
- Control of infiltration of seepage from sanitary sewers to municipal separate storm sewer systems (MS4s).

Prohibition of Illicit and/or Inappropriate Discharges

Applicants must develop and implement an effective program to prohibit illicit and/or inappropriate discharges from entering MS4s. This is accomplished through the implementation of inspection procedures, local ordinances, and other legal authorities. In addition to adopting prohibition procedures, a schedule of the implementation process should be developed, and sufficient staff and resources should be allocated. The prohibition of illicit and/or inappropriate discharges should be linked to legal authority to ensure proper enforcement.

Field Screening

Applicants must propose procedures for a continued outfall field screening program. They can use the procedures from their Part 1 applications or use alternative methods. The field screening procedures in the Part 2 application should identify target areas to be examined for continued field screening and the reasons for selecting these areas. Also, any additional major outfalls recently identified should be included in the Part 2 field screening process. Of particular concern are areas of older development, areas with automobile-related industries, and areas with high concentrations of industrial facilities, among others.

This section should provide a detailed summary of the departmental responsibility for field activities, frequency of inspections, inspection procedures, inspection equipment, and documentation procedures for field activities.

Investigation of Potential Illicit and/or Inappropriate Discharges

Applicants should propose criteria to identify the parts of the MS4 that need investigation. Procedures for investigating likely locations for illicit and/or inappropriate connections include an MS4 inspection,

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use of remote control cameras, onsite facility inspections and dye-testing, and additional monitoring to pinpoint pollutant sources. To adequately address these procedures, a checklist should be developed to ensure a comprehensive evaluation of the problem. The checklist should emphasize the use of the easiest, least expensive, and most effective methods for detecting illicit and/or inappropriate discharges. EPA suggests that a map be developed to supplement the investigation by identifying the illicit and/or inappropriate discharge locations.

Spill Response and Prevention

The purpose of spill response programs is to reduce the risk of spills to the public. These programs usually require coordination among fire, police, health, and public works departments. The municipal departments responsible for implementing the program should be identified and should address topics such as employee training, reporting procedures, spill containment, storage and disposal activities, documentation, and followup procedures. For each of these elements, particular attention should be given to good housekeeping and materials management practices. Procedures can be implemented through modification of the land use planning process and ordinance enforcement or through coordination with existing spill prevention or spill containment programs.

Public Awareness and Reporting Program

Applicants should promote, publicize, and facilitate public reporting of illicit and/or inappropriate discharges or water quality impacts associated with discharges from MS4s. The public awareness program should stress that the public is the beneficiary of this program. Typical public awareness and reporting programs may include developing a hotline number, educating school students, using inserts in utility bills, and media announcements. Effectively implementing these programs should lead to a reduction in the residential discharges noted in Table 4-1.

Proper Management of Used Oil and Toxic Materials

This program component should facilitate the proper disposal of used oil and toxic materials from households, industrial, and commercial users by establishing municipal collection sites or identifying private collection sites. This program should also include any outreach plans for handlers of used oil, as well as the general public.

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Control of Infiltration of Seepage

This program component should describe procedures that would control infiltration of seepage from sanitary sewers to MS4s. Some controls to consider for limiting seepage include inspection programs, preventive maintenance surveys, and ongoing infiltration and inflow programs for locating seepage sites. Seepage from malfunctioning septic systems should also be controlled.

EPA'S SUGGESTED METHOD FOR DETECTING ILLICIT AND/OR INAPPROPRIATE CONNECTIONS

EPA's suggested method for detecting illicit and/or inappropriate discharge connections, developed by the Office of Research and Development, is described in *Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems* (user's guide), which is available from the Center for Environmental Research Information, (513) 569-7562. This method focuses on data collection and quantitative analysis to implement a proper illicit and/or inappropriate discharge connection program.

The user's guide may be used as part of a comprehensive storm water management plan that addresses all sources of storm water pollution. Correcting only the most obvious pollutant entries is unlikely to significantly improve the quality of storm water discharges or receiving waters.

A municipality planning to investigate inappropriate entries to its storm drainage system needs to base this on local conditions. This user's guide describes the issues and provides examples to facilitate the design of a local investigation.

All the applicable procedures described in the user's guide may be used to successfully identify pollutant sources. For example, attempting to reduce costs by only examining a certain class of outfalls or using inappropriate testing procedures will significantly reduce the utility of the testing program and result in inaccurate data. Cursory data analyses are also likely to result in inaccurate conclusions.

The methodology (appropriately modified) can also be applied to other types of sewerage systems, such as combined and separate sanitary sewerage, to locate inappropriate entries (e.g., untreated or toxic industrial wastewater/wastes and infiltration/inflow) into sanitary systems.

Figure 4-1 presents a simplified flow chart for the detailed methodology contained in the user's guide.

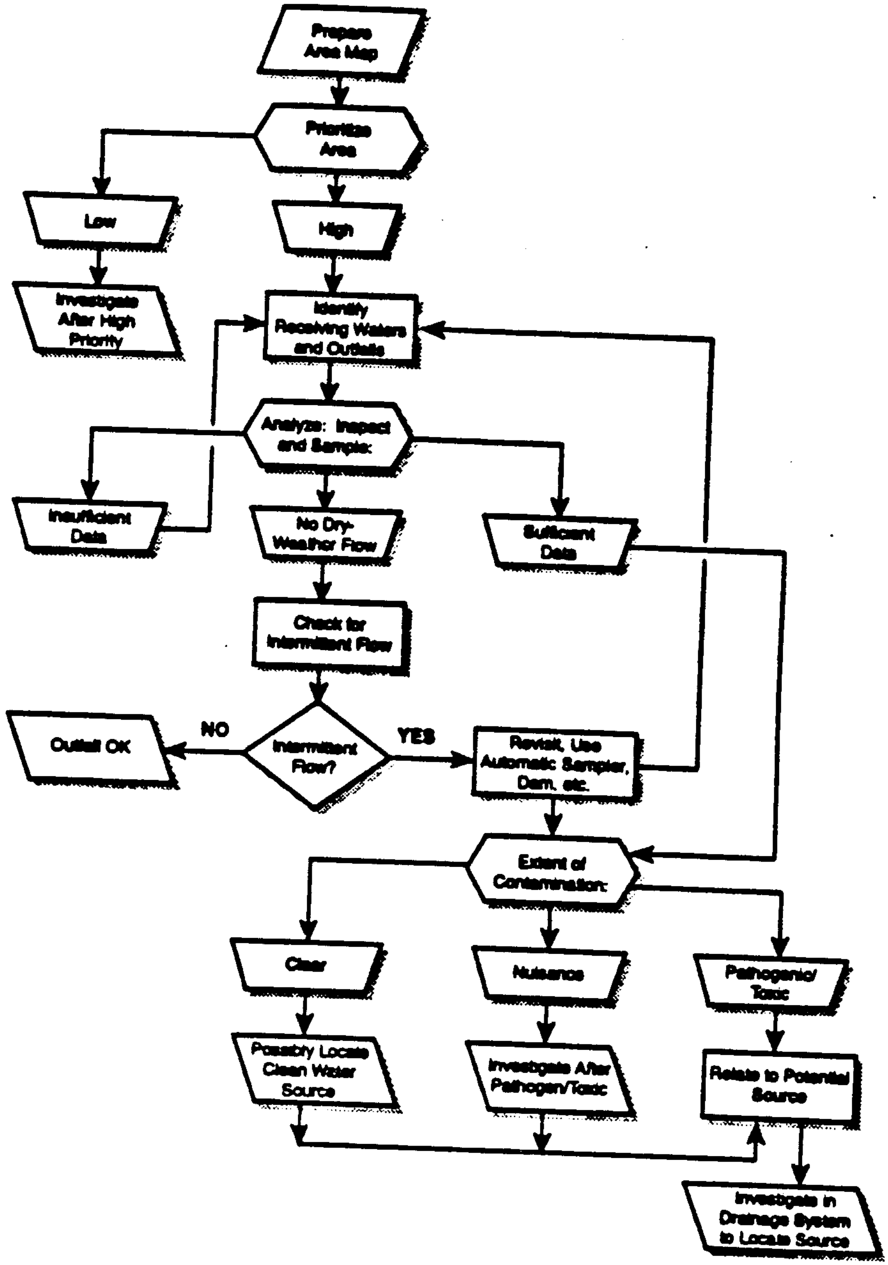

FIGURE 4-1. SIMPLIFIED FLOW CHART SHOWING THE DETAILED METHODOLOGY CONTAINED IN THE USER'S GUIDE

The initial phase of the investigative protocol includes initial mapping and surveys. These activities require minimal effort and result in little chance of missing a seriously contaminated outfall. More detailed watershed surveys are then performed to locate and correct the sources of the contamination in the identified problem areas. After corrective action has been taken, repeated outfall field surveys are required to ensure that the outfalls remain uncontaminated. Receiving water monitoring should also be conducted to analyze water quality improvements. If expected improvements are not noted, then additional contaminant sources are likely present, and additional outfall and watershed surveys are needed.

The user's guide is designed to provide information and guidance to agencies planning or implementing an investigation of illicit and/or inappropriate entries to a storm water or wastewater drainage system. This is achieved by:

- Providing a methodology to identify and describe potential sources of non-storm water pollutant entries into the storm drainage system
- Describing an investigative procedure that will allow a user first to determine whether significant non-storm water entries are present in a storm drain and then to identify the potential type of industrial, residential, or commercial sources responsible, as an aid to determining the ultimate location of the source.

Procedure

The user's guide describes the following investigation steps:

- Drainage area mapping
- Tracer identification
- Field survey and data collection
- Analyses of data collected
- Categorization of outfalls
- Investigation and remediation
- Pollution prevention program.

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Mapping

The mapping exercise is carried out as both a desktop operation by using existing information and with field visits to collect further data and to confirm existing information. The maps should provide complete descriptions of the drainage areas, including outfall locations, watershed boundaries for each outfall, critical land use areas (mostly commercial and industrial areas), permitted discharges to the storm drainage system, city limits, major streets, and streams. The user's guide discusses critical land use areas and lists major industries and their potential to be non-storm water entry sources.

The drainage areas are ranked in the order of their potential to cause problems. This allows priorities to be set for field investigation of the outfalls. Note that all outfalls will eventually require investigations, and the mapping stage is important because the entire investigation is based on it.

Geographical information systems (GIS) are computer-based tools that can be used to store, display, and analyze geographical information; GIS can be used by municipalities when mapping their storm sewer systems for the purpose of documenting illicit and/or inappropriate connections. The GIS system also serves as a data base to store information about the illicit and/or inappropriate connections, such as field screening and enforcement activities. If GIS is not being used or is not available to a municipality, then zoning maps, marked with important features (e.g., identification of potential discharge points) can also be used to target potential discharges for identification and further action, as necessary.

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Tracer Identification

To detect and identify non-storm water entries, dry-weather outfall discharges are analyzed for selected tracers (e.g., ammonia, surfactant), which are found in the potential contaminating sources. Ideally, the selected tracers should be unique for each potential non-storm water contaminating source and should exhibit the following properties:

- Significant difference in concentrations between possible pollutant sources
- Small variations in concentrations within each likely pollutant source category
- A conservative behavior (i.e., no significant concentration change due to physical, chemical, or biological processes)
- Ease of measurement with adequate detection limits, good sensitivity, and repeatability.

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The user's guide suggests tracers for common pollutant sources (e.g., sanitary wastewater, septic tank effluent, laundry wastewater, and vehicle washwater, as well as potable water and "natural waters"). A non-storm water entry investigation may need to select additional tracers specific to potential pollutant sources, especially industries, in the study area (e.g., major ions, specific heavy metals). For each selected tracer, the concentration means and standard deviations in all the potential source flows in the drainage area are needed (use of data from other drainage area investigations is not recommended).

Local data collected on tracers will be essential to identify the contamination sources in the outfall discharge. It is important that the tracer data be accurate. Guidance is provided in the user's guide on representative sampling and on the number of samples required for valid data.

Field Survey and Data Collection

Field investigations are used to locate and record all outfalls, including outfalls not previously identified from the mapping exercise. During field investigations, outfalls are physically inspected and samples are taken of any dry-weather flow for analyses. The field survey should, at a minimum, include:

- Accurately locating outfalls and assigning ID numbers
- Photographing outfalls
- Estimating outfall discharge flow rate (or identifying likely intermittent discharge)
- Physically inspecting and recording outfall characteristics, including discharge odor, color, turbidity, floatable matter (e.g., solids, oil sheen), temperature, deposits, stains, vegetation affected by pollutants, and damage to outfall structure
- Collecting dry-weather discharge samples for tracer analyses of specific conductivity (can be field measured with temperature), fluorides, hardness, ammonia, potassium, surfactants, fluorescence, and pH, as well as other samples, depending on industrial activities.

Intermittent flows will be more difficult to confirm and sample. Additional field visits, use of automatic samplers, and flow damming techniques may prove successful for obtaining samples of intermittent flows.

Analyses of Data Collected

Simple testing procedures are suggested for analyzing the tracer parameters. Except for temperature and specific conductivity measurements, the analyses should be carried out in a laboratory and not in the field to ensure consistent results. The laboratory need not be sophisticated; it can be a room or a trailer set up on a temporary basis.

The recommended analytical procedures for each tracer parameter are based on the following criteria:

- Appropriate detection limits
- Freedom from interferences
- Good analytical precision
- Low cost, good equipment durability
- Reasonable operator training requirements.

The user's guide also includes guidance on appropriate levels of analytical detection and precision (repeatability) needed to achieve acceptable results.

Categorization of Outfalls

Three levels of outfall discharges are defined: (1) pathogenic or toxic substance pollution, (2) pollution that is a nuisance or threatens aquatic life, and (3) unpolluted.

Pathogenic and toxic pollutants can cause illness upon water contact or consumption. They can cause significant water treatment problems for downstream consumers, especially if the pollutants are soluble metal and organic toxicants. These pollutants may originate from sanitary, commercial, or industrial wastewater non-storm water entries; household toxicant disposal; automobile engine degreasing; and excessive use of fertilizers and pesticides.

Nuisance and aquatic-life-threatening pollutants include laundry wastewaters, lawn irrigation runoff, vehicle washwaters, construction site dewatering, and washing of concrete ready-mix trucks. These pollutants can cause excessive algal growths, tastes, and odors in downstream water supplies, offensive coarse solids and floatables, and noticeably colored, turbid or odorous waters.

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Clean water discharged through storm water outfalls can originate from natural springs feeding urban creeks that have been converted to storm drains, infiltrating ground water, infiltrating domestic water from watering leaks, etc.

Outfalls can be classified by comparing the collected dry-weather outfall discharge data with potential sources flow data. At the very least, outfalls with major pollutant sources should be identified for immediate remediation.

Investigation and Remediation

Drainage area investigations to locate the source(s) of non-storm water entries can take a number of forms:

- In-depth watershed evaluation (e.g., evaluate whether sources are likely to be an individual industry or an areawide problem, such as general failure of sanitary wastewater sewers)
- Drainage system upstream surveys (e.g., tracer analyses, visual inspections, smoke and dye tests, and TV surveys to trace the individual sources of the pollutant)
- Industrial and commercial site studies (e.g., identify materials/chemicals used and/or produced and whether the sites discharge to a storm drainage system).

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Pollution Prevention Program

The goal of eliminating all non-storm water entries will probably not be achieved completely; however, any action that prevents future entries should be promoted. Typical actions include educating the public (industrial, commercial, residential, and governmental) and developing zoning and ordinances.

Discussion

In addition to these steps, the user's guide provides background information in the form of discussions, tables, and checklists to assist the user in identifying contaminated outfall discharges and potential sources and in using the tracer data to estimate the proportion of each contaminating source flow in the outfall flow.

SUMMARY

This chapter discussed the components of an effective illicit and/or inappropriate discharge detection program. The presence of illicit and/or inappropriate connections within a storm sewer system can adversely affect water quality. By implementing an effective illicit and/or inappropriate discharge detection program, a municipality can identify the source(s) of illicit and/or inappropriate discharges and take the action necessary to eliminate the discharges. Before the development of an adequate illicit and/or inappropriate discharge detection program, however, municipalities must identify the available fiscal resources, assess the public's knowledge of water quality issues, and develop an SWMP that will successfully complement the illicit and/or inappropriate discharge program. This chapter presented the components of an effective program, EPA's method of detecting illicit and/or inappropriate discharges, and detailed examples of programs from various municipalities. The components of an effective program include a mechanism for prohibiting illicit and/or inappropriate discharges, field screening, investigation of potential illicit and/or inappropriate discharges, spill response and prevention procedures, public awareness and reporting program, used oil/toxic materials management and disposal procedures, and methods to control infiltration from sanitary sewers to storm sewers. Within these components, the use of GIS for mapping illicit and/or inappropriate connections and for maintaining a data base of information on illicit and/or inappropriate discharges throughout the municipality is essential. EPA's method for detecting illicit and/or inappropriate connections is discussed within the user's guide. This method relies on the quantitative analysis of dry weather flows to identify the pollutants within illicit and/or inappropriate discharges. This information is then used to locate the potential source(s) of the discharges.

CASE STUDIES

The following case studies provide information on the various ways illicit and/or inappropriate discharge programs can be developed and implemented. These municipalities have incorporated the components of an effective program in ways that are most effective to their specific needs.

In 1985, the Fort Worth Public Health Department (Health Department) developed and implemented a unique program for detecting illicit and/or inappropriate discharge connections to its MS4s. The program, known as the Drainage Water Pollution Control Program, focuses on empowering people to take action against illicit and/or inappropriate dischargers and places less emphasis on excessive data collection. As a result, Fort Worth's program is cost efficient and ensures corrective compliance. The four components of Fort Worth's program are:

- Problem detection
- Source investigation
- Correction of problems
- Prevention of problems.

Problem Detection

The Health Department identified three means of detecting surface water contamination: (1) a drainage water quality assessment and monitoring program, (2) a biotoxicity testing method, and (3) a program for determining the concentrations of six metals in drainage sediments.

Assessment and Monitoring

The drainage water quality assessment and monitoring program examines the types of discharges entering a receiving water body (Trinity River). To properly assess the affect these discharges have on the water body, the Health Department thinks it is essential to monitor the discharges over an extended period of time. The monitoring technique used, however, is not one of quantitative analysis but relies mostly on visual observation of the outfalls or drainage ways. From its observations, the Health Department concluded that the presence or absence of persistent features (e.g., vegetation, animal life) at an outfall are directly related to water quality. Even though persistent features are a direct indication of water quality, one has to know which features are associated with good water quality and vice versa. One indication of a healthy waterway is the presence of a variety of plant and animal life; unhealthy waterways have little or no plant and animal life.

The assessment and monitoring phase of this program is based on detecting subtle changes in the waterways from frequent observations and by the use of modified versions of conventional chemical tests. The Health Department's methodology does not readily utilize consulting firms or laboratories to determine if a problem exists; however, if exact determinations are required, then the services of the aforementioned are solicited.

The Health Department chose 24 drainage outfalls and one control site for monthly water quality monitoring to assess the presence or absence of the undesirable features in the outfalls. Undesirable features include filamentous sewage bacteria, mosquito larvae, fish kills, water color, water odor, water clarity, water pH, oil sheen, floatable solids, and positive water tests to Nessler reagent. The information gathered from the monthly monitoring is recorded on data sheets. The data are compiled from all of the sites and displayed on a table with a 45-month profile. The occurrence and persistence of undesirable features indicate the impact that outfall drainage has on the Trinity River and the effectiveness of correction and prevention measures within the program.

Biotoxicity Testing

The 24 drainage outfalls are then subjected to biotoxicity testing. The purpose of the testing is to determine the presence of toxins in the waterway, the hazard level created by the toxins, and the source of the toxins. The object of the test is not to define the properties of toxic substances. Instead of a laboratory biotoxicity test, the Health Department conducts in-situ toxicity tests. Native aquatic species are used to assess the environmental affects of the toxins on the waterway habitat. The use of native species is key because they are accustomed to the environmental characteristics of the ecological region. To test these species, the Health Department used homemade minnow buckets, which are floating, ventilated, transparent combiners used to hold test organisms. The test is also used to examine surface water contamination.

Metal Testing

In addition to biotoxicity, the 24 sampling sites are analyzed for 6 metals. Water and sediment samples are collected for the following metals: cadmium, chromium, copper, lead, nickel, and zinc. To establish a basis for comparison, three nonpolluted background sampling sites were chosen to reflect the natural occurrence of these six metals within the waterway. The samples are analyzed according to the protocol within Standard Methods for the Examination of Water and Wastewater.

Source Investigation

After the detection of a drainage source of pollution, an investigation follows to determine whether the source of the problem is known or unknown. If the source is known, then the responsible party is connected, and action is taken to stop the discharge as soon as possible. The notification is done by a pollution control officer or other designated official. Unknown sources are traced back from the detection point to the source. The Health Department has a specially trained Storm Tunnel Investigation Team to trace illicit and/or inappropriate discharges through the sewer system to the source. The Health Department uses the following tools for source investigation: Storm Tunnel Investigation Team; a safety equipment Step Van; biotoxicity testing devices; fluorescent dyes and smoke generators for obscure tunnels and leaks; water evaluation equipment; Federal, State, and local regulations; and drainage maps.

All investigative activities are documented with photographs, reports, and samples. Required sampling is done according to Standard Methods and is handled through the chain of custody procedures specified by the legal authority. Other important information recorded during the investigation include time and date of the violation and investigation, location of the violation, location of the responsible party, name and telephone number of the responsible party and witnesses, description and results of any tests conducted during the investigation, and the name(s) of the investigator(s). All of this information is recorded on a Discharge Report Form.

Correction of Problems

The Health Department's approach is to correct the problem at the source, instead of the typical "end-of-the-pipe" treatment. Correcting problems at the source is essential because the drainage way below the outfall improves and the responsibility is placed on the pollution generator and not the municipality. Fort Worth notifies the responsible party, explains the violation(s) and the need to make corrections, issues time-dated notices on when to make corrections, and checks the violator's progress. If the pollution generator refuses to make corrections, then legal enforcement agencies (e.g., EPA) are notified.

Prevention of Problems

In addition, the Health Department uses a strategy of "concentric containment." Concentric confinement includes the recognition, containment, and resolution of existing illicit and/or inappropriate connections to prevent their spread to other areas of the city. To achieve this, the Health Department conducts weekly "roving patrols" of various city sectors and critiques the development plans of new industries and businesses. Public education programs (e.g., videotapes, workshops) are also available to community groups, schools, and other regulatory organizations.

To receive more information about Fort Worth's program, contact Gene Rattan at (817) 871-5463.

In Charlotte, North Carolina, controlling illicit and/or inappropriate discharges is an important issue. In conjunction with Mecklenburg County, Charlotte is in the process of developing an extensive program for detecting and removing sources of illicit and/or inappropriate discharges. A discussion of the components of Charlotte's illicit and/or inappropriate connections program follows.

Ordinances

Presently, Charlotte does not have an ordinance prohibiting illicit and/or inappropriate discharges into storm sewers or surface waters. However, the city is proposing an ordinance that will prohibit plumbed-in connection, intermittent discharges, and the dumping of trash and wastes (hazardous and nonhazardous) into surface waters. Other aspects of the ordinance will define non-storm water discharges and address the enforcement process, penalties for violation, and due process for appeals of violations. The development effort will be coordinated with Mecklenburg County's ordinance and will occur during the first year of the permit. The cost is estimated to be about $11,300.

Field Screen

Charlotte's proposed field screening program will result in a one-time visual field screen of every outfall in the city. The program will specifically address improving the efficiency of field screening methodology; a one-time visual screen of all outfalls; field screening of problem area outfalls; continuation, support, and expansion of Mecklenburg County's Stream Walk program; and maintenance of a GIS storm water data base.

Field Screening Methodology

To improve the efficiency of the field screening methodology, Charlotte takes a two-phased approach. Phase one will utilize the observation protocol used in the Part 1 application process. Observations will be made for the presence of dry weather flow, color, turbidity, and oil sheen. Phase two will identify sources of the illicit and/or inappropriate discharges and ensure compliance with the illicit and/or inappropriate discharge ordinance. The cost of this program is $10,000.

One-Time Visual Field Screen

Charlotte is in the process of developing a storm water utility, which includes a preventive maintenance program for the storm sewer system infrastructure. The storm drainage system is currently being inventoried. As part of this inventory, the city has initiated a 2-year, one-time visual field screen for dry weather flow of all outfalls. The cost of the program is $8,000 per year.

Problem Area Outfalls

As part of field screening the problem areas, Charlotte and Mecklenburg County investigated known water quality problems throughout the municipality. The city was broken down into polygons, which represented neighborhoods, land uses, and stream segments. These polygons were then prioritized on the types and magnitudes of the problems. To address the problems identified in the investigation, the city will be divided into zones and each zone will be assigned a zone team. This will be implemented in the second year of the permit and costs $130,000.

Mecklenburg County Stream Walk Program

The Mecklenburg County Department of Environmental Protection (MCDEP) sponsors a Stream Walk program. The participants in the program are volunteers from the county, Charlotte, and other surrounding counties. The volunteers are split into teams and assigned a resource person from the MCDEP staff. They walk streams that are affected by point and nonpoint source pollution and are responsible for investigating and determining the pollutant source(s). The weaknesses of the program, to be addressed by Charlotte and MCDEP, are available personnel, volunteer motivation, volunteer training, and public education. The program will cost approximately $36,000.

GIS Data Base Maintenance Program

A GIS data base will be used to track all field screening activities. The results of initial and followup field screening will be entered into the data base and used to identify the problem areas. The program is currently in use and the estimated cost is high.

Followup Investigation

The program tries to identify and remove all sources of illicit and/or inappropriate discharges by enhancing MCDEP's current program. The only two possible improvements to the program are to add more staff and to computerize it. Charlotte will be:

- Developing followup program procedures
- Developing and implementing a training program
- Implementing the followup procedures
- Maintaining a GIS data base.

Followup Procedures Development

The followup procedures will respond to the problems identified by the visual field screenings, MCDEP's Stream Walk, MCDEP's monitoring programs, problem area investigations, and citizen complaints. The areas to be addressed will be prioritized based on the urgency and magnitude of the problem. Teams will be assigned to the problem areas and are responsible for the determination and elimination of pollutant sources. To accomplish this task, the teams have to review existing data on the area, perform field reconnaissance, locate and identify problem sources, perform source identification methods (e.g., video, smoke, and dye testing), distribute violation notices, perform other enforcement actions, and notify higher authorities when appropriate. The program will be implemented during the first year and will cost $22,200.

Training Program

The training program for the followup investigations team will be developed with the training programs for industrial and related facilities. Charlotte will also coordinate the development of this training with supervisors of MCDEP's Stream Walk and Charlotte Mecklenburg Utility Department (CMUD). The training will address the reconnaissance followup methods (e.g., observation techniques, chemical screening), detailed followup methods (e.g., closed circuit television, dye and smoke testing), and enforcement methods. Training should begin in the middle of the first year and is estimated to cost $23,100 over the 5-year period.

Followup Procedures Implementation

During field investigations, the followup teams will identify sources of illicit and/or inappropriate connections using the prioritization system and the followup procedures. This will begin in the second half of the first year and will cost $50,000 annually.

GIS Data Base Maintenance

All of the information, including information on violations, received during the followup investigations will be entered into a GIS data base. This data base will be used to track repeat offenders and to produce annual reports to be presented to the State. The data base will cost approximately $14,000 per year.

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Spill Response Program

The objective of the spill response program is to prevent and respond to spills. The existing program is well developed; therefore, Charlotte will only enhance the public education and awareness aspect of the program. In Charlotte, the Fire Department is responsible for the spill response program and maintains a Hazardous Materials (HAZMAT) team. The city will review the types of spills and their causes in order to minimize the risk to storm systems and surface waters. The public education and awareness component will educate people on the illicit and/or inappropriate connections ordinance and encourage public reporting of spills. This program, which has an estimated cost of $30,000, will begin immediately.

Public Reporting Program

The objective of this program is to increase and improve public reporting of spills and improper disposal. The program will focus on public education and information to inform the public of the importance of reporting spills and illicit and/or inappropriate discharges. This program will be coordinated with other public education programs and will include information on:

- Charlotte's overall storm water management program
- The importance of the illicit and/or inappropriate connections component
- Charlotte's illicit and/or inappropriate connections ordinance
- Proper disposal and recycling programs
- The purpose of stenciling catch basins.

In addition, the program will:

- Publicize Charlotte's storm water hotline
- Encourage the public to readily report signs of illicit and/or inappropriate discharges
- Urge the public to participate in MCDEP's Stream Walk.

Information will be disseminated through public speaking, distribution of written materials at civic functions, participation of neighborhood groups and associations, and local media announcements. This program will begin immediately with an estimated cost of more than $70,000.

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Used Oil/Household Hazardous Waste Program

The objective of this program is to properly dispose of and manage used oil and household hazardous waste. Charlotte will address this problem with public education and changes to existing programs. The program will include used oil recycling, permanent household hazardous waste program, and a review of the current small quantity generators.

Used Oil Recycling Program

The used oil program is currently based on extensive public education. The components to revise/expand this program include:

- Review of the public and private facilities that accept used oil and a determination of additional facility locations

- Review of the existing Mecklenburg County program to determine the feasibility of expanding the program to include recycling other automotive parts

- Review of the possibility of providing curb-side pick-up of nonhazardous materials
- Inventory of used oil recycling facilities and implementation of a regular inspection program to prevent storm water pollution.

Household Hazardous Waste Program

The used oil public education program will provide information to the public and private sectors and will be coordinated with the household hazardous waste program. It will include education on:

- Illicit and/or inappropriate connections ordinance
- Negative impacts of dumping used oil into storm sewers
- Stenciling of catch basins
- Misconception that dumping in sanitary sewer is an alternative to the storm sewer
- Education of operators of recycling facilities the proper handling procedures of materials
- Economic incentives for private companies to encourage participation in used oil program.

The development of this program will begin immediately but will not be implemented until the third year. The estimated cost is $30,000 per year.

Charlotte, in conjunction with Mecklenburg County, will develop a permanent household hazardous waste turn-in program. The proposed methods of disposing of the wastes will include:

- <u>Modular Structures (Bare Bones)</u>: This is a continuous service program in which the public would bring their household hazardous wastes to a permanent site for temporary storage to be removed later by a licensed contractor. There is a minimum allocation for storage space.
- <u>Modular Structures</u>: This is the same program as above but it allows for more storage space.
- <u>Fixed Structure</u>: A continuous service program that will operate similarly to the modular structure except that it would be in a fixed place and allow for maximum storage.
- <u>Independent Fixed Structure</u>: This is the same as the fixed structure but would be located at a site different than the fixed location.
- <u>Mobile Unit</u>: This is a continuous service program in which the public would bring their household hazardous waste to a mobile unit that would move from one place to another.

Mecklenburg County currently has an educational plan which utilizes videos and brochures. This plan will be expanded by the use of utility bill inserts and media announcements. The planning of the household hazardous waste program is in progress and will be implemented in the second year. The costs for the city and county are estimated to be high.

Review of Small Quantity Generators

The purpose of the small quantity generators review is to determine what is required of the participants and how they impact storm water runoff. The data base of small quantity generators will be reviewed with HAZMAT and MCDEP to decide if any spill-related problems or contaminated site runoff have occurred in the past. As a result of this review, these facilities may included in Charlotte's inspection program for industrial facilities. The review program will begin immediately with an estimated cost of $15,000.

Infiltration and Seepage Program

Sanitary Sewer Program

The object of this program is to reduce and eliminate sanitary sewer seepage into the storm sewer system. This program should also increase city/county coordination in dealing with problems related to infiltration and seepage from sanitary sewers and septic systems to storm sewers and surface waters. Charlotte currently has city codes in place that require new and replacement sanitary and onsite waste disposal systems to be built to lessen or eliminate leakage and infiltration of floodwaters into the system and discharge from the system into floodwaters. There is also a code that allows the city to fix inoperative sanitary sewer lines on private property and requires payment from the property owner.

MCDEP responds to sanitary flow issues on a complaint basis. CMUD has a cross connection program for the sanitary sewer that requires periodic inspection for leakage and overflows. The Mecklenburg County Health Department issues septic tank permits for the inspection of new and failed septic systems within Charlotte. The Health Department also requires remediation of failed septic systems, which are usually reported by citizen complaint, an MCDEP stream walker, or government inspector.

CMUD is currently developing a dynamic sanitary system model, along with a monitoring program for sanitary system flows and rainfall. Charlotte's role in the development of this program includes:

- Coordinating the preparation of ordinances to enforce the programs
- Ascertaining whether storm water detention facilities should continue to be built over sanitary sewer lines
- Ensuring that illicit and/or inappropriate disconnections from the storm sewer will not increase connections to sanitary sewer
- Implementing a source control program that will limit the dumping of materials into the sanitary sewer that are not treatable
- Developing public education and awareness programs.

The review and coordination of the infiltration and cross connection program with CMUD will begin immediately with an estimated cost of $15,000.

Septic Tank Program

Charlotte, in conjunction with the Mecklenburg County Health Department, will review and revise the current septic tank program. The weaknesses they will address include:

- Notification/inspection procedure
- Lack of contractor supervision
- Abandoned septic tanks not required to be sealed
- Allowable construction of septic tanks in sensitive areas.

The septic tank program will also include a public education component and a data base of septic tank failures. The review and revisions will begin immediately with an estimated cost of $15,000.

The city of Seattle realizes the negative impacts of illicit and/or inappropriate discharges and currently operates a program that detects and eliminates such discharges. Public education and awareness is an important component of this program, but emphasis is also placed on enforcement.

Ordinances

Seattle's key ordinance to prevent illicit and/or inappropriate discharges is the Storm Water, Grading and Drainage Code. Other ordinances, with pollution prevention components, include the Side Sewer Ordinance, the Street Use Ordinance, and the Solid Waste Ordinance. The Storm Water, Grading and Drainage Code prohibits certain discharges into the storm drainage system, requires existing dischargers and land users to implement pollution prevention practices to minimize the pollutants entering storm water discharges, requires the city to review plans for drainage control and grading activity, regulates sediment and erosion controls for construction sites, designates responsibility for maintenance of drainage control facilities and erosion practices, and establishes enforcement procedures. The Storm Water, Grading and Drainage Control Code is enforced by the Department of Construction and Land Use (DCLU), the Department of Engineering - Street Use Section, and the Department of Engineering - Drainage and Wastewater Utility (DWU).

Metro's Key Manhole Monitoring Program

The Municipality of Metropolitan Seattle (Metro) uses a manhole monitoring program to ascertain whether or not illicit and/or inappropriate connections are present and, if so, to identify the sources. After the sources are identified, companies are brought into compliance with Metro's discharge limits and pretreatment standards. This program also requires inspections of facilities that violate the permit requirements.

Field Screening

Seattle DWU's field screening program consists of responding to citizen complaints, responding to city employees or other agency calls, and implementing source control programs and long-term monitoring of surface waters. Seattle will rely on its ordinances, the erosion control program, citizen response, and field personnel to control future illicit and/or inappropriate connections problems.

Followup Investigation Program

The objectives of Seattle's Source Control Program are to eliminate cross connections, reduce spill-related risks, promote better waste disposal, promote good housekeeping practices, provide educational materials on water quality, and require routine maintenance of storm water control facilities where new storm drains will be constructed to reduce combined sewer overflows. This program is implemented on a watershed basis and responds to the unique characteristics of that watershed. The Source Control Program is first implemented in watersheds identified by the Department of Ecology as having surface waters of concern. These are areas of concern because they are used for recreation or as a fisheries resource. The Source Control Program contains the following steps:

- Data Gathering: All the water and sediment quality data from the storm drainage system and all the basin information (e.g., size, topography, industry type) are compiled. Drainage maps and side sewer cards identify outfalls and sewer lines.

- Initial Investigation: Drainage basins are field checked. The side sewer cards are examined, industrial sites are inspected, historical information from the owner is obtained, dye testing is performed to prove connections, and a television inspection is done when necessary. Seattle's storm drain lines and catch basin maintenance schedule is evaluated and when necessary revised to improve water quality.

- Business Inspection and Education Program: Businesses with a high potential to pollute storm water discharges are visited by Source Control Water Quality Investigators. During the visit, the operator will receive a copy of the written inspection procedures. If necessary, followup visits are conducted to guarantee compliance. The operators are encouraged to implement new BMPs or improve old ones to ensure compliance. The facilities are also given information on current programs, including enforcement information. Repeat offenders are referred to the appropriate agency for enforcement action.

- Education and Outreach: Educational materials describing the negative impacts illicit and/or inappropriate discharges have on the storm sewers and surface waters are distributed within watersheds to the public and to industrial facilities. An incentive program is provided for businesses to encourage participation.

The Source Control Program approach by watershed allows for onsite visits and for pipes to be checked for illicit and/or inappropriate connections and has been very effective. Seattle also works with Metro's Industrial Waste Staff because of their authority to enforce pretreatment limits on discharges from industries.

Spill Prevention Program

As required by the Source Control Program, site inspections are performed at industries identified as significant polluters. The inspectors ensure that each facility has a spill prevention plan, including the materials to respond to a spill. The Seattle Municipal Code requires all industrial facilities to develop and implement spill prevention plans.

Seattle Fire Department - Hazardous Materials Unit

Within Seattle, the Fire Department is the main responder to spills within the city, as well as those to surface waters. The Fire Department enforces sections of the Uniform Building Code that address buildings used for storing, handling, or using hazardous wastes. Each industry that uses or stores certain amounts of hazardous wastes is required to obtain a permit from the Fire Department. Facilities are inspected when they apply for the permit and are inspected each year after permit issuance.

Seattle Police Department - Harbor Patrol Unit

The Seattle Harbor Patrol is responsible for the enforcement of oil spill regulations within the Seattle Harbor Code. The patrol investigates complaints received from a 24-hour hotline and reports from the Department of Ecology and the U.S. Coast Guard. If a pollution problem exists, the source is traced and enforcement actions taken.

Trouble Call Network

Metro runs a Trouble Call Network for public use for handling potential water quality problems, including spills. Seattle works with Metro on this project.

Public Reporting Program

DWU published literature with telephone numbers for citizen use when reporting water quality problems or for requesting information on disposal of hazardous materials.

DWU recognizes the importance of public education in relation to protecting water quality and has taken an approach that combines the following three components: public involvement, in-school education, and general public outreach.

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Public Involvement

Citizen involvement was important in developing Seattle's storm water program, and DWU involves citizens at various levels of the decisionmaking process. The public involvement programs include the following:

- Comprehensive Drainage Plan Citizens Advisory Committee: Citizens were key in developing the DWU. The DWU is charged with developing a Comprehensive Drainage Plan to determine which areas would benefit the most from the new fees. A Citizens Advisory Committee (CAC) was created to represent the community interests. The Comprehensive Drainage Plan is the foundation of Seattle's water quality projects and will be updated in 5 years with public involvement.

- Drainage and Wastewater Utility Citizens Advisory Committee: The CAC is now the advisory committee for the ongoing activity of the DWU. The Drainage and Wastewater Utility Citizens Advisory Committee (DWUCAC) has expanded its membership to include minority communities and industrial interests that are concerned about water quality and utility services.

- Capital Project Development: When plans for new capital facilities are developed, DWU involves the public. The public interest usually focuses on the impacts of construction but may expand to include water quality and environmental improvement.

- Watershed Planning: The Puget Sound Water Quality Authority and the Department of Ecology administer a program that addresses planning for the control of nonpoint source pollution within watersheds. The watershed plans are developed by a Watershed Management Committee (WMC), which comprises members from community and business organizations and government agencies that are interested in the watershed.

Schools Education Program

These educational programs emphasize respect for water resources and encourage responsible behavior. DWU's schools program builds on existing environmental education and has reached 80 Seattle schools. The following list describes several of these programs:

- Salmon in the Classroom: DWU has provided the training and equipment for teachers in schools to raise salmon from egg to fry and then release the fry into local receiving waters. The salmon are raised in aquariums that simulate spawning stream conditions. DWU trains the teachers participating in the project and provides a manual for additional training and lesson planning. DWU also sponsors two field trips: one to obtain the eggs and the other to release the fry.

- Water Quality Field Trip: DWU sponsors a field trip every year for fourth or fifth grade students to the Seattle Aquarium to learn about aquatic species, their habitat, and the impacts of human activity on their habitat. DWU also sponsors a fishing field trip to a trout farm. Students receive a tour and learn about the impacts of nonpoint source pollution.

- Middle School Water Quality Education Video Program: "Water You Doing?" is a 35-minute educational video produced by DWU with a grant from the Department of Ecology. The video's audience is middle school students and includes a teacher's manual and field trip guide. Five video segments address five different water quality issues. The manual describes lesson planning, is a resource guide, and contains a field trip directory. DWU has given workshops on how to use the video and has distributed it to every public middle school in Seattle.

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- Speakers Bureau: DWU employees who work on water quality issues, community volunteers, and others are part of DWU's speakers bureau. The speakers give classroom presentations on water quality education activities sponsored by the DWU.

- Puget Sound on Wheels: DWU is sponsoring the development of a mobile educational display by the Seattle Aquarium. The display will include a truck outfitted with a walk-through exhibit describing the Puget Sound water resource, habitat, and pollution issues. The exhibit will be shown at schools and community fairs.

- Education Coordination: Other educational efforts sponsored by DWU include a teachers advisory committee that evaluates the water quality classroom and field trip activities to help DWU enhance its programs; DWU participation on Seattle's Environmental Education Committee and promotion of its programs, as well as work with other organizations; and membership in the Washington Environmental Education Committee sponsored by the State Superintendent for Public Instruction.

General Public Education Program

Many residents have an out-of-sight, out-of-mind attitude about their behaviors concerning water quality. General public education should change the negative everyday activities people perform on a regular basis. The following DWU programs encourage appropriate behavior and community initiative to protect water quality:

- Source Control Education: With a grant from the Department of Ecology, DWU has implemented a program to control nonpoint source pollution at the source. DWU accomplishes this through a three-pronged approach: Consumer Education, Clean Water Business Partners, and Targeted Education Campaigns.

- Watershed Education: DWU currently sponsors two watershed action plans in Seattle. The WMC responsible for developing the plans concluded that the people living and working within the watersheds must be educated on water quality in order to prevent further degradation of the watersheds.

- Storm Drain Stenciling: DWU uses volunteer school and community groups to paint a message on Seattle's storm drain inlets. With this program, DWU hopes to rid Seattle of the out-of-sight, out-of-mind attitude.

- Motor Oil Recycling: DWU and the Seattle Solid Waste Utility coordinate a used oil recycling program. Waste oil collection tanks are located at the 12 locations of an auto supply store in Seattle. The supply store, along with the utilities, publicizes the program.

- Waterfront Awareness Company: DWU and an association of waterfront businesses have initiated a cleanup campaign for the waterfront. DWU has also added a pollution prevention message to the effort and has recruited children to paint pollution prevention messages on trash cans.

- Seattle Aquarium Intertidal Exhibit: DWU has contributed to a new aquarium exhibit displaying an intertidal ecosystem and explaining the potential negative impacts of human activity on the ecosystem.

- Bill Inserts and Citywide Direct Mailings: DWU includes education and public awareness materials in its bimonthly billings. Customers are also mailed brochures about water quality protection and storm water management.

- Outreach to Non-English Speaking Communities: DWU is developing water quality messages in different languages for publication in community newspapers.

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- Television Public Service Announcements: DWU has developed four public service announcements for broadcast on local television. The announcements address the importance of watersheds, the difference between sanitary and storm sewers, nonpoint source pollution, and pet waste.

- Seattle Public Libraries: DWU is currently working to distribute copies of the educational videos to all branches of the public library. The video has also been made available for broadcast on the public access cable station. DWU will develop educational displays for all of the libraries.

Local Hazardous Waste Management Plan for Seattle-King County

Seattle is part of the local hazardous waste management plan and is currently developing and implementing programs for small businesses. The components of the program are to provide free onsite consultations to small businesses; organize seminars, workshops, and classes for business persons; create brochures, booklets, and other materials; create a resource library on hazardous waste issues; provide response to complaint calls and agency referrals; conduct onsite surveys of business practices; and research new treatment methods. Participating agencies include the Seattle-King County Health Department, King County, Seattle, Metro, and 29 suburban cities.

Solid Waste Utility Household Hazardous Waste Program

The Seattle Solid Waste Utility operates one permanent household hazardous waste collection site and sponsors a used motor oil collection system. The household hazardous waste component also provides educational materials to the public on alternative products, collection services, and the proper use and disposal of products.

Metro's Small Quantity Generator Program

This program provides small businesses with information and assistance on the proper use and disposal of hazardous wastes and on ways to minimize the pollutants entering storm drains and surface waters. The Waste Information Network was developed through this program and consists of private businesses, public agencies, and other groups that try to resolve waste management concerns.

Seattle-King County Department of Public Health Environmental Services Program

The health department operates a telephone information line that provides information on waste reduction and the proper storage and disposal of household hazardous wastes. The health department also operates a materials exchange, known as "Industrial Materials Exchange" (IMEX). IMEX oversees the transfer of hazardous materials from the generator to a party that can use them.

Infiltration Control Program

If infiltration from the sanitary sewer to the storm sewer occurs, the city's maintenance crew will conduct a television or walk-through inspection to locate the leak and make the necessary repairs. Storm drain maintenance activities include upgrading surface drainage facilities (e.g., inlets, catch basins, junction boxes, ditches) and removing debris from detention facilities. Sewer maintenance includes inspection, routine cleaning, and system repairs.

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Virginia Beach presently facilitates or participates in existing programs that address illicit and/or inappropriate discharges and other forms of pollution. The illicit and/or inappropriate discharge program described below will supplement the current programs for detecting and eliminating sources of illicit and/or inappropriate discharges.

<u>Ordinances</u>

The city of Virginia Beach has developed the Storm Sewer Discharge Ordinance, which authorizes the city to regulate non-storm water discharges to storm sewers and surface waters. This ordinance will supplement other codes currently in effect, specifically the building code, which requires sanitary and storm sewers of a building to be kept separate. The Department of Public Works will be responsible for implementing and enforcing the ordinance. The Storm Sewer Discharge Ordinance also grants inspection and monitoring authority, as necessary, for administration and enforcement to the Department of Public Works. An existing program conducted by Public Works through the Department of Permits and Inspections inspects construction sites for illicit and/or inappropriate discharges. Other city agencies that perform inspections are to report violations to the Department of Public Works.

<u>Ongoing Field Screening Program</u>

The purpose of this program is to test field screening points throughout the term of the permit for dry weather flows and other indications of possible illicit and/or inappropriate discharges. The program will screen points identified in the city's Part 1 application and screen new points.

Part 1 Sites

Out of the 112 field screening points with dry weather flow identified in Part 1, 30 sites were chosen for continued dry weather monitoring. The sampling results are compiled and added to the existing GIS data base. If dry weather flow continues at these sites, the possible source(s) will be investigated.

New Sites

New field screening sites will be chosen from areas with high concentrations of commercial, industrial, and older residential areas and from major highways and roads that have automotive and commercial service areas. The final selection of the new screening points will be determined by field inspection. The chosen outfalls are examined for dry weather flow. If flow is present, then a sample is taken. Twenty-five new field screening points will be evaluated during each year of the permit. The sampling data for each site will be compiled and entered into the GIS data base. If dry weather flow continues at these sites, the possible source(s) will be investigated.

<u>Investigation of the Storm Sewer System</u>

To locate the sources of illicit and/or inappropriate discharges, sections of the storm sewer will have to be investigated. Investigations will be conducted based on analysis of the data received from field screening activities and any other information the city receives concerning illicit and/or inappropriate connections. This program will emphasize public reporting to aid investigations. Investigations will occur at the problem areas and will involve mapping and evaluation, field surveys, and source identification.

Mapping and Evaluation

Each area to be investigated will be highlighted on the storm sewer map, and the drainage area will be defined. The types of land uses will also be evaluated to determine the types of residential, commercial, and industrial areas that may be potential polluters. Other areas that will receive special attention include sanitary, septic tanks, and vehicle maintenance activity sources.

Field Surveys

The city will utilize the strategy of "halving-intervals" to locate the area of the source. This method will be applied to the main trunk of the sewer system and branch lines as necessary. Investigations will occur halfway between the field screening points and the upper most headwater locations. These investigations will use the same criteria as the field screening, except only one site visit will be conducted. The Department of Public Works will perform the field surveys.

Source Identification

After the area and the probable activity have been identified, field visits will be conducted to identify the source(s). Five actions are taken to eliminate a source once it is identified: sending a letter with a questionnaire; site visit and interview; dye tests or smoke tests, if needed; noncompliance notification; and followup inspections.

- Letter with Questionnaire: The Department of Public Works will send a letter to the owner/operator of the suspected source to advise the owner/operator of the problem and to request that the owner/operator complete the attached questionnaire. The completed questionnaire should describe the industrial activities and indicate the possible sources of non-storm water discharges.

- Site Visit and Interview: After the questionnaire is received, a staff person from the Department of Public Works will conduct a site visit and interview to further pinpoint the source.

- Dye Tests and Smoke Tests: If the questionnaire, site visit, and interview do not support the field screening data, then it is necessary to perform fluorometric dye tests of plumbing fixtures and floor drains. If several sources are suspected, a smoke test may be needed to limit the number of possible sources and to allow for a more detailed analysis. These tests will be performed by the Department of Public Works.

- Notification of Noncompliance: Once the suspected source is confirmed, the owner/operator will be issued a notification of noncompliance with the Storm Sewer Discharge Ordinance and will be subject to the penalties in the ordinance.

- Followup Inspection: The Public Works staff will conduct followup inspections to ensure that corrective action was taken and the illicit and/or inappropriate discharge has been eliminated. If the negligent violation continues, the Virginia Water Control Board (VWCB) and/or the news media will be notified.

Spills Program

The spills program in Virginia Beach has two components: hazardous material spill response and inspection of sites for proper compliance with State and Federal regulations for gas, oil, and hazardous chemicals.

Spill Response Program

The city will continue to implement its Hazardous Materials Emergency Response Plan through the Virginia Beach Fire Department. The plan is structured to comply with SARA Title III, Emergency Planning and Community Right-to-Know legislation. The response plan details the proper procedures to be followed in the event of a hazardous materials spill, which could affect persons, property, or the environment. The plan also describes the roles and responsibilities of local government and private agencies when responding to hazardous materials emergencies.

The Fire Department is responsible for the command and control of activities during a spill event. The Fire Department provides initial containment, fire suppression, rescue operations, and evacuation procedures. However,

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cleanup is the responsibility of the spiller, or owner/operator of the facility, with monitoring from the Fire Department. When necessary, the Fire Department contacts local, State, and Federal government offices. The Department of Public Works will be notified if any spills enter or have the potential to enter the storm sewer or surface waters. Public Works will then assist the Fire Department with material and equipment to prevent the spill from entering the storm sewer and/or to remove an existing spill from within the storm sewer.

Inspection Program

The VWCB is responsible for regulating waste materials for wastewater and petroleum products, and the Virginia Department of Waste Management regulates solid and hazardous wastes. Under the Hazardous Waste Management Regulations, the Virginia Department of Waste Management requires facilities that generate more than 1,000 kilograms per month of hazardous waste to develop a contingency plan and emergency procedures. The Federal Government requires a spill prevention and containment countermeasures (SPCC) plan for facilities that have the potential to discharge oil in reportable quantities to surface waters. VWCB requires facilities covered under an SPCC to develop an oil discharge contingency plan for bulk storage of 25,000 gallons or more.

- The city has an inspection program that delineates the proper methods for the storage and handling of hazardous wastes to prevent spills from entering the storm sewer or surface waters. The Fire Marshal's office inspects all commercial properties for compliance. Inspection frequency is based on the nature of the perceived hazard. New buildings and construction sites are inspected by the Permits and Inspections Division of the Department of Public Works to ensure compliance with State and Federal regulations for gas, oil, and hazardous chemicals.

Reporting of Illicit and/or Inappropriate Discharges and Water Quality Impacts

Virginia Beach has implemented various programs to address water quality issues. Public education programs in relation to storm water are coordinated through the Public Information Office at Public Works. The city's local cable television channel has shown videos on water quality, litter control, sediment and erosion control, and storm water management. The city has also distributed literature in the form of leaflets and brochures on similar topics. On a regional level, storm water public information programs are developed through the Hampton Roads Municipal Communicators (HRMC). HMRC's membership includes the cities/counties of Virginia Beach, Norfolk, Hampton, Chesapeake, James City, Newport News, Portsmouth, Suffolk, and York. Upcoming projects include stenciling storm drains and developing public service announcements for media broadcast.

Awareness and Reporting

The current programs increase public awareness of water quality issues and of potential impacts of illicit and/or inappropriate discharges. The city would like the public to increase reporting of illicit and/or inappropriate discharges. The Department of Planning within the Division of Environmental Management, along with other departments, takes reports of odor, color, turbidity, and the presence of trash in storm sewers and waterways. The following information programs will continue to increase public awareness and encourage the public to report signs of illicit and/or inappropriate discharges. These information programs include a brochure, Cityline message, and a slide show:

- Brochure: The brochure will address "what to look for" and "who to report to." The public will receive discharges. The brochure will present the options of a hotline and a mailing address for reporting. The Public Information Office will develop and distribute the brochure with funding from Public Works. The brochure will be mailed with the water/sewer bill every 2 years and be distributed to schools and community groups.

- Cityline Message: Virginia Beach has a public information service line called Cityline. A taped message concerning illicit and/or inappropriate discharges will be developed for Cityline and will include information similar to that in the brochure.

- Slide Show: A slide show with accompanying text will be developed by the Public Information Office. The target audience will be children and community groups. The slide show will be presented once a year at elementary, middle, and high schools. A copy of the slide show will also be given to the Virginia Marine Science Museum.

Proper Management and Disposal of Used Oil and Toxic Materials

The City currently participates in programs that facilitate the proper disposal of used oil and toxic materials. The Southeastern Public Service Authority (SPSA) has various recycling programs, including curbside collection and drop-off centers. SPSA produces and distributes brochures explaining the recycling program and listing the locations of the drop-off centers. Household hazardous wastes are accepted at the regional landfill and at seven transfer stations free of charge to private citizens. The State of Virginia operates a used oil recycling program through the Department of Mines, Minerals and Energy. This program recruits service stations to accept and properly dispose of used oil. A toll free number that gives the names and locations of the service stations is available to the public.

New Programs

The following new programs will be developed:

- Brochure: The Public Information Office will develop and distribute a brochure to promote and explain all programs within the city that handle the proper management activities of used oil and toxic materials. The brochure will list the telephone numbers of the various agencies with such programs. The brochure will be available at slide show presentations and mailed every 2 years with the water/sewer bill separate from the illicit and/or inappropriate discharges brochure.

- Cityline Message: A hyped message will be developed by the Public Information Office that will state the major programs and information sources that deal with the management and disposal of used oil and toxic materials.

- Slide Show: A slide show will be developed on the proper management and disposal of used oil and toxic materials. The slide show will be made available to schools, community groups, and the Virginia Marine Science Museum.

Controls to Limit Infiltration from Sanitary Sewers and Septic Systems

Sanitary Sewers

Problems with infiltration of seepage from sanitary sewers to storms sewers in Virginia Beach are rare because the storm sewer is located under the curb and the sanitary sewer is in the middle of the road. The Sewer and Water Standard Specifications and Details of the Department of Public Utilities requires consideration of design, pipe depth, and alignment to avoid conflict between the two sewer systems and to facilitate maintenance. When a leak or spill does occur from the sanitary sewer to the storm sewer, the sewage is contained in the storm sewer and pumped to the sanitary sewer or tanker trucks to prevent discharge to surface waters. If the sewage cannot be collected, Public Utilities will disinfect the site and obtain a special discharge permit from VWCB. Sanitary overflows are reported to VWCB's Tidewater Regional Office within 24 hours. A written report is also required within 5 days. Public Utilities reports any overflows to Public Works.

The Department of Public Utilities has an inspection program for locating defects within the sanitary sewer system. Television inspections for infiltration problems are performed on 80,000 feet of sewer lines per year.

Septic Systems

Subdivision regulations require every subdivision to have an adequate sanitary sewerage system cohesive with the type of development proposed. If public sewerage is not an option, then private septic tanks must be built. These individual sewerage systems must be permitted by the Virginia Beach Health District in cooperation with the Virginia State Health Department.

If the public health director determines that the area chosen for the septic system has poorly drained soils, then a land management plan must be developed by the property owner and approved by the director. The plan must contain the location of the septic tanks and a proposed drainage plan. The owner is also responsible for the construction, repair, maintenance, and operation of the system.

If septic tanks are located in the Chesapeake Bay Preservation Area, the Chesapeake Bay Preservation Area Ordinance requires the property owner to provide a reserve sewage disposal drainfield site with a capacity at least equal to the primary sewage disposal drainfield site. The same is true for septic systems located in the Southern Watersheds, as stipulated in the Southern Watersheds Management Ordinance.

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1994 Report to Congress

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

THE ADMINISTRATOR

The Honorable Albert Gore
President of the Senate
Washington, D.C. 20510

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Dear Mr. President:

As required by Section 305(b) of the Clean Water Act (CWA), I am transmitting to the Congress the 1994 National Water Quality Inventory Report. This biennial report is the tenth in a series of national water quality assessments published since 1975 by the U.S. Environmental Protection Agency. On December 14, 1995, we transmitted to you the executive summary of the report and summaries of water quality conditions in each of the States and Territories; the enclosed includes the entirety of the report.

Based on surveys conducted by the States, this report indicates that, while most of the Nation's surveyed waters are of good quality, about 40 percent of the Nation's surveyed rivers, lakes, and estuaries are too polluted for basic uses, such as fishing or swimming. These results are consistent with those reported in 1992 and show that, on the whole, we have managed to hold the line or prevent further degradation, and still maintain continued population growth and growth in economic activity.

States reported that the beneficial uses that they designate for the waters in their water quality standards, such as drinking water supply, swimming, and the propagation of aquatic life, were impaired in 36 percent of surveyed river miles, 37 percent of surveyed lake acres, and 36 percent of surveyed estuarine square miles. In addition, States report that they consider some of the good quality waters threatened because they could become impaired if pollution prevention or control actions are not taken.

According to the States, the most commonly reported problem in impaired waters is polluted runoff from agricultural lands and urban streets. Pollutants include nutrients, siltation, and bacteria. Agriculture is the leading source of pollution in rivers and lakes, and ranks in the top three sources in estuaries.

It is important to recognize that, despite the remarkable accomplishments of the past two decades, significant water pollution problems remain. The cost of sewage treatment still needed is estimated to be over $100 billion. Toxic pollutants discharged by industry continue to pose a threat to humans, aquatic life, and wildlife. Runoff from agricultural operations, city streets, and construction sites also causes significant water pollution problems. Wetlands, which cleanse our waters, protect our property from floods, and provide breeding grounds for our Nation's fisheries and waterfowl, continue to be lost and degraded. For these reasons, we want to ensure that we continue the progress we have made toward cleaner water and address our remaining water pollution problems. We look forward to working with Congress in efforts leading toward this goal.

Sincerely,

Carol M. Browner

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WASHINGTON, D.C. 20460

THE ADMINISTRATOR

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The Honorable Newt Gingrich
Speaker of the House of
Representatives
Washington, D.C. 20515

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Carol M. Browner

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Acknowledgments

This report is based primarily on water quality assessments submitted to the U.S. Environmental Protection Agency by the States, Territories, American Indian Tribes, the District of Columbia, and Interstate Commissions of the United States. The EPA wishes to thank the authors of these assessments for the time and effort spent in preparing these reports and reviewing the draft of this national assessment. Additional thanks go to the water quality assessment coordinators from all 10 EPA Regions who work with the States, Tribes, and other jurisdictions.

The project manager and editor of this document was Barry Burgan of the Monitoring Branch, Assessment and Watershed Protection Division, Office of Wetlands, Oceans and Watersheds. Key contributions were also made by the following individuals in other EPA program offices: Roger Anzzolin and Chuck Job, Office of Ground Water and Drinking Water; Dan Weese, Mike Mundell, and David Sprague, Permits Division; Michael Plehn, Wetlands Division; Ann Beier, Nonpoint Source Control Branch; Joe Hall, Oceans and Coastal Protection Division; Susan Ratcliffe, formerly of the Watershed Branch; Wayne Davis, Office of Policy, Planning and Evaluation; Kevin Summers and Steve Paulsen, Ecological Monitoring and Assessment Program; Joseph Macknis, Chesapeake Bay Program; Larinda Tervelt, Gulf of Mexico Program; Bob Beltran, the Great Lakes National Program Office; Melissa McCullough, the Great Waters Program; Marlene Regelski, American Indian Environmental Office; Ginny Kibler, Office of Water; and Alice Mayio, Assessment and Watershed Protection Division. Additional information was provided by the U.S. Geological Survey, the Tennessee Valley Authority, the National Oceanic and Atmospheric Administration, and the National Centers for Disease Control and Prevention.

EPA would also like to thank all of the artists and photographers who contributed their work for inclusion in this document. We regret that we were unable to include all of their fine work in this document.

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For more information about the National Water Quality Inventory Report, the companion summary document, or their content and presentation, contact:

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For additional copies of this report, the appendixes, the companion summary document, or other water quality assessment materials, please see the order form at the back of this report.

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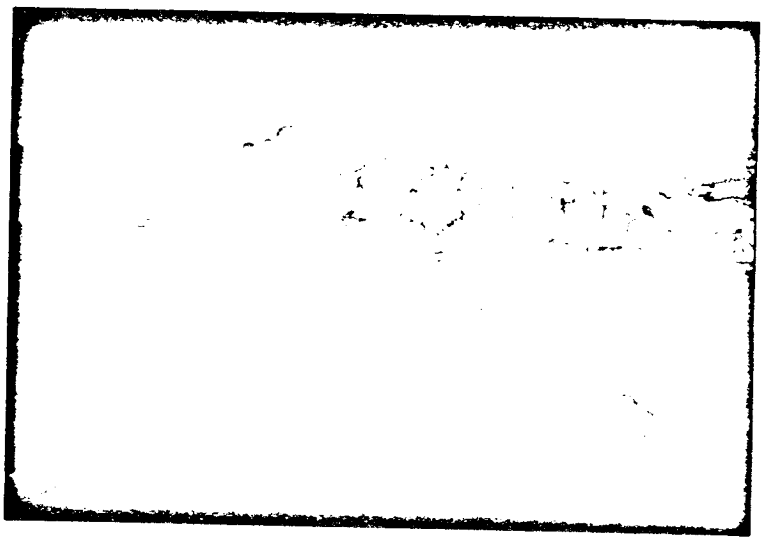
The Quality of Our Nation's Water

Introduction

The *National Water Quality Inventory Report to Congress* is the primary vehicle for informing Congress and the public about general water quality conditions in the United States. This document characterizes our water quality, identifies widespread water quality problems of national significance, and describes various programs implemented to restore and protect our waters.

The *National Water Quality Inventory Report to Congress* summarizes the water quality information submitted by 61 States, American Indian Tribes, Territories, Interstate Water Commissions, and the District of Columbia (hereafter referred to as States, Tribes, and other jurisdictions) in their 1994 water quality assessment reports. As such, the report identifies water quality issues of concern to the States, Tribes, and other jurisdictions, not just the issues of concern to the U.S. Environmental Protection Agency (EPA). Section 305(b) of the Clean Water Act (CWA) requires that the States and other participating jurisdictions submit water quality assessment reports every 2 years. Most of the survey information in the 1994 Section 305(b) reports is based on water quality information collected and evaluated by the States, Tribes, and other jurisdictions during 1992 and 1993.

It is important to note that this report is based on information submitted by States, Tribes, and other jurisdictions that do not use identical survey methods and criteria to rate their water quality. The States, Tribes, and other jurisdictions favor flexibility in the 305(b) process to accommodate natural variability in their waters, but there is a trade-off between flexibility and consistency. Without known and consistent survey methods in place, EPA must use caution in comparing data or determining the accuracy of data submitted by different States and jurisdictions. Also, EPA must use caution when comparing water quality information submitted during different 305(b) reporting periods because States and other jurisdictions may modify their criteria or survey different waterbodies every 2 years.



Paul Goetz, Cary, NC

For over 10 years EPA has pursued a balance between flexibility and consistency in the Section 305(b) process. Recent actions by EPA, the States, Tribes, and other jurisdictions include implementing the recommendations of the National 305(b) Consistency Workgroup and the Intergovernmental Task Force on Monitoring Water Quality. These actions will enable States and other jurisdictions to share data across political boundaries as they develop watershed protection strategies.

EPA recognizes that national initiatives alone cannot clean up our waters; water quality protection and restoration must happen at the local watershed level, in conjunction with State, Tribal, and Federal activities. Similarly, this document alone cannot provide the detailed information needed to manage water quality at all levels. This document should be used together with the individual Section 305(b) reports (see the inside back cover for information on obtaining the State and Tribal Section 305(b) reports), watershed management plans, and other local documents to develop integrated water quality management options.

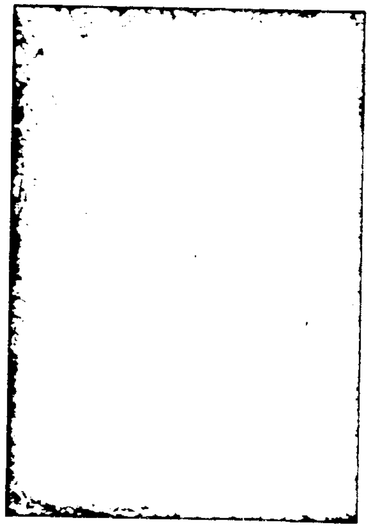
Key Concepts

Measuring Water Quality

The States, participating Tribes, and other jurisdictions survey the quality of their waters by determining if their waters attain the water quality standards they established. Water quality standards consist of beneficial uses, numeric and narrative criteria for supporting each use, and an antidegradation statement:

■ **Designated beneficial uses** are the desirable uses that water quality should support. Examples are drinking water supply, primary contact recreation (such as swimming), and aquatic life support. Each designated use has a unique set of water quality requirements or criteria that must be met for the use to be realized. States, Tribes, and other jurisdictions may designate an individual waterbody for multiple beneficial uses.

■ **Numeric water quality criteria** establish the minimum physical, chemical, and biological parameters required to support a beneficial use. Physical and chemical numeric criteria may set maximum concentrations of pollutants, acceptable ranges of physical parameters, and minimum concentrations of desirable parameters, such as dissolved oxygen. Numeric biological criteria describe the expected attainable community attributes and establish values based on measures such as species richness, presence or absence of indicator taxa, and distribution of classes of organisms.



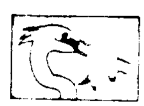
Barry Burgan, U.S. EPA

■ **Narrative water quality criteria** define, rather than quantify, conditions and attainable goals that must be maintained to support a designated use. Narrative biological criteria establish a positive statement about aquatic community characteristics expected to occur within a waterbody. For example, "Ambient water quality shall be sufficient to support life stages of all native aquatic species." Narrative criteria may also describe conditions that are desired in a waterbody, such as "Waters must be free of substances that are toxic to humans, aquatic life, and wildlife."

■ **Antidegradation statements**, where possible, protect existing uses and prevent waterbodies from deteriorating, even if their water quality is better than the fishable and swimmable water quality goals of the Act.

The CWA allows States, Tribes, and other jurisdictions to set their own standards but requires that all beneficial uses and their criteria comply with the goals of the Act. At a minimum, beneficial uses must provide for "the protection and propagation of fish, shellfish, and wildlife" and provide for "recreation in and on the water" (i.e., the fishable and swimmable goals of the Act), where attainable. The Act prohibits States and other jurisdictions from designating waste transport or waste assimilation as a beneficial use, as some States did prior to 1972.

Section 305(b) of the CWA requires that the States biennially survey their water quality for attainment of the fishable and swimmable goals of the Act and report the results to EPA. The States, participating Tribes, and other jurisdictions measure attainment of the CWA goals by determining how well their waters support their designated beneficial uses. EPA encourages the surveying of waterbodies for support of the following individual beneficial uses:



Aquatic Life Support

The waterbody provides suitable habitat for protection and propagation of desirable fish, shellfish, and other aquatic organisms.

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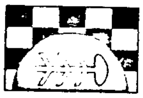
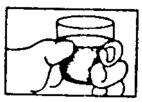


Fish Consumption

The waterbody supports fish free from contamination that could pose a human health risk to consumers.

Shellfish Harvesting

The waterbody supports a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.



Drinking Water Supply

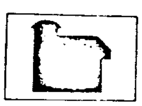
The waterbody can supply safe drinking water with conventional treatment.

Primary Contact Recreation – Swimming

People can swim in the waterbody without risk of adverse human health effects (such as catching waterborne diseases from raw sewage contamination).

Secondary Contact Recreation

People can perform activities on the water (such as boating) without risk of adverse human health effects from ingestion or contact with the water.



Agriculture

The water quality is suitable for irrigating fields or watering livestock.

States, Tribes, and other jurisdictions may also define their own individual uses to address special concerns. For example, many Tribes and States designate their waters for the following beneficial uses:

Ground Water Recharge

The surface waterbody plays a significant role in replenishing ground water, and surface water supply and quality are adequate to protect existing or potential uses of ground water.

Wildlife Habitat

Water quality supports the waterbody's role in providing habitat and resources for land-based wildlife as well as aquatic life.

Tribes may designate their waters for special cultural and ceremonial uses:

Water Quality Monitoring

Water quality monitoring consists of data collection and sample analysis performed using accepted protocols and quality control procedures. Monitoring also includes subsequent analysis of the body of data to support decisionmaking. Federal, Interstate, State, Territorial, Tribal, Regional, and local agencies, industry, and volunteer groups with approved quality assurance programs monitor a combination of chemical, physical, and biological water quality parameters throughout the country.

- Chemical data often measure concentrations of pollutants and other chemical conditions that influence aquatic life, such as pH (i.e., acidity) and dissolved oxygen concentrations. The chemical data may be analyzed in water samples, fish tissue samples, or sediment samples.
- Physical data include measurements of temperature, turbidity (i.e., light penetration through the water column), and solids in the water column.
- Biological data measure the health of aquatic communities. Biological data include counts of aquatic species that indicate healthy ecological conditions.
- Habitat and ancillary data (such as land use data) help interpret the above monitoring information.

Monitoring agencies vary parameters, sampling frequency, and sampling site selection to meet program objectives and funding constraints. Sampling may occur at regular intervals (such as monthly, quarterly, or annually), irregular intervals, or during one-time intensive surveys. Sampling may be conducted at fixed sampling stations, randomly selected stations, stations near suspected water quality problems, or stations in pristine waters.

Culture

Water quality supports the waterbody's role in Tribal culture and preserves the waterbody's religious, ceremonial, or subsistence significance.

The States, Tribes, and other jurisdictions assign one of five levels of use support categories to each of their waterbodies (Table ES-1). If possible, the States, Tribes, and other jurisdictions determine the level of use support by comparing monitoring data with numeric criteria for each use designated for a particular waterbody. If monitoring data are not available, the State, Tribe, or other jurisdiction may determine the level of use support with qualitative information. Valid qualitative information includes land use data, fish and game surveys, and predictive model results. **Monitored assessments** are based on monitoring data. **Evaluated assessments** are based on qualitative information or monitored information more than 5 years old.

For waterbodies with more than one designated use, the States, Tribes, and other jurisdictions consolidate the individual use support information into a single overall use support determination:

Good/Fully Supporting Overall Use – All designated beneficial uses are fully supported.

Good/Threatened Overall Use – One or more designated beneficial uses are threatened and the remaining uses are fully supported.

Fair/Partially Supporting Overall Use – One or more designated beneficial uses are partially supported and the remaining uses are fully supported or threatened. These waterbodies are considered impaired.

Poor/Not Supporting Overall Use – One or more designated beneficial uses are not supported. These waterbodies are considered impaired.

Poor/Not Attainable – The State, Tribe, or other jurisdiction has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six biological, chemical, physical, or economic/social conditions specified in the *Code of Federal Regulations* (40 CFR Section 131.10). These conditions include naturally high concentrations of pollutants (such as metals); other natural physical features that create

Table ES-1. Levels of Use Support

Symbol	Use Support Level	Water Quality Condition	Definition
	Fully Supporting	Good	Water quality meets designated use criteria.
	Threatened	Good	Water quality supports beneficial uses now but may not in the future unless action is taken.
	Partially Supporting	Fair (Impaired)	Water quality fails to meet designated use criteria at times.
	Not Supporting	Poor (Impaired)	Water quality frequently fails to meet designated use criteria.
	Not Attainable	Poor	The State, Tribe, or other jurisdiction has performed a use-attainability analysis and demonstrated that use support is not attainable due to one of six biological, chemical, physical, or economic/social conditions specified in the *Code of Federal Regulations*.

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unsuitable aquatic life habitat (such as inadequate substrate, riffles, or pools); low flows or water levels; dams and other hydrologic modifications that permanently alter waterbody characteristics; poor water quality resulting from human activities that cannot be reversed without causing further environmental degradation; and poor water quality that cannot be improved without imposing more stringent controls than those required in the CWA, which would result in widespread economic and social impacts.

- Impaired Waters – The sum of waterbodies partially supporting uses and not supporting uses.

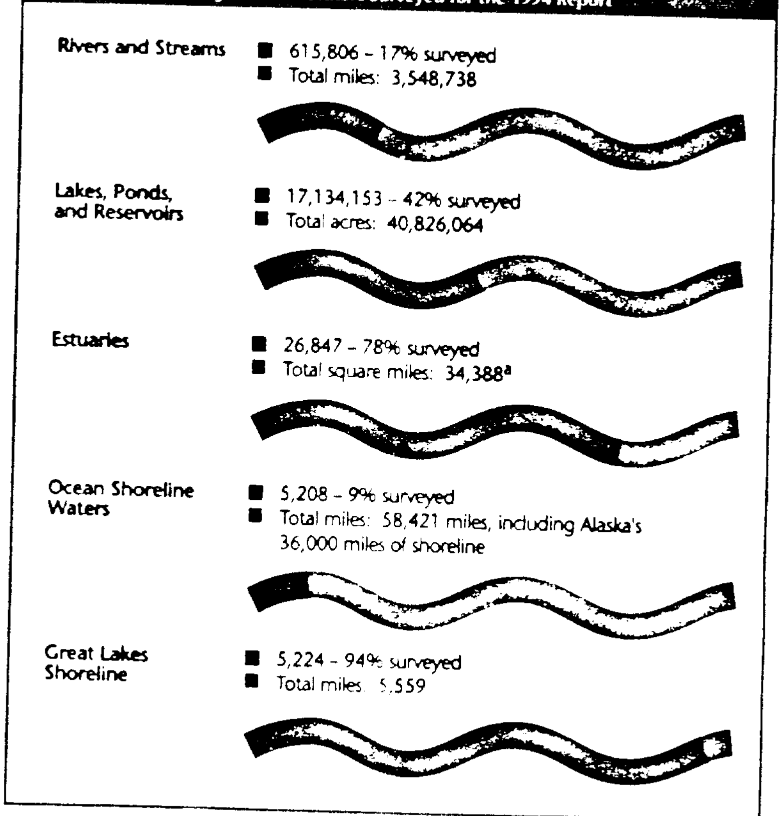
The EPA then aggregates the use support information submitted by the States, Tribes, and other jurisdictions into a national assessment of the Nation's water quality.

How Many of Our Waters Were Surveyed for 1994?

National estimates of the total waters of our country provide the foundation for determining the percentage of waters surveyed by the States, Tribes, and other jurisdictions and the portion impaired by pollution. For the 1992 reporting period, EPA provided the States with estimates of total river miles and lake acres derived from the EPA Reach File, a database containing traces of waterbodies adapted from 1:100,000 scale maps prepared by the U.S. Geological Survey. The States modified these total water estimates where necessary. Based on the 1992 EPA/State figures, the national estimate of total river miles doubled in large part because the EPA/State estimates included nonperennial streams, canals, and ditches that were previously excluded from estimates of total stream miles.

Estimates for the 1994 reporting cycle are a minor refinement of the 1992 figures and indicate that the United States has:

Figure ES-1. Percentage of Total Waters Surveyed for the 1994 Report



Source: 1994 Section 305(b) reports submitted by the States, Tribes, Territories, and Commissions.

[a] Excluding estuarine waters in Alaska because no estimate was available.

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- More than 3.5 million miles of rivers and streams, which range in size from the Mississippi River to small streams that flow only when wet weather conditions exist (i.e., nonperennial streams)
- Approximately 40.8 million acres of lakes, ponds, and reservoirs
- About 34,388 square miles of estuaries (excluding Alaska)
- More than 58,000 miles of ocean shoreline, including 36,000 miles in Alaska
- 5,559 miles of Great Lakes shoreline
- More than 277 million acres of wetlands such as marshes, swamps, bogs, and fens, including 170 million acres of wetlands in Alaska.

Most States do not survey all of their waterbodies during the 2-year reporting cycle required under CWA Section 305(b). Thus, the surveyed waters reported in Figure ES-1 are a subset of the Nation's total waters. In addition, the summary information based on surveyed waters may not represent general conditions in the Nation's total waters because States, Tribes, and other jurisdictions often focus on surveying major perennial rivers, estuaries, and public lakes with suspected pollution problems in order to direct scarce resources to areas that could pose the greatest risk. Many States, Tribes, and other jurisdictions lack the resources to collect use support information for nonperennial streams, small tributaries, and private ponds. This report does not predict the health of these unassessed waters, which include an unknown ratio of pristine waters to polluted waters.

The Intergovernmental Task Force on Monitoring Water Quality

In 1992, the Intergovernmental Task Force on Monitoring Water Quality (ITFM) convened to prepare a strategy for improving water quality monitoring nationwide. The ITFM is a Federal/State partnership of 10 Federal agencies, 9 State and interstate agencies, and 1 American Indian Tribe. The EPA chairs the ITFM with the USGS as vice chair and Executive Secretariat as part of their Water Information Coordination Program pursuant to OMB memo 92-01.

The mission of the ITFM is to develop and aid implementation of a national strategic plan to achieve effective collection, interpretation, and presentation of water quality data and to improve the [illegible] of existing information for decisionmaking at all levels of [illegible] and the private sector. A permanent successor to the ITFM, [illegible] National Monitoring Council will provide guidelines and support for [illegible] collaboration, comparable field and laboratory methods, quality assurance/quality control, environmental indicators, data management and sharing, ancillary data, interpretation and techniques, and training.

The ITFM and its successor, the National Monitoring Council, [illegible] products that can be used by monitoring [illegible] such as an outline for a recommended [illegible] environmental indicator selection criteria, and a [illegible] assessment of State and Tribal designated uses.

For a copy of the first, second, and final ITFM reports, contact:

The U.S. Geological Survey
4[illegible] National Center
Reston, VA 22092
1-800-426-9000

Pollutants and Processes That Degrade Water Quality

Where possible, States, Tribes, and other jurisdictions identify the pollutants or processes that degrade water quality and indicators that document impacts of water quality degradation. The most widespread pollutants and processes identified in rivers, lakes, and estuaries are presented in Table ES-2. Pollutants include sediment, nutrients, and chemical contaminants (such as dioxins and metals). Processes that

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degrade waters include habitat modification (such as destruction of streamside vegetation) and hydrologic modification (such as flow reduction). Indicators of water quality degradation include physical, chemical and biological parameters. Examples of biological parameters include species diversity and abundance. Examples of physical and chemical parameters include pH, turbidity, and temperature. Following are descriptions of the effects of the pollutants and processes most commonly identified in rivers, lakes, estuaries, coastal waters, wetlands, and ground water.

Low Dissolved Oxygen

Dissolved oxygen is a basic requirement for a healthy aquatic ecosystem. Most fish and beneficial aquatic insects "breathe" oxygen dissolved in the water column. Some fish and aquatic organisms (such as carp and sludge worms) are adapted to low oxygen conditions, but most desirable fish species (such as trout and salmon) suffer if dissolved oxygen concentrations fall below 3 to 4 mg/L (3 to 4 milligrams of oxygen dissolved in 1 liter of water, or 3 to 4 parts of oxygen per million parts of water). Larvae and juvenile fish are more sensitive and require even higher concentrations of dissolved oxygen.

Many fish and other aquatic organisms can recover from short periods of low dissolved oxygen availability. However, prolonged episodes of depressed dissolved oxygen concentrations of 2 mg/L or less can result in "dead" waterbodies. Prolonged exposure to low dissolved oxygen conditions can suffocate adult fish or reduce their reproductive survival by suffocating sensitive eggs and larvae or can starve fish by killing aquatic insect larvae and other prey. Low dissolved oxygen concentrations also favor anaerobic bacterial activity that produces noxious gases or foul odors often associated with polluted waterbodies.

Table ES-2. Five Leading Causes of Water Quality Impairment

Rank	Rivers	Lakes	Estuaries
1	Bacteria	Nutrients	Nutrients
2	Siltation	Siltation	Bacteria
3	Nutrients	Oxygen-Depleting Substances	Oxygen-Depleting Substances
4	Oxygen-Depleting Substances	Metals	Habitat Alterations
5	Metals	Suspended Solids	Oil and Grease

Source: Based on 1994 Section 305(b) reports submitted by States, Tribes, Territories, Commissions, and the District of Columbia.

Fish Kills

Fish kill reporting is a voluntary process; States, Tribes, and other jurisdictions are not required to report on how many fish kills occur, or what might have caused them. In many cases it is the public–anglers, and hunters, recreational boaters, or hikers–who first notice fish kills and report them to game wardens or other State officials. Many fish kills go undetected or unreported and others may be difficult to investigate, especially if they occur in remote areas. This is because dead fish may be carried quickly downstream or may be difficult to count because of turbid conditions. It is therefore likely that the statistics presented by the States, Tribes, and other jurisdictions underestimate the total number of fish kills that occurred nationwide between 1992 and 1994.

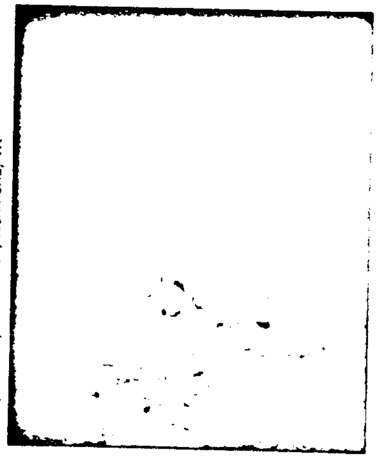
Despite these problems, fish kills are an important consideration in water quality assessments. In 1994, 32 States, Tribes, and other jurisdictions reported a total of 1,454 fish kill incidents. These States attributed 737 of the fish kills to pollution, 257 to unknown causes, 263 to natural conditions (such as low flow and high temperatures), and 229 kills to ambiguous causes. Pollutants most often cited as the cause of kills include oxygen-depleting substances, sewage, pesticides, manure and silage, oil and gas, chlorine, and ammonia. Leading sources of fish kills include agricultural activities, industrial discharges, municipal sewage treatment plant discharges, spills, runoff, and pesticide applications.

Oxygen concentrations in the water column fluctuate under natural conditions, but severe oxygen depletion usually results from human activities that introduce large quantities of biodegradable organic materials into surface waters. Biodegradable organic materials contain plant, fish, or animal matter. Leaves, lawn clippings, sewage, manure, shellfish processing waste, milk solids, and other food processing wastes are examples of oxygen-depleting organic materials that enter our surface waters.

In both pristine and polluted waters, beneficial bacteria use oxygen to break apart (or decompose) organic materials. Pollution-containing organic wastes provide a continuous glut of food for the bacteria, which accelerates bacterial activity and population growth. In polluted waters, bacterial consumption of oxygen can rapidly outpace oxygen replenishment from the atmosphere and photosynthesis performed by algae and aquatic plants. The result is a net decline in oxygen concentrations in the water.

Toxic pollutants can indirectly lower oxygen concentrations by killing algae, aquatic weeds, or fish, which provides an abundance of food for oxygen-consuming bacteria. Oxygen depletion can also result from chemical reactions that do not involve bacteria. Some pollutants trigger chemical reactions that place a chemical oxygen demand on receiving waters.

Other factors (such as temperature and salinity) influence the amount of oxygen dissolved in water. Prolonged hot weather will depress oxygen concentrations and may cause fish kills even in clean



Chesapeake Bay Foundation, Richmond, VA

waters because warm water cannot hold as much oxygen as cold water. Warm conditions further aggravate oxygen depletion by stimulating bacterial activity and respiration in fish, which consumes oxygen. Removal of streamside vegetation eliminates shade, thereby raising water temperatures, and accelerates runoff of organic debris. Under such conditions, minor additions of pollution-containing organic materials can severely deplete oxygen.

Nutrients

Nutrients are essential building blocks for healthy aquatic communities, but excess nutrients (especially nitrogen and phosphorus compounds) overstimulate the growth of aquatic weeds and algae. Excessive growth of these organisms, in turn, can clog navigable waters, interfere with swimming and boating, outcompete native submerged aquatic vegetation (SAV), and lead to oxygen depletion. Oxygen concentrations can fluctuate daily during algal blooms, rising during the day as algae perform photosynthesis, and falling at night as algae continue to respire, which consumes oxygen. Beneficial bacteria also consume oxygen as they decompose the abundant organic food supply in dying algae cells.

Lawn and crop fertilizers, sewage, manure, and detergents contain nitrogen and phosphorus, the nutrients most often responsible for water quality degradation. Rural areas are vulnerable to ground water contamination from nitrates (a compound containing nitrogen) found in fertilizer and manure. Very high concentrations of nitrate (>10 mg/L) in drinking water cause methemoglobinemia, or blue baby syndrome, an inability to fix oxygen in the blood.

Nutrients are difficult to control because lake and estuarine ecosystems recycle nutrients. Rather than leaving the ecosystem, the nutrients cycle among the water column, algae and plant tissues, and the bottom sediments. For example, algae may temporarily remove all the nitrogen from the water column, but the nutrients will return to the water column when the algae die and are decomposed by bacteria. Therefore, gradual inputs of nutrients tend to accumulate over time rather than leave the system.

Sediment and Siltation

In a water quality context, sediment usually refers to soil particles that enter the water column from eroding land. Sediment consists of particles of all sizes, including fine clay particles, silt, sand, and gravel. Water quality managers use the

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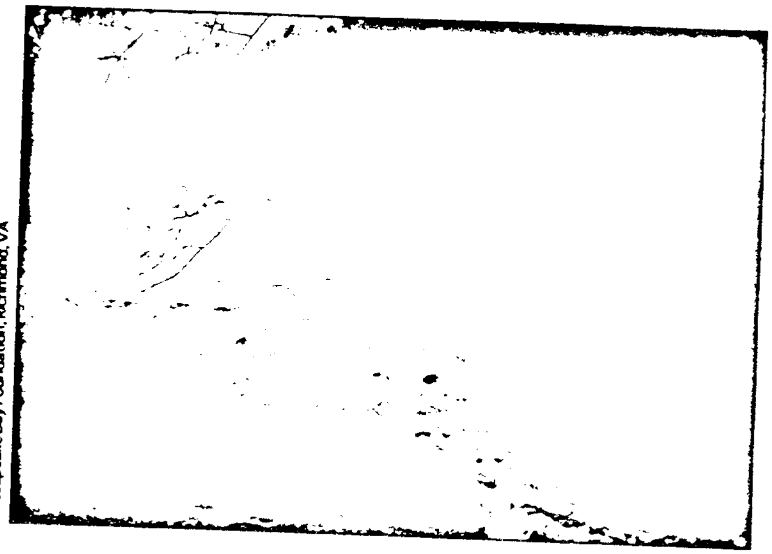
term "siltation" to describe the suspension and deposition of small sediment particles in waterbodies.

Sediment and siltation can severely alter aquatic communities. Sediment may clog and abrade fish gills, suffocate eggs and aquatic insect larvae on the bottom, and fill in the pore space between bottom cobbles where fish lay eggs. Silt and sediment interfere with recreational activities and aesthetic enjoyment at waterbodies by reducing water clarity and filling in waterbodies. Sediment may also carry other pollutants into waterbodies. Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or detach and become soluble in the water column.

Rain washes silt and other soil particles off of plowed fields, construction sites, logging sites, urban areas, and strip-mined lands into waterbodies. Eroding stream banks also deposit silt and sediment in waterbodies. Removal of vegetation on shore can accelerate streambank erosion.


Chesapeake Bay Foundation, Richmond, VA

Bacteria and Pathogens

Some waterborne bacteria, viruses, and protozoa cause human illnesses that range from typhoid and dysentery to minor respiratory and skin diseases. These organisms may enter waters through a number of routes, including inadequately treated sewage, stormwater drains, septic systems, runoff from livestock pens, and sewage dumped overboard from recreational boats. Because it is impossible to test waters for every possible disease-causing organism, States and other jurisdictions usually measure indicator bacteria that are found in great numbers in the stomachs and intestines of warm-blooded animals and people. The presence of indicator bacteria suggests that the waterbody may be contaminated with untreated sewage and that other, more dangerous organisms may be present. The States, Tribes, and other jurisdictions use bacterial criteria to determine if waters are safe for recreation and shellfish harvesting.

Toxic Organic Chemicals and Metals

Toxic organic chemicals are synthetic compounds that contain carbon, such as polychlorinated biphenyls (PCBs), dioxins, and the pesticide DDT. These synthesized compounds often persist and accumulate in the environment because they do not readily break down in natural ecosystems. Many of these compounds cause cancer in people and birth defects in other predators near the top of the food chain, such as birds and fish.

Metals occur naturally in the environment, but human activities (such as industrial processes and mining) have altered the distribution of metals in the environment. In most reported cases of metals contamination, high concentrations of metals appear in fish tissues rather than the water column because the metals accumulate in greater concentrations in predators near the top of the food chain.

pH

Acidity, the concentration of hydrogen ions, drives many chemical reactions in living organisms. The standard measure of acidity is

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pH, and a pH value of 7 represents a neutral condition. A low pH value (less than 5) indicates acidic conditions; a high pH (greater than 9) indicates alkaline conditions. Many biological processes, such as reproduction, cannot function in acidic or alkaline waters. Acidic conditions also aggravate toxic contamination problems because sediments release toxicants in acidic waters. Common sources of acidity include mine drainage, runoff from mine tailings, and atmospheric deposition.

Habitat Modification/ Hydrologic Modification

Habitat modifications include activities in the landscape, on shore, and in waterbodies that alter the physical structure of aquatic ecosystems and have adverse impacts on aquatic life. Examples of habitat modifications include:

- Removal of streamside vegetation that stabilizes the shoreline and provides shade, which moderates instream temperatures
- Excavation of cobbles from a stream bed that provide nesting habitat for fish
- Stream burial
- Excessive suburban sprawl that alters the natural drainage patterns by increasing the intensity, magnitude, and energy of runoff waters.

Hydrologic modifications alter the flow of water. Examples of hydrologic modifications include channelization, dewatering, damming, and dredging.

Other pollutants include salts and oil and grease. Fresh waters may become unfit for aquatic life and some human uses when they become contaminated by salts. Sources of salinity include irrigation runoff, brine used in oil extraction, road deicing operations, and the intrusion of sea water into ground and surface waters in coastal areas. Crude oil and processed petroleum products may be spilled during extraction, processing, or transport or leaked from underground storage tanks.

Table ES-[illegible]. Pollution Source Categories Used in This Report

Category	Examples
Industrial	Pulp and paper mills, chemical manufacturers, steel plants, metal process and product manufacturers, textile manufacturers, food processing plants
Municipal	Publicly owned sewage treatment plants that may receive indirect discharges from industrial facilities or businesses
Combined Sewers	Single facilities that treat both storm water and sanitary sewage, which may become overloaded during storm events and discharge untreated wastes into surface waters.
Storm Sewers/ Urban Runoff	Runoff from impervious surfaces including streets, parking lots, buildings, lawns, and other paved areas.
Agricultural	Crop production, pastures, rangeland, feedlots, other animal holding areas
Silvicultural	Forest management, tree harvesting, logging road construction
Construction	Land development, road construction
Resource Extraction	Mining, petroleum drilling, runoff from mine tailing sites
Land Disposal	Leachate or discharge from septic tanks, landfills, and hazardous waste sites
Hydrologic Modification	Channelization, dredging, dam construction, streambank modification

Sources of Water Pollution

Sources of impairment generate the pollutants that violate use support criteria (Table ES-3). Point sources discharge pollutants directly into surface waters from a conveyance. Point sources include industrial facilities, municipal sewage treatment plants, and combined sewer overflows. Nonpoint sources deliver pollutants to surface waters from diffuse origins. Nonpoint sources include urban runoff, agricultural runoff, and atmospheric deposition of contaminants in air pollution. Habitat alterations, such as hydromodification, dredging, and streambank destabilization, can also degrade water quality.

Throughout this document, EPA rates the significance of causes and sources of pollution by the percentage of impaired waters impacted by each individual cause or source (obtained from the Section 305(b) reports submitted by the States, Tribes, and other jurisdictions). Note that the cause and source rankings do not describe the condition of all waters in the United States because the States identify the causes and sources degrading some of their impaired waters, which are a small subset of surveyed waters, which are a subset of the Nation's total waters. For example, the States identified sources degrading some of the 224,236 impaired river miles, which represent 36% of the surveyed river miles and only 6% of the Nation's total stream miles.

"The term 'point source' means any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture."

Clean Water Act Section 502(14)

Table ES-4 lists the leading sources of impairment related to human activities as reported by States, Tribes, and other jurisdictions for their rivers, lakes, and estuaries. Other sources cited include removal of riparian vegetation, forestry activities, land disposal, petroleum extraction and processing activities, and construction. In addition to human activities, the States, Tribes, and other jurisdictions also reported impairments from natural sources. Natural sources refer to an assortment of water quality problems:

- Natural deposits of salts, gypsum, nutrients, and metals in soils that leach into surface and ground waters
- Warm weather and dry conditions that raise water temperatures, depress dissolved oxygen concentrations, and dry up shallow waterbodies
- Low-flow conditions and tannic acids from decaying leaves that lower pH and dissolved oxygen concentrations in swamps draining into streams.

With so many potential sources of pollution, it is difficult and expensive for States, Tribes, and other jurisdictions to identify specific sources responsible for water quality impairments. Many States and other jurisdictions lack funding for monitoring to identify all but the most apparent sources degrading waterbodies. Local management priorities may focus monitoring budgets on other water quality issues, such as identification of contaminated fish populations that pose a human health risk. Management priorities may also direct monitoring efforts to larger waterbodies and overlook sources impairing smaller waterbodies. As a result, the States, Tribes, and other jurisdictions do not associate every impacted waterbody with a source of impairment in their 305(b) reports, and the summary cause and source information presented in this report applies exclusively to a subset of the Nation's impaired waters.

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Urban Runoff/ Storm Sewers
2	Municipal Sewage Treatment Plants	Municipal Sewage Treatment Plants	Municipal Sewage Treatment Plants
3	Hydrologic/Habitat Modification	Urban Runoff/ Storm Sewers	Agriculture
4	Urban Runoff/ Storm Sewers	Unspecified Nonpoint Sources	Industrial Point Sources
5	Resource Extraction	Hydrologic/Habitat Modification	Petroleum Activities

Source: Based on 1994 Section 305(b) reports submitted by States, Tribes, Territories, Commissions, and the District of Columbia.

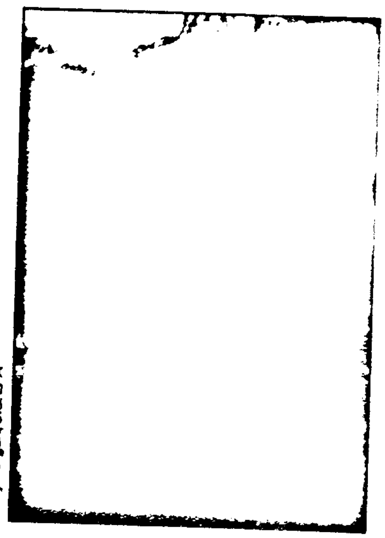
Rivers and Streams

Rivers and streams are characterized by flow. Perennial rivers and streams flow continuously, all year round. Nonperennial rivers and streams stop flowing for some period of time, usually due to dry conditions or upstream withdrawals. Many rivers and streams originate in nonperennial headwaters that flow only during snowmelt or heavy showers. Nonperennial streams provide critical habitats for nonfish species, such as amphibians and dragonflies, as well as safe havens for juvenile fish to escape from predation by larger fish.

The health of rivers and streams is directly linked to habitat integrity on shore and in adjacent wetlands. Stream quality will deteriorate if activities damage shoreline (i.e., riparian) vegetation and wetlands, which filter pollutants from runoff and bind soils. Removal of vegetation also eliminates shade that moderates stream temperature as well as the land temperature that can warm runoff entering surface waters. Stream temperature, in turn, affects the availability of dissolved oxygen in the water column for fish and other aquatic organisms.

Overall Water Quality

For the 1994 Report, 58 States, Territories, Tribes, Commissions, and the District of Columbia surveyed 615,806 miles (17%) of the Nation's total 3.5 million miles of rivers and streams (Figure ES-2). The surveyed rivers and streams represent 48% of the 1.3 million miles of perennial rivers and streams that flow year round in the lower 48 States.



Barry Burgan, U.S. EPA

Altogether, the States and Tribes surveyed 27,075 fewer river miles in 1994 than in 1992. Individually, most States reported that they surveyed more river miles in 1994, but their increases were offset by a decline of 85,000 surveyed river miles reported by Montana, Mississippi, and Maryland. For 1994, these States reported use support status for only those river miles that they surveyed in direct monitoring programs or evaluations rather than using inferences for unsurveyed waters.

The following discussion applies exclusively to surveyed waters and cannot be extrapolated to describe conditions in the Nation's rivers as a whole because the States, Tribes, and other jurisdictions do not consistently use statistical or probabilistic survey methods to characterize all their waters at this time. EPA is working with the States, Tribes, and other jurisdictions to expand survey coverage of the Nation's waters and expects future survey information to cover a greater portion of the Nation's rivers and streams.

Figure ES-2. River Miles Surveyed

Total rivers = 3.5 million miles
Total surveyed = 615,806 miles

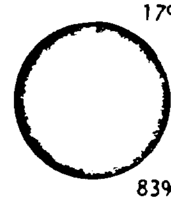
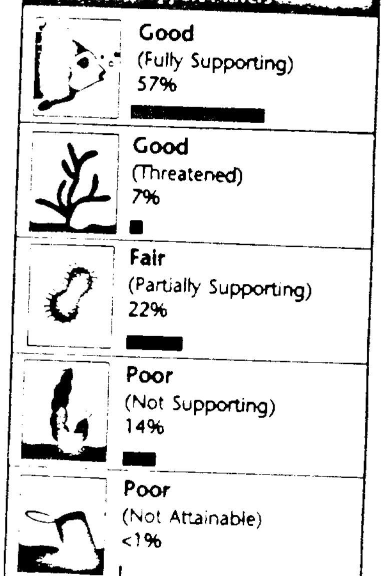


Figure ES-3. Levels of Overall Use Support—Rivers



Source: Based on 1994 Section 305(b) reports submitted by States, Tribes, Territories, Commissions, and the District of Columbia

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Of the Nation's 615,806 surveyed river miles, the States, Tribes, and other jurisdictions found that 64% have good water quality. Of these waters, 57% fully support their designated uses, and an additional 7% support uses but are threatened and may become impaired if pollution control actions are not taken (Figure ES-3).

Some form of pollution or habitat degradation prevents the remaining 36% (224,236 miles) of the surveyed river miles from fully supporting a healthy aquatic community or human activities all year round. Twenty-two percent of the surveyed river miles have fair water quality that partially supports designated uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Fourteen percent of the surveyed river miles have poor water quality that consistently stresses aquatic life and/or prevents people from using the river for activities such as swimming and fishing.

What Is Polluting Our Rivers and Streams?

The States and Tribes report that bacteria pollute 76,397 river miles (which equals 34% of the impaired river miles) (Figure ES-4). Bacteria provide evidence of possible fecal contamination that may cause illness if the public ingests the water.

Siltation, composed of tiny soil particles, remains one of the most widespread pollutants impacting rivers and streams. The States and Tribes reported that siltation impairs 75,792 river miles (which equals 34% of the impaired river miles).

Bacteria and siltation are the most widespread pollutants in rivers and streams, affecting 34% of the impaired river miles.

Siltation alters aquatic habitat and suffocates fish eggs and bottom-dwelling organisms. Excessive siltation can also interfere with drinking water treatment processes and recreational use of a river.

In addition to siltation and bacteria, the States and Tribes also reported that nutrients, oxygen-depleting substances, metals, and habitat alterations impact more miles of rivers and streams than other pollutants and processes. Often, several pollutants and processes impact a single river segment. For example, a process, such as removal of shoreline vegetation, may accelerate erosion of sediment and nutrients into a stream.

Where Does This Pollution Come From?

The States and Tribes reported that agriculture is the most widespread source of pollution in the Nation's surveyed rivers (Figure ES-4). Agriculture generates pollutants that degrade aquatic life or interfere with public use of 134,557 river miles (which equals 60% of the impaired river miles) in 49 States and Tribes.

Twenty-one States reported the size of rivers impacted by specific types of agricultural activities:

- Nonirrigated Crop Production – crop production that relies on rain as the sole source of water.
- Irrigated Crop Production – crop production that uses irrigation systems to supplement rainwater.
- Rangeland – land grazed by animals that is seldom enhanced by the application of fertilizers or pesticides, although managers sometimes modify plant species to a limited extent.
- Pastureland – land upon which a crop (such as alfalfa) is raised to feed animals, either by grazing the animals among the crops or harvesting the crops.
- Feedlots – facilities where animals are fattened and confined at high densities.
- Animal Holding Areas – facilities where animals are confined briefly before slaughter.

The States reported that nonirrigated crop production impaired the most river miles, followed by irrigated crop production, rangeland, feedlots, pastureland, and animal holding areas.

Many States reported declines in pollution from sewage treatment

Agriculture is the leading source of impairment in the Nation's rivers, affecting 60% of the impaired river miles.

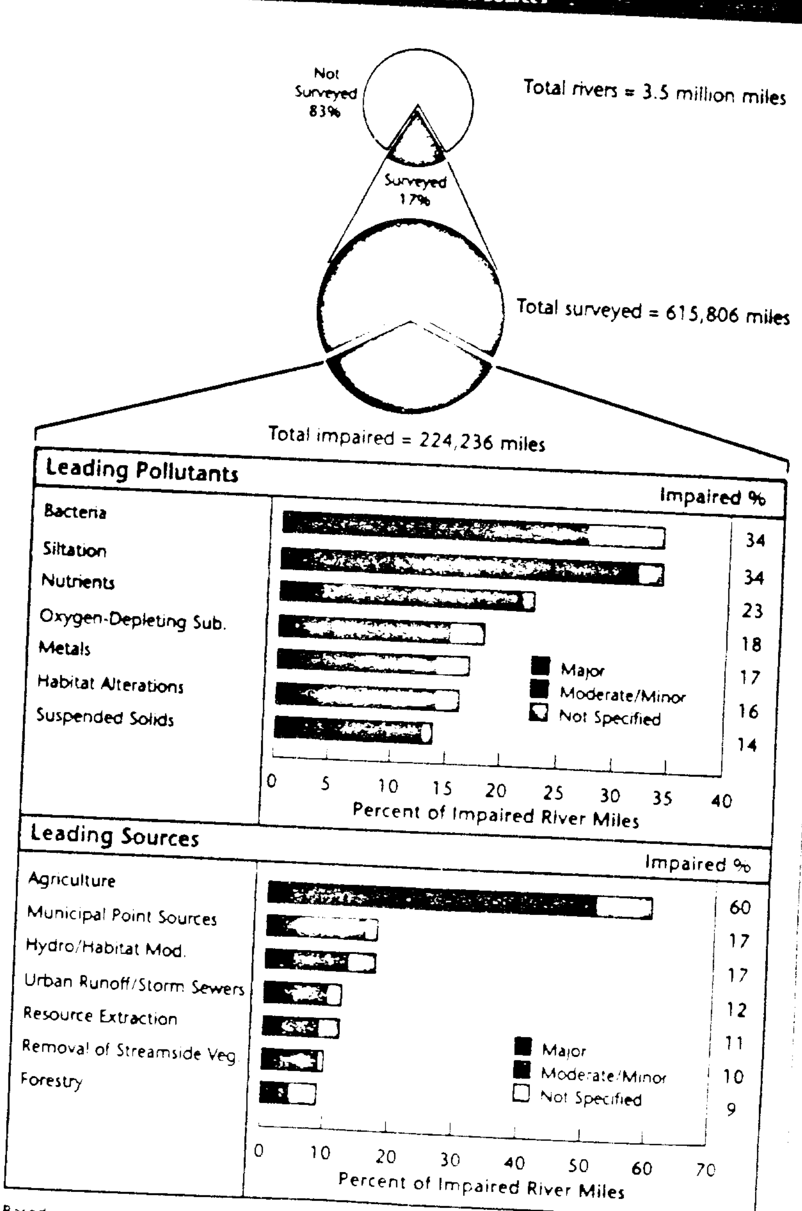
plants and industrial discharges as a result of sewage treatment plant construction and upgrades and permit controls on industrial discharges. Despite the improvements, municipal sewage treatment plants remain the second most common source of pollution in rivers (impairing 37,443 miles) because population growth increases the burden on our municipal facilities.

Hydrologic modifications and habitat alterations are a growing concern to the States. Hydrologic modifications include activities that alter the flow of water in a stream, such as channelization, dewatering, and damming of streams. Habitat alterations include removal of streamside vegetation that protects the stream from high temperatures, and scouring of stream bottoms. Additional gains in water quality conditions will be more subtle and require innovative management strategies that go beyond point source controls.

The States, Tribes, and other jurisdictions also reported that urban runoff and storm sewers impair 26,862 river miles (12% of the impaired rivers), resource extraction impairs 24,059 river miles (11% of the impaired rivers), and removal of streamside vegetation impairs 21,706 river miles (10% of the impaired rivers).

The States, Tribes, and other jurisdictions also report that "natural" sources impair significant stretches of rivers and streams. "Natural" sources such as low flow and soils with arsenic deposits, can prevent waters from supporting uses in the absence of human activities.

Figure ES-4. Impaired River Miles: Pollutants and Sources



Based on data contained in Appendix A, Tables A-4 and A-5

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Lakes, Ponds, and Reservoirs

Lakes are sensitive to pollution inputs because lakes flush out their contents relatively slowly. Even under natural conditions, lakes undergo eutrophication, an aging process that slowly fills in the lake with sediment and organic matter (see sidebar). The eutrophication process alters basic lake characteristics such as depth, biological productivity, oxygen levels, and water clarity. The eutrophication process is commonly defined by a series of trophic states as described in the sidebar.

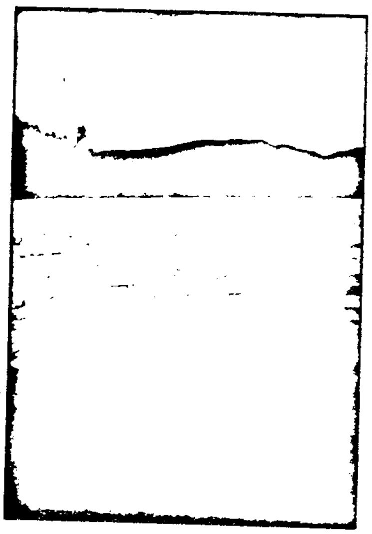
Overall Water Quality

Forty-eight States, Tribes, and other jurisdictions surveyed overall use support in more than 17.1 million lake acres representing 42% of the approximately 40.8 million total acres of lakes, ponds, and reservoirs in the Nation (Figure ES-5). For 1994, the States surveyed about 1 million fewer lake acres than in 1992.

The number of surveyed lake acres declined because several States separated fish tissue data from their survey of overall use support. Some of these States, such as Minnesota, have established massive databases of fish tissue contamination information (which is used to establish fish consumption advisories), but lack other types of water quality data for many of their lakes. In 1994, these States chose not to assess overall use support entirely with fish tissue data alone, which is a very narrow indicator of water quality.

The States and Tribes reported that 63% of their surveyed 17.1 million lake acres have good water quality. Waters with good quality include 50% of the surveyed lake acres fully supporting uses and 13% of the surveyed lake acres that are threatened and might deteriorate if we fail to manage potential sources of pollution (Figure ES-6).

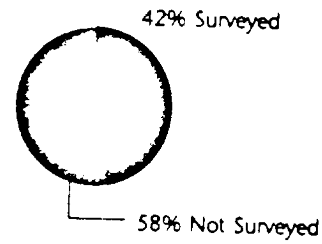
Some form of pollution or habitat degradation impairs the remaining 37% of the surveyed lake acres. Twenty-eight percent of the surveyed lake acres have fair water quality that partially supports designated uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Nine percent of the surveyed lake acres suffer from poor water quality that consistently stresses aquatic life and/or prevents people from using the lake for activities such as swimming and fishing.

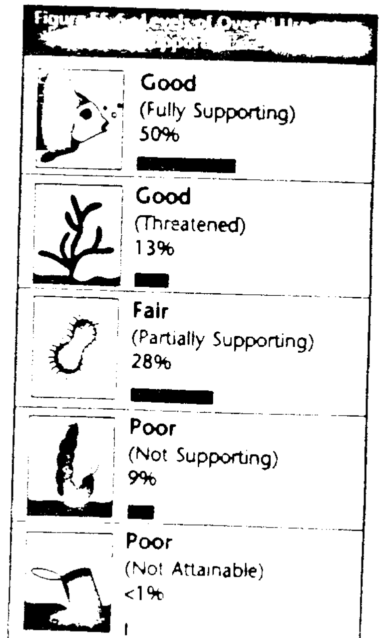


John Theilgard, Byrum, NC

Figure ES-5. Lake Acres Surveyed

Total lakes = 40.8 million acres
Total surveyed = 17.1 million acres





Source: Based on 1994 Section 305(b) reports submitted by States, Tribes, Territories, Commissions, and the District of Columbia

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What Is Polluting Our Lakes, Ponds, and Reservoirs?

Forty-one States, the District of Columbia, and Puerto Rico reported the number of lake acres impacted by individual pollutants and processes.

Thirty-seven States and Puerto Rico identified more lake acres polluted by nutrients than any other pollutant or process (Figure ES-7). The States and Puerto Rico reported that extra nutrients pollute 2.8 million lake acres (which equals 43% of the impaired lake acres). Healthy lake ecosystems contain nutrients in small quantities, but extra inputs of nutrients from human activities unbalance lake ecosystems.

In addition to nutrients, the States, Puerto Rico, and the District of Columbia report that siltation pollutes 1.8 million lake acres (which equals 28% of the impaired lake acres), enrichment by organic wastes that deplete oxygen impacts 1.6 million lake acres (which equals 24% of the impaired lake acres), and metals pollute 1.4 million acres (which equals 21% of the impaired lake acres).

Metals declined from the most widespread pollutant impairing lakes in the 1992 305(b) reporting cycle

Trophic States

Oligotrophic	Clear waters with little organic matter or sediment and minimum biological activity.
Mesotrophic	Waters with more nutrients and, therefore, more biological productivity.
Eutrophic	Waters extremely rich in nutrients, with high biological productivity. Some species may be choked out.
Hypereutrophic	Murky, highly productive waters, closest to the wetlands status. Many clearwater species cannot survive.
Dystrophic	Low in nutrients, highly colored with dissolved humic organic matter. (Not necessarily a part of the natural trophic progression.)

The Eutrophication Process

Eutrophication is a natural process, but human activities can accelerate eutrophication by increasing the rate at which nutrients and organic substances enter lakes from their surrounding watersheds. Agricultural runoff, urban runoff, leaking septic systems, sewage discharges, eroded streambanks, and similar sources can enhance the flow of nutrients and organic substances into lakes. These substances can overstimulate the growth of algae and aquatic plants, creating conditions that interfere with the recreational use of lakes and the health and diversity of native fish, plant, and animal populations. Enhanced eutrophication from nutrient enrichment due to human activities is one of the leading problems facing our Nation's lakes and reservoirs.

Acid Effects on Lakes

Increases in lake acidity can radically alter the community of fish and plant species in lakes and can increase the solubility of toxic substances and magnify their adverse effects. Twenty-eight States reported the results of lake acidification assessments. These States assessed pH (a measure of acidity) at more than 5,933 lakes and detected acidic conditions in 526 lakes and a threat of acidic conditions in 423 lakes. Most of the States that assessed acidic conditions are located in the Northeast, upper Midwest, and the South.

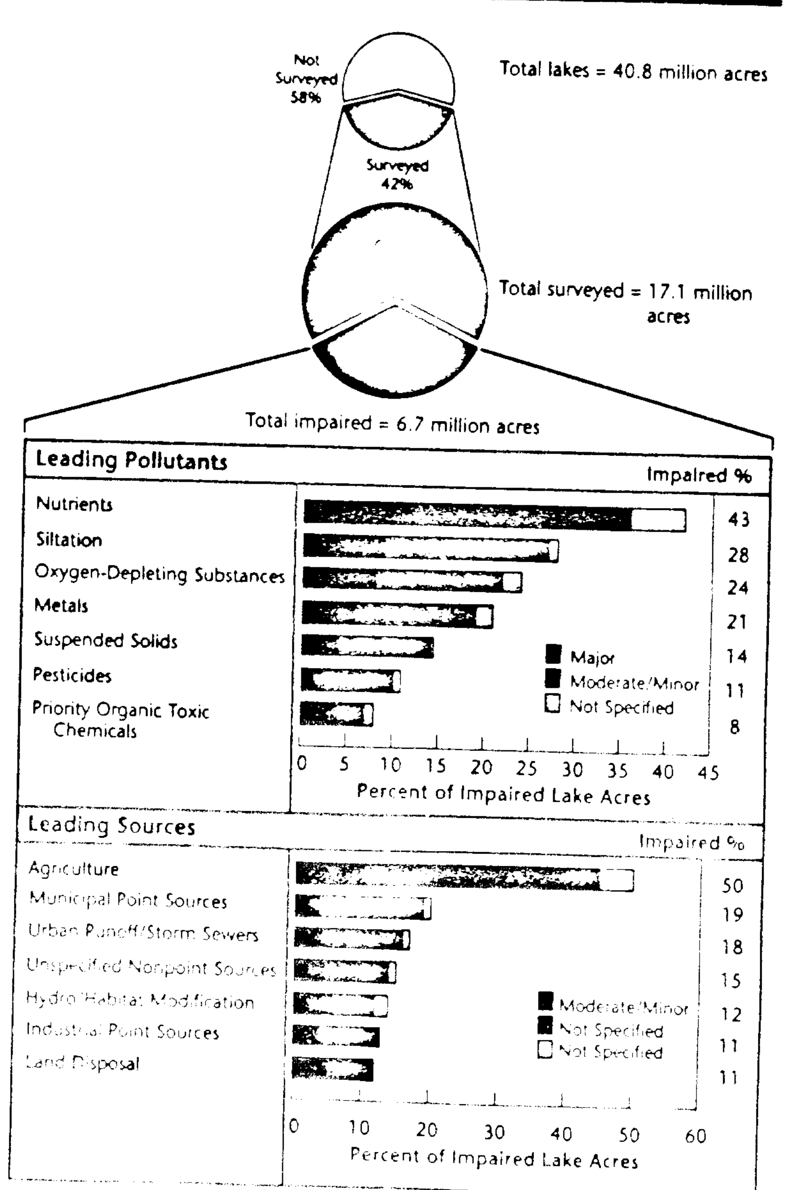
Only 11 States identified sources of acidic conditions. Maine and New Hampshire attributed most of their acid lake conditions to acid deposition from acidic rain, fog, or dry deposition in conjunction with natural conditions that limit a lake's capacity to neutralize acids. Alabama, Kansas, Maryland, Montana, Oklahoma, and Tennessee reported that acid mine drainage resulted in acidic lake conditions or threatened lakes with the potential to generate acidic conditions.

to the fourth leading pollutant impairing lakes in 1994. The decline is due to changes in State reporting and assessment methods rather than a measured decrease in metals contamination. In 1994, several States chose to no longer assess overall use support with fish contamination data alone. Much of that data consisted of measurements of metals in fish tissue. As a result of excluding these fish tissue data, the national estimate of lake acres impaired by metals fell by over 2 million acres in 1994.

More States reported impairments due to nutrients than any other single pollutant.

Forty-one States also surveyed trophic status, which is associated with nutrient enrichment, in 9,735 of their lakes. Nutrient enrichment tends to increase the proportion of lakes in the eutrophic and hypereutrophic categories. These States reported that 18% of the lakes they surveyed for trophic status were oligotrophic, 32% were mesotrophic, 36% were eutrophic, 6% were hypereutrophic, and 3% were dystrophic. This information may not be representative of national lake conditions because States often assess lakes in response to a problem or public complaint or because of their easy accessibility. It is likely that more remote lakes—which are probably less impaired—are underrepresented in these assessments.

Figure ES-7. Impaired Lake Acres—Pollutants and Sources



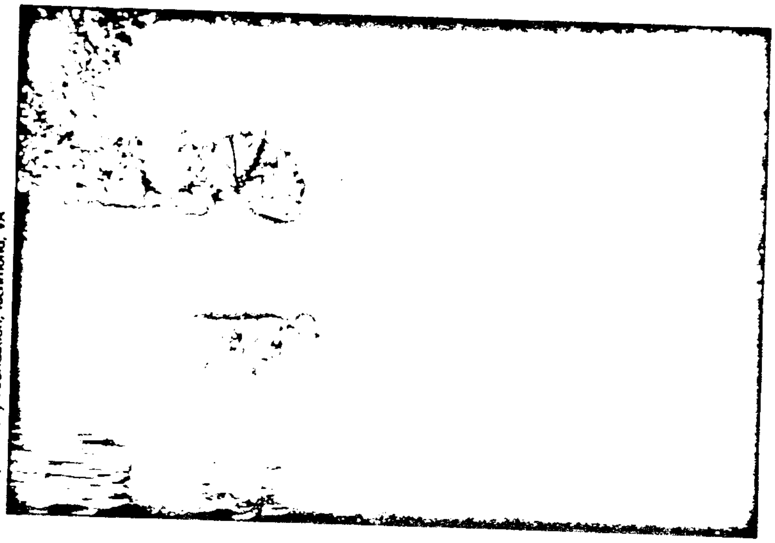
Based on data contained in Appendix B, Tables B-4 and B-5.

Where Does This Pollution Come From?

Forty-two States and Puerto Rico reported sources of pollution in some of their impacted lakes, ponds, and reservoirs. These States and Puerto Rico reported that agriculture is the most widespread source of pollution in the Nation's surveyed lakes (Figure ES-7). Agriculture generates pollutants that degrade aquatic life or interfere with public use of 3.3 million lake acres (which equals 50% of the impaired lake acres).

Agriculture is the leading source of impairment in lakes, affecting 50% of impaired lake acres.

The States and Puerto Rico also reported that municipal sewage treatment plants pollute 1.3 million lake acres (19% of the impaired lake acres), urban runoff and storm sewers pollute 1.2 million lake acres (18% of the surveyed lake acres), unspecified nonpoint sources impair 989,000 lake acres (15% of the impaired lake acres), hydrologic modifications and habitat alterations degrade 832,000 lake acres (12% of the impaired lake acres), and industrial point sources pollute 759,000 lake acres (11% of the impaired lake acres). Many States prohibit new point source discharges into lakes, but existing municipal sewage treatment plants remain a leading source of pollution entering lakes.



Chesapeake Bay Foundation, Richmond, VA

The States and Puerto Rico listed numerous sources that impact several hundred thousand lake acres, including land disposal of wastes, construction, flow regulation, highway maintenance and runoff, contaminated sediments, atmospheric deposition of pollutants, and onsite wastewater systems (including septic tanks).

The Great Lakes

The Great Lakes contain one-fifth of the world's fresh surface water and are stressed by a wide range of pollution sources, including air pollution. Many of the pollutants that reach the Great Lakes remain in the system indefinitely because the Great Lakes are a relatively closed water system with few natural outlets. Despite dramatic declines in the occurrence of algal blooms, fish kills, and localized "dead" zones depleted of oxygen, less visible problems continue to degrade the Great Lakes.

Paul Goetz, Cary, NC

Overall Water Quality

The States surveyed 94% of the Great Lakes shoreline miles for 1994 and reported that fish consumption advisories and aquatic life concerns are the dominant water quality problems, overall, in the Great Lakes (Figure ES-8). The States reported that most of the Great Lakes nearshore waters are safe for swimming and other recreational activities and can be used as a source of drinking water with normal treatment. However, only 2% of the surveyed nearshore waters fully support designated uses, overall, and 1% support uses but are threatened (Figure ES-9). About 97% of the surveyed waters do not fully support designated uses, overall, because fish consumption advisories are posted throughout the nearshore waters of the Great Lakes and water quality conditions are unfavorable for supporting aquatic life in many cases. Aquatic life impacts result from persistent toxic pollutant burdens in birds, habitat degradation and destruction, and competition

Figure ES-8: Great Lakes Shore [illegible] Surveyed

Total Great Lakes = 5,559 miles
Total surveyed = 5,224 miles

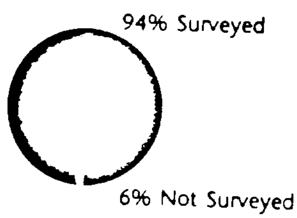
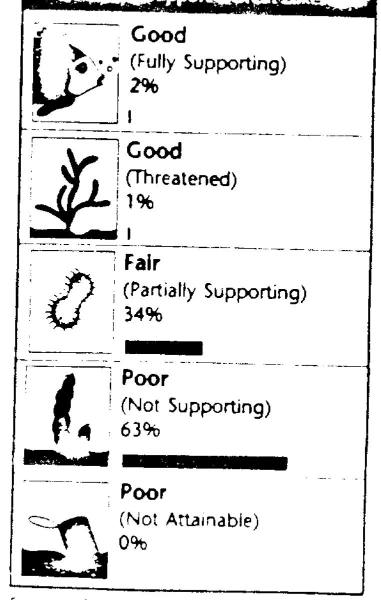


Figure ES-9: [illegible] Overall Use Support [illegible]



Source: Based on 1994 State Section 305(b) reports and predation by nonnative species such as the zebra mussel and the sea lamprey.

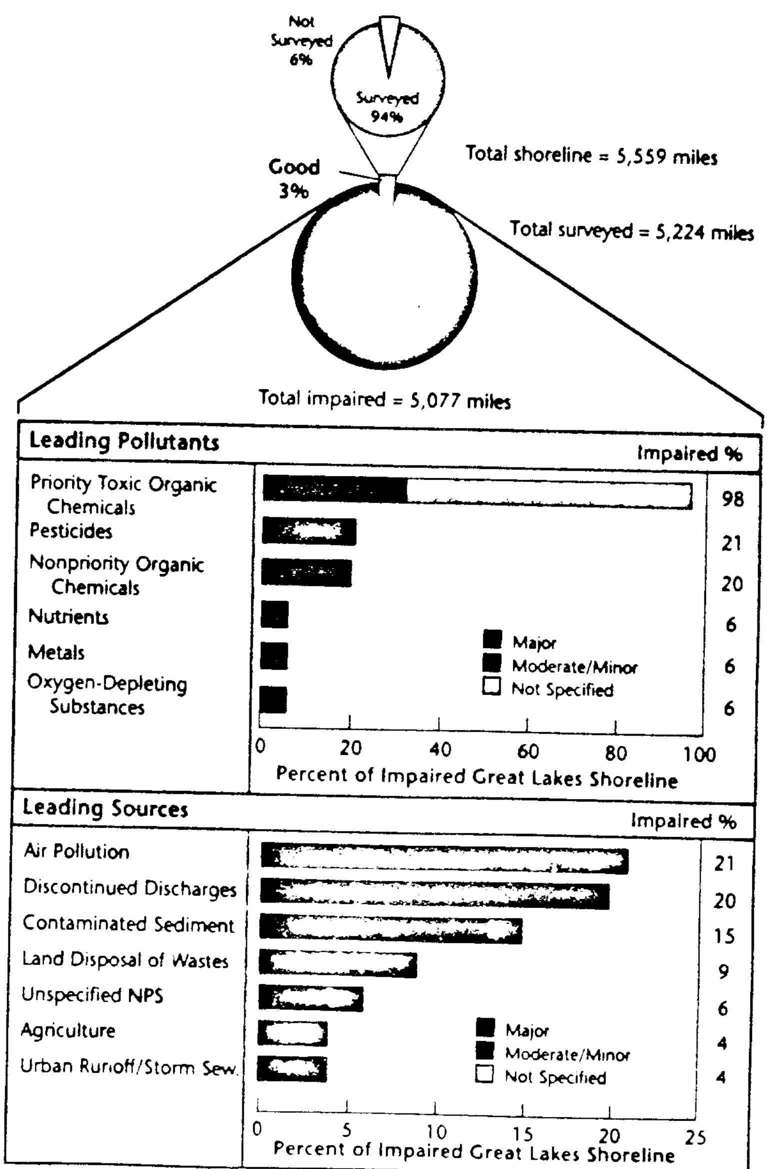
Considerable progress has been made in controlling conventional pollutants, but the Great Lakes are still subject to the effects of toxic pollutants.

These figures do not address water quality conditions in the deeper, cleaner, central waters of the Lakes.

What Is Polluting the Great Lakes?

The States reported that most of the Great Lakes shoreline is polluted by toxic organic chemicals–primarily PCBs–that are often found in fish tissue samples. The Great Lakes States reported that toxic organic chemicals impact 98% of the impaired Great Lakes shoreline miles. Other leading causes of impairment include pesticides, affecting 21%; nonpriority organic chemicals, affecting 20%; nutrients, affecting 6%; and metals, affecting 6% (Figure ES-10).

Figure ES-10. Impaired Great Lakes Shoreline: Pollutants and Sources



Based on data contained in Appendix F, Tables F-4 and F-5.

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Where Does This Pollution Come From?

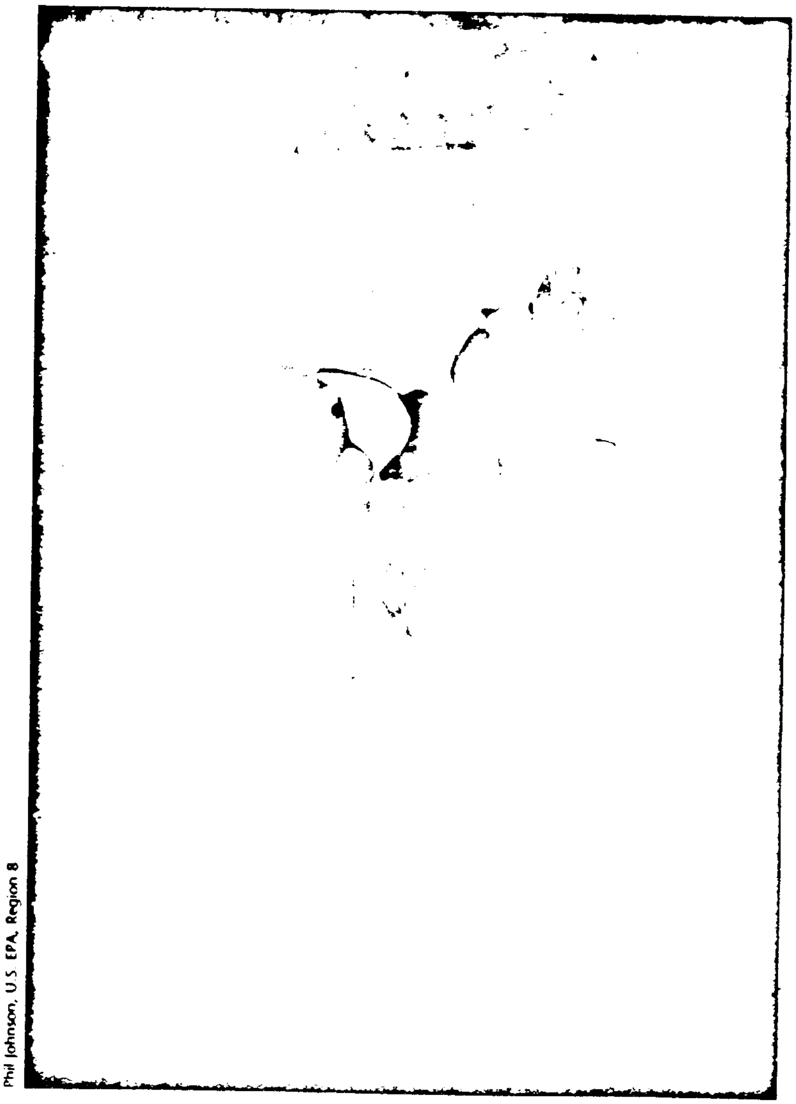
Only four of the eight Great Lakes States measured the size of their Great Lakes shoreline polluted by specific sources. These States have jurisdiction over one-third of the Great Lakes shoreline, so their findings do not necessarily reflect conditions throughout the Great Lakes Basin.

- Wisconsin identifies air pollution and discontinued discharges as a source of pollutants contaminating all 1,017 of their surveyed shoreline miles. Wisconsin also identified smaller areas impacted by contaminated sediments, nonpoint sources, industrial and municipal discharges, agriculture, urban runoff and storm sewers, combined sewer overflows, and land disposal of waste.

- Indiana attributes all of the pollution along its entire 43-mile shoreline to air pollution, urban runoff and storm sewers, industrial and municipal discharges, and agriculture.

- Ohio reports that nonpoint sources pollute 86 miles of its 236 miles of shoreline, in-place contaminants impact 33 miles, and land disposal of waste impacts 24 miles of shoreline.

- New York identifies many sources of pollutants in their Great Lakes waters, but the State attributes the most miles of degradation to contaminated sediments (439 miles) and land disposal of waste (374 miles).



Phil Johnson, U.S. EPA, Region 8

Estuaries

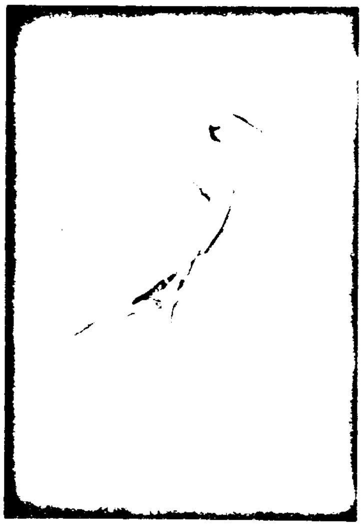
Estuaries are areas partially surrounded by land where rivers meet the sea. They are characterized by varying degrees of salinity, complex water movements affected by ocean tides and river currents, and high turbidity levels. They are also highly productive ecosystems with a range of habitats for many different species of plants, shellfish, fish, and animals.

Many species permanently inhabit the estuarine ecosystem; others, such as shrimp, use the nutrient-rich estuarine waters as nurseries before traveling to the sea.

Estuaries are stressed by the particularly wide range of activities located within their watersheds. They receive pollutants carried by rivers from agricultural lands and cities; they often support marinas, harbors, and commercial fishing fleets; and their surrounding lands are highly prized for development. These stresses pose a continuing threat to the survival of these bountiful waters.

Overall Water Quality

Twenty-five coastal States and jurisdictions surveyed 78% of the Nation's total estuarine waters in 1994 (Figure ES-11). The States and other jurisdictions reported that 63% of the surveyed estuarine waters have good water quality that fully supports designated uses (Figure ES-12). Of these waters, 6% are threatened and might deteriorate if we fail to manage potential sources of pollution.



Brian Murphy, Walnut Creek, CA

Some form of pollution or habitat degradation impairs the remaining 37% of the surveyed estuarine waters. Twenty-seven percent of the surveyed estuarine waters have fair water quality that partially supports designated uses. Most of the time these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Nine percent of the surveyed estuarine waters suffer from poor water quality that consistently stresses aquatic life and/or prevents people from using the estuarine waters for activities such as swimming and shellfishing.

Figure ES-11. Estuary Square Miles Surveyed

Total estuaries = 34,388 square miles
Total surveyed = 26,847 square miles

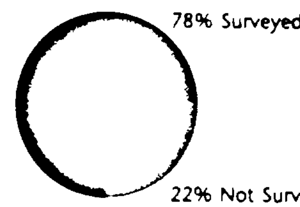
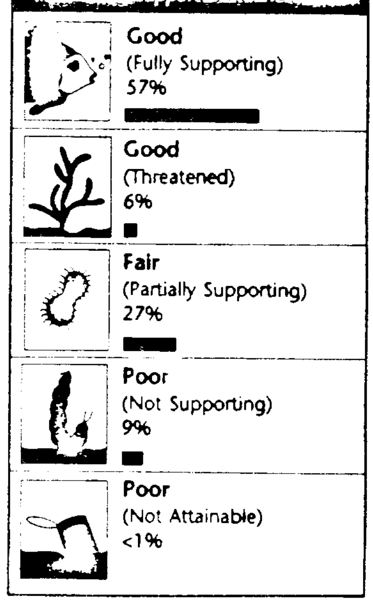


Figure ES-12. Levels of Overall Use Support Estuaries



Source: Based on 1994 Section 305(b) reports submitted by States, Tribes, Territories, Commissions, and the District of Columbia.

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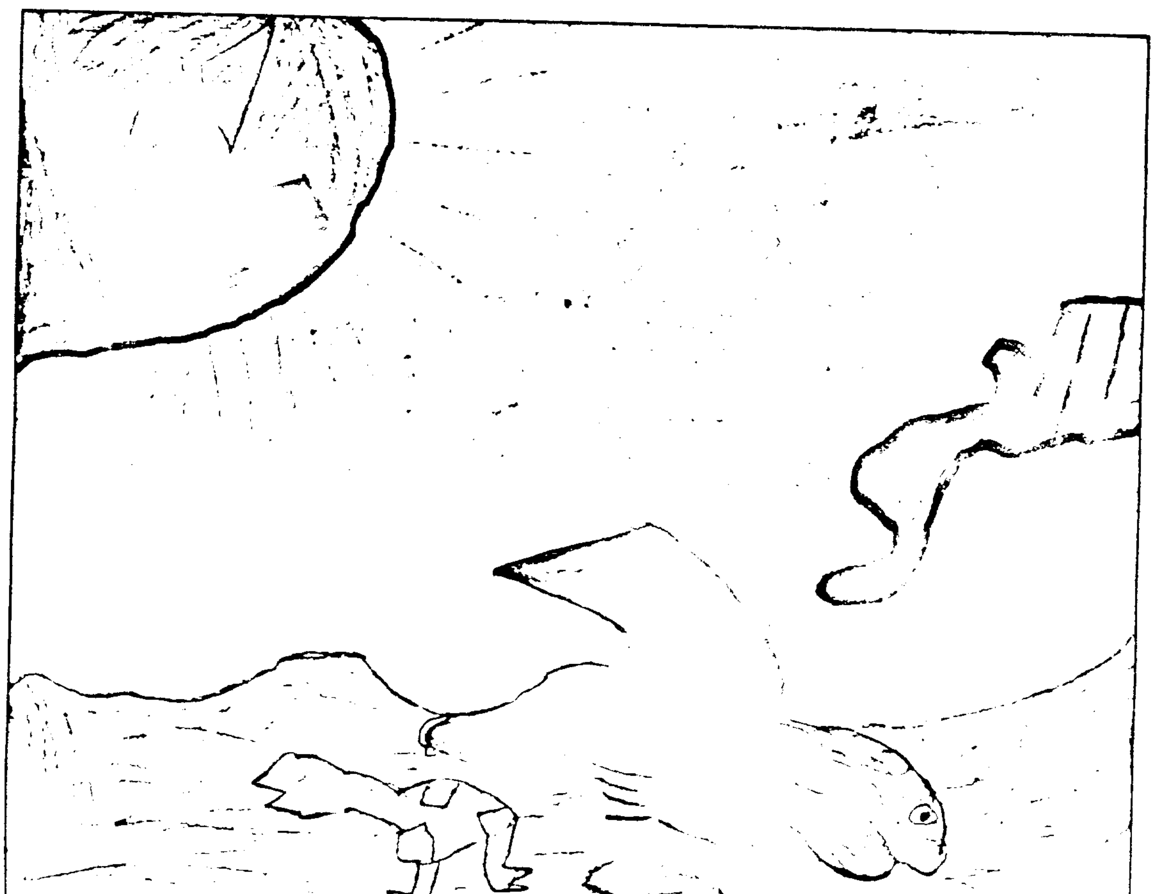
What Is Polluting Our Estuaries?

The States identified more square miles of estuarine waters polluted by nutrients and bacteria than any other pollutant or process (Figure ES-13). Fifteen States reported that extra nutrients pollute 4,548 square miles of estuarine waters (which equals 47% of the impaired estuarine waters). As in lakes, extra inputs of nutrients from human activities destabilize estuarine ecosystems.

Twenty-five States reported that bacteria pollute 4,479 square miles of estuarine waters (which equals 46% of the impaired estuarine waters). Bacteria provide evidence that an estuary is contaminated with sewage that may contain numerous viruses and bacteria that cause illness in people.

The States also report that oxygen depletion from organic wastes impacts 3,127 square miles (which equals 32% of the impaired estuarine waters), habitat alterations impact 1,564 square miles (which equals 16% of the impaired estuarine waters), and oil and grease pollute 1,344 square miles (which equals 14% of the impaired estuarine waters.

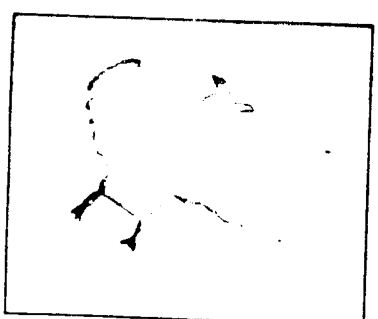


Chris Ingram, age 8, Bruner Elementary, North Las Vegas, NV

Where Does This Pollution Come From?

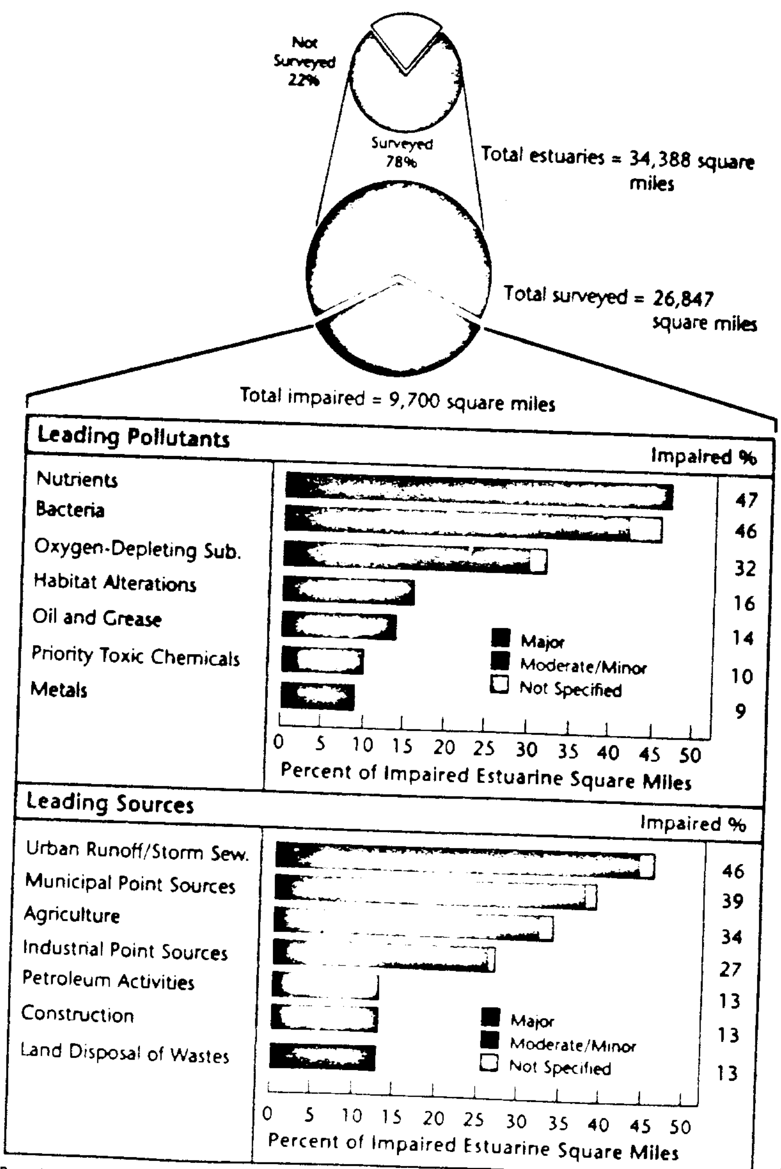
Twenty-three States reported that urban runoff and storm sewers are the most widespread source of pollution in the Nation's surveyed estuarine waters. Pollutants in urban runoff and storm sewer effluent degrade aquatic life or interfere with public use of 4,508 square miles of estuarine waters (which equals 46% of the impaired estuarine waters) (Figure ES-13).

The States also reported that municipal sewage treatment plants pollute 3,827 square miles of estuarine waters (39% of the impaired estuarine waters), agriculture pollutes 3,321 square miles of estuarine waters (34% of the impaired estuarine waters), and industrial discharges pollute 2,609 square miles (27% of the impaired estuarine waters). Urban sources contribute more to the degradation of estuarine waters than agriculture because urban centers are located adjacent to most major estuaries.



Krista Rose, age 8, Bruner Elementary, North Las Vegas, NV

Figure ES-13. Impaired Estuaries: Pollutants and Sources



Based on data contained in Appendix C, Tables C-4 and C-5

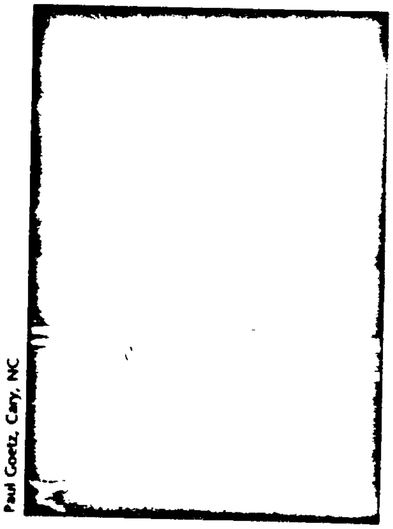
Ocean Shoreline Waters

Although the oceans are expansive, they are vulnerable to pollution from numerous sources, including city storm sewers, ocean outfalls from sewage treatment plants, overboard disposal of debris and sewage, oil spills, and bilge discharges that contain oil and grease. Nearshore ocean waters, in particular, suffer from the same pollution problems that degrade our inland waters.

Overall Water Quality

Thirteen of the 27 coastal States and Territories surveyed only 9% of the Nation's estimated 58,421 miles of ocean coastline (Figure ES-14). Most of the surveyed waters (4,834 miles, or 93%) have good quality that supports a healthy aquatic community and public activities (Figure ES-15). Of these waters, 225 miles (4% of the surveyed shoreline) are threatened and may deteriorate in the future.

Some form of pollution or habitat degradation impairs the remaining 7% of the surveyed shoreline (374 miles). Five percent of the surveyed estuarine waters have fair water quality that partially supports designated uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Only 2% of the surveyed shoreline suffers from poor water quality that consistently stresses aquatic life and/or prevents people from using the shoreline for activities such as swimming and shellfishing.



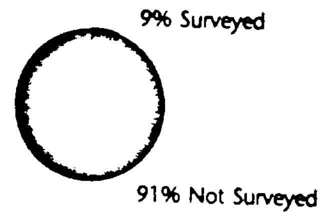
Paul Goetz, Cary, NC

Only six of the 27 coastal States identified pollutants and sources of pollutants degrading ocean shoreline waters. General conclusions cannot be drawn from the information supplied by these States because these States border less than 1% of the shoreline along the contiguous States. The six States identified impacts in their ocean shoreline waters from bacteria, metals, nutrients, turbidity, siltation, and pesticides. The six States reported that urban runoff and storm sewers, industrial discharges, land disposal of wastes, septic systems, agriculture, unspecified nonpoint sources, and combined sewer overflows (CSOs) pollute their coastal shoreline waters.

Figure ES-14. Ocean Sh[illegible] Surveyed

Total ocean shore = 58,421 miles including Alaska's shoreline

Total surveyed = 5,208 miles



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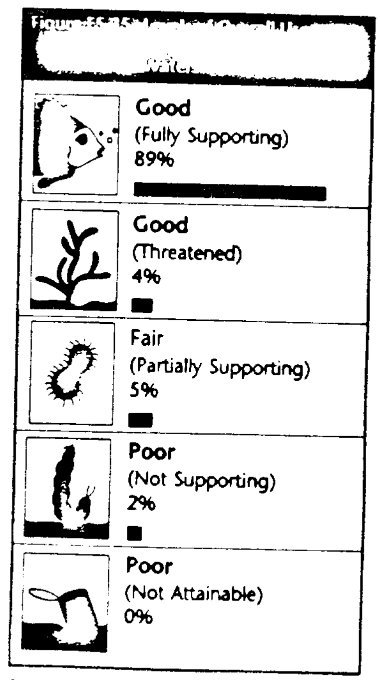

Source: Based on 1994 Section 305(b) reports submitted by States and Territories.

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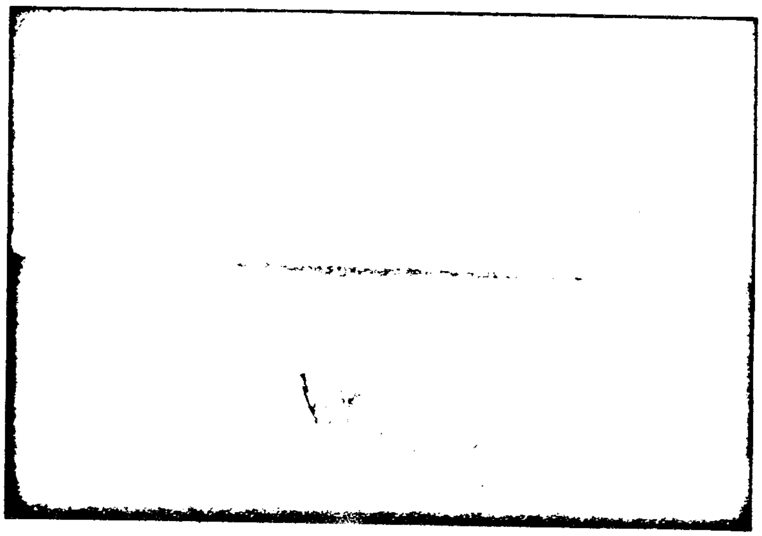
Wetlands

Wetlands are areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support (and that under normal circumstances does support) a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands, which are found throughout the United States, generally include swamps, marshes, bogs, and similar areas.

Wetlands are now recognized as some of the most unique and important natural areas on earth. They vary in type according to differences in local and regional hydrology, vegetation, water chemistry, soils, topography, and climate. Coastal wetlands include estuarine marshes; mangrove swamps found in Puerto Rico, Hawaii, Louisiana, and Florida; and Great Lakes coastal wetlands. Inland wetlands, which may be adjacent to a waterbody or isolated, include marshes and wet meadows bottomland hardwood forests, Great Plains prairie potholes, cypress-gum swamps, and southwestern playa lakes.

In their natural condition, wetlands provide many benefits, including food and habitat for fish and wildlife, water quality improvement, flood protection, shoreline erosion control, ground water exchange, as well as natural products for human use and opportunities for recreation, education, and research.

Wetlands help maintain and improve water quality by intercepting surface water runoff before it reaches open water, removing or retaining nutrients, processing chemical and organic wastes, and reducing sediment loads to receiving waters. As water moves through a wetland, plants slow the water, allowing sediment and pollutants to settle out. Plant roots trap sediment and are then able to metabolize and detoxify pollutants and remove nutrients such as nitrogen and phosphorus.



Audrey Moore, U.S. EPA, Region 2

Wetlands function like natural basins, storing either floodwater that overflows riverbanks or surface water that collects in isolated depressions. By doing so, wetlands help protect adjacent and downstream property from flood damage. Trees and other wetlands vegetation help slow the speed of flood waters. This action, combined with water storage, can lower flood heights and reduce the water's erosive potential. In agricultural areas, wetlands can help reduce the likelihood of flood damage to crops. Wetlands within and upstream of urban areas are especially valuable for flood protection because urban development increases the rate and volume of surface water runoff, thereby increasing the risk of flood damage.

Wetlands produce a wealth of natural products, including fish and shellfish, timber, wildlife, and wild rice. Much of the Nation's fishing and shellfishing industry harvests wetlands-dependent species. A national survey conducted by the Fish and Wildlife Service (FWS) in 1991 illustrates the economic value of some of the wetlands-dependent products. Over 9 billion pounds of fish and shellfish landed in the United States in 1991 had a direct, dockside value of $3.3 billion. This served as the basis of a seafood processing and sales industry that generated total expenditures of $26.8 billion. In addition, 35.6 million anglers spent $24 billion on freshwater and saltwater fishing. It is estimated that 71% of commercially valuable fish and shellfish depend directly or indirectly on coastal wetlands.

Overall Water Quality

The States, Tribes, and other jurisdictions are making progress in developing specific designated uses and water quality standards for wetlands, but many States and Tribes still lack specific water quality criteria and monitoring programs for wetlands. Without criteria and monitoring data, most States and Tribes cannot evaluate use support. To date, only nine States and Tribes reported the designated use support status for some of their wetlands. Only one State used quantitative data as a basis for the use support decisions.

EPA cannot derive national conclusions about water quality conditions in all wetlands because the States used different methodologies to survey only 3% of the total wetlands in the Nation. Summarizing State wetlands data would also produce misleading results because two States (North Carolina and Louisiana) contain 91% of the surveyed wetlands acreage.

What Is Polluting Our Wetlands and Where Does This Pollution Come From?

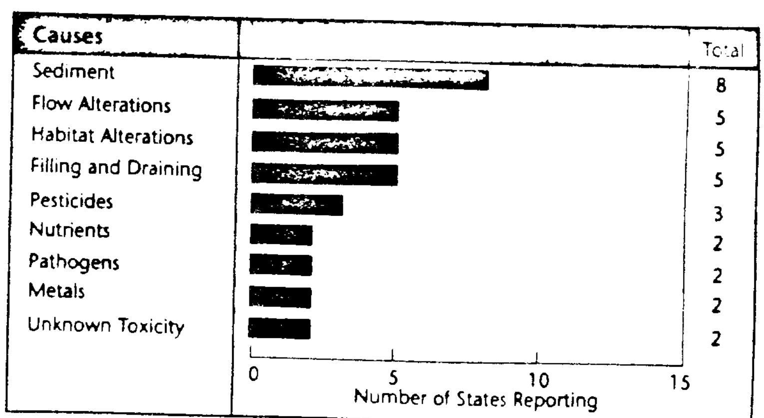
The States have even fewer data to quantify the extent of pollutants degrading wetlands and the sources of these pollutants. Although most States cannot quantify wetlands area impacted by individual causes and sources of degradation, 12 States identified causes and 13 States identified sources known to degrade wetlands integrity to some extent. These States listed sediment as the most widespread cause of degradation impacting wetlands, followed by flow alterations, habitat modifications, and draining (Figure ES-16). Agriculture topped the list of sources degrading wetlands, followed by urban runoff, hydrologic modification, and municipal point sources (Figure ES-17).

Wetlands Loss: A Continuing Problem

It is estimated that over 200 million acres of wetlands existed in the lower 48 States at the time of European settlement. Since then, extensive wetlands acreage has been lost, with many of the original wetlands drained and converted to farmland and urban development. Today, less than half of our original wetlands remain. The losses amount to an area equal to the size of California. According to the U.S. Fish and Wildlife Service's *Wetlands Losses in the United States 1780's to 1980's*, the three States that have sustained the greatest percentage of wetlands loss are California (91%), Ohio (90%), and Iowa (89%).

According to FWS status and trends reports, the average annual loss of wetlands has decreased over the past 40 years. The average annual loss from the mid-1950s to the mid-1970s was 458,000 acres, and from the mid-1970s to the mid-1980s it was 290,000 acres. Agriculture was responsible for 87% of the loss from the mid-1950s to the mid-1970s and 54% of the loss from the mid-1970s to the mid-1980s.

Figure ES-16. Causes Degrading Wetlands Integrity (12 States Reporting)



Based on data contained in Appendix D, Table D-2.

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A more recent estimate of wetlands losses from the National Resources Inventory (NRI), conducted by the Natural Resources Conservation Service (NRCS), indicates that 792,000 acres of wetlands were lost on non-Federal lands between 1982 and 1992 for a yearly loss estimate of 70,000 to 90,000 acres. This net loss is the result of gross losses of 1,561,300 acres of wetlands and gross gains of 768,700 acres of wetlands over the 10-year period. The NRI estimates are consistent with the trend of declining wetlands losses reported by FWS. Although losses have decreased, we still have to make progress toward our interim goal of no overall net loss of the Nation's remaining wetlands and the long-term goal of increasing the quantity and quality of the Nation's wetlands resource base.

The decline in wetlands losses is a result of the combined effect of several trends: (1) the decline in profitability in converting wetlands for agricultural production;
(2) passage of Swampbuster provisions in the 1985 and 1990 Farm Bills that denied crop subsidy benefits to farm operators who converted wetlands to cropland after 1985; (3) presence of the CWA Section 404 permit programs as well as development of State management programs; (4) greater public interest and support for wetlands protection; and (5) implementation of wetlands restoration programs at the Federal, State, and local level.

Nineteen States listed sources of recent wetlands losses in their 1994 305(b) reports. Residential development and urban growth were cited as the leading sources of current losses. Other losses were due to commercial development; construction of roads, highways, and bridges; agriculture; and industrial development. In addition to human activities, a few States also reported that natural sources, such as rising lake levels, resulted in wetlands losses and degradation.

Figure ES-17. Sources Degrading Wetlands Integrity (12 States Reporting)

Sources	Total
Agriculture	8
Urban Runoff	6
Hydrologic Modification	5
Municipal Point Sources	4
Construction	4
Road Construction	4
Land Disposal	4

Number of States Reporting (axis: 0, 5, 10, 15)

Based on data contained in Appendix D, Table D-3.

Kings Park Elementary, 3rd Grade, Springfield, VA

More information on wetlands can be obtained from the EPA Wetlands Hotline at 1-800-832-7828.

Ground Water

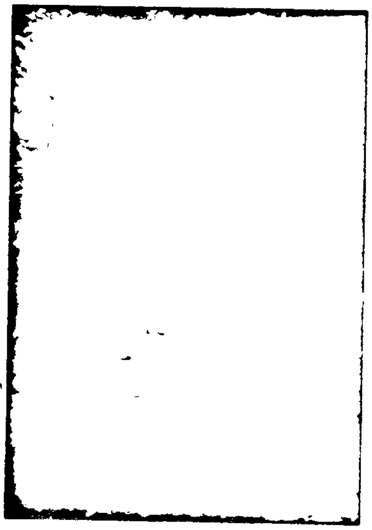
Ninety-five percent of all fresh water available on earth (exclusive of icecaps) is ground water. Ground water–water found in natural underground rock formations called aquifers–is a vital natural resource with many uses. The extent of the Nation's ground water resources is enormous. At least 60% of the land area in the conterminous United States overlies aquifers that may be susceptible to contamination. Usable ground water exists in every State.

Aquifers can range in size from thin surficial formations that yield small quantities of ground water to large systems such as the High Plains aquifer that underlies eight western States and provides water to millions. Although the Nation's ground water is of good quality, it is recognized that ground water is more vulnerable to contamination than previously reported and that an increasing number of pollution events and contamination sources are threatening the integrity of the resource.

Ground Water Use

Nationally, 51% of the population relies to some extent on ground water as a source of drinking water. This percentage is even higher in rural areas where most residents rely on potable or treatable ground water as an economical source of drinking water. Eighty-one percent of community water systems are dependent on ground water. Seventy-four percent of community water systems are small ground water systems serving 3,300 people or less. Ninety-five percent of the approximately 200,000 noncommunity water systems (serving schools, parks, and other small facilities) are ground water systems.

Ground water provides drinking water for 51% of the population.



Jeff Reynolds, Raleigh, NC

Irrigation accounts for approximately 63% of national ground water withdrawals. Public drinking water supplies account for approximately 19% of the Nation's total ground water withdrawals. Domestic, commercial, livestock, industrial, mining, and thermoelectric withdrawals together account for approximately 18% of national ground water withdrawals.

Ground Water Quality

Although the 1994 Section 305(b) State Water Quality Reports indicate that, overall, the Nation's ground water is of good quality, many local areas have experienced significant ground water contamination. The sources and types of ground water contamination vary depending upon the region of the country. Those most frequently reported by States include:

- **Leaking underground storage tanks.** Approximately 1.2 million federally regulated underground storage tanks are buried at over 500,000 sites nationwide. An estimated 139,000 tanks have leaked and impacted ground water quality.
- **Agricultural activities.** Seventy-seven percent of the 1.1 billion pounds of pesticides produced annually in the United States is applied to land in agricultural production, which usually overlies aquifers.
- **Superfund sites.** More than 85% of all Superfund sites have some degree of ground water contamination. Most of these sites impact aquifers that are currently used, or potentially may be used, for drinking water purposes.
- **Septic tanks.** Approximately 23 million domestic septic tanks are in operation in the United States. These tanks impact ground water quality through the discharge of fluids into or above aquifers.

The most common contaminants associated with these sources include petroleum compounds, nitrates, metals, volatile organic compounds (VOCs), and pesticides.

States are reporting that ground water quality is most likely to be adversely affected by contamination in areas of high demand or stress.

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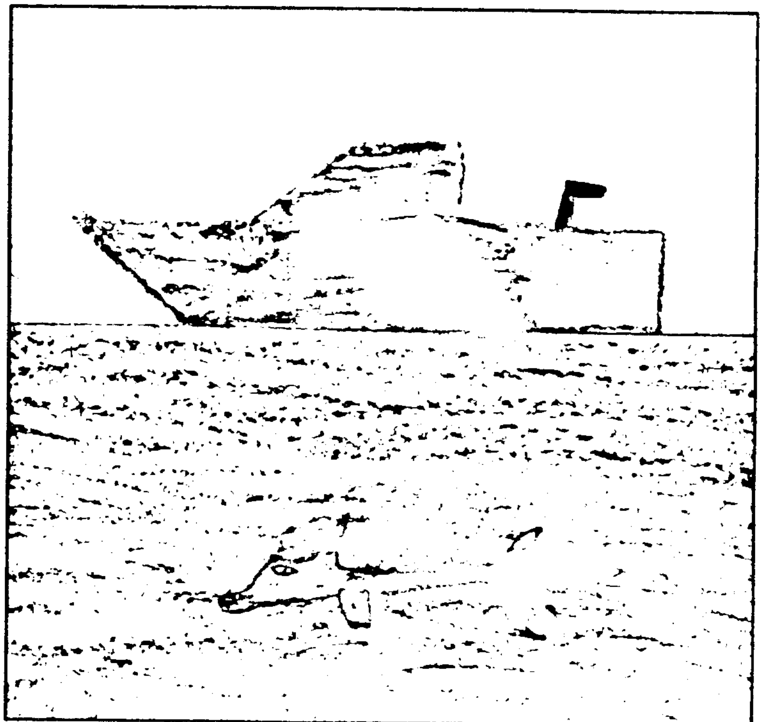
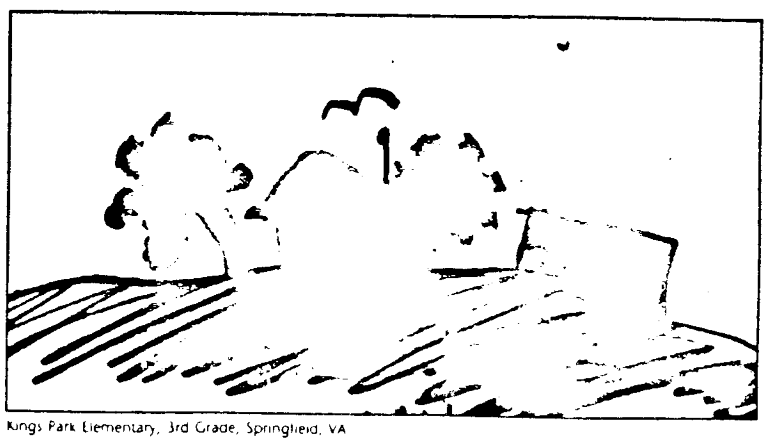
To combat these problems, States are developing programs designed to evaluate the overall quality and vulnerability of their ground water resources, to identify potential threats to ground water quality, and to identify methods to protect their ground water resources. Thirty-three States indicate that they have implemented statewide ground water monitoring programs.

Ground water monitoring programs vary widely among the States, depending upon the special needs of each of the States. For example, some States choose to monitor ground water quality in specific areas that are especially vulnerable to contamination, whereas other States may choose to monitor ground water quality on a statewide basis. When it comes to selecting chemicals to test for in the ground water, some States monitor for a large suite of chemicals, whereas other States limit monitoring to one or two specific chemicals that are a definite threat to ground water quality.

Ground water monitoring provides a great deal of information about the nature and quality of our Nation's ground water resources. Still, there is much we do not know about how human activities influence ground water quality. Our continued quest for information about the status of our ground water will help protect and preserve this vast and vulnerable resource. Through a greater understanding of how human activities influence ground water quality, we can better ensure the long-term availability of high-quality water for future generations.



Alisha Batten, age 8, Bruner Elementary, North Las Vegas, NV



Kings Park Elementary, 3rd Grade, Springfield, VA

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Water Quality Protection Programs

Although significant strides have been made in reducing the impacts of discrete pollutant sources, our aquatic resources remain at risk from a combination of point sources and complex nonpoint sources, including air pollution. Since 1991, EPA has promoted the watershed protection approach as a holistic framework for addressing complex pollution problems.

The watershed protection approach is a place-based strategy that integrates water quality management activities within hydrologically defined drainage basins—watersheds—rather than areas defined by political boundaries. Thus, for a given watershed, the approach encompasses not only the water resource (such as a stream, lake, estuary, or ground water aquifer), but all the land from which water drains to the resource. To protect water resources, it is increasingly important to address the condition of land areas within the watershed because water carries the effects of human activities throughout the watershed as it drains off the land into surface waters or leaches into the ground water.

Under the Watershed Protection Approach (WPA), a "watershed" is a hydrogeologic area defined for addressing water quality problems. For example, a WPA watershed may be a river basin, a county-sized watershed, or a small drinking water supply watershed.

Mike Steuart, Minnesota Pollution Control Agency

EPA's Office of Water envisions the watershed protection approach as the primary mechanism for achieving clean water and healthy, sustainable ecosystems throughout the Nation. The watershed protection approach enables stakeholders to take a comprehensive look at ecosystem issues and tailor corrective actions to local concerns within the coordinated framework of a national water program. The emphasis on public participation also provides an opportunity to incorporate environmental justice issues into watershed restoration and protection solutions.

In May of 1994, the EPA Assistant Administrator for Water, Robert Perciasepe, created the Watershed Management Policy Committee to coordinate the EPA water program's support of the watershed protection approach. During 1995, EPA's water program managers, under the direction of the Watershed Management Policy Committee, evaluated their programs and identified additional activities needed to support the watershed protection approach in an action plan.

EPA's Office of Water will continue to promote and support the watershed protection approach at local, State, Tribal, Territorial, and Federal levels. The Office of Water recognizes that the watershed protection approach relies on active participation by local governments and citizens who have the most direct knowledge of local problems and opportunities in their watersheds. However, the Office of Water will look to the States, Tribes, and Territories to create the framework for supporting local efforts because most EPA programs are implemented by the States, Tribes, and Territories.

The Clean Water Act

A number of laws provide the authority to develop and implement pollution control programs. The primary statute providing for water quality protection in the Nation's rivers, lakes, wetlands, estuaries, and coastal waters is the Federal Water Pollution Control Act of 1972, commonly known as the Clean Water Act.

The CWA and its amendments are the driving force behind many of the water quality improvements we have witnessed in recent years. Key provisions of the CWA provide the following pollution control programs.

Water quality standards and criteria - States, Tribes, and other jurisdictions adopt EPA-approved standards for their waters that define water quality goals for individual waterbodies. Standards consist of designated beneficial uses to be made of the water, criteria to protect those uses, and antidegradation provisions to protect existing water quality.

Effluent guidelines - The EPA develops nationally consistent guidelines limiting pollutants in discharges from industrial facilities and municipal sewage treatment plants. These guidelines are then used in permits issued to dischargers under the

The Watershed Protection Approach (WPA)

Several key principles guide the watershed protection approach:

- **Place-based focus** – Resource management activities are directed within specific geographical areas, usually defined by watershed boundaries, areas overlying or recharging ground water, or a combination of both.
- **Stakeholder involvement and partnerships** – Watershed initiatives involve the people most likely to be affected by management decisions in the decision making process. Stakeholder participation ensures that the objectives of the watershed initiative will include economic stability and that the people who depend on the water resources in the watershed will participate in planning and implementation activities. Watershed initiatives also establish partnerships between Federal, State, and local agencies and nongovernmental organizations with interests in the watershed.
- **Environmental objectives** – The stakeholders and partners identify environmental objectives (such as "populations of striped bass will stabilize or increase") rather than programmatic objectives (such as "the State will eliminate the backlog of discharge permit renewals") to measure the success of the watershed initiative. The environmental objectives are based on the condition of the ecological resource and the needs of people in the watershed.
- **Problem identification and prioritization** – The stakeholders and partners use sound scientific data and methods to identify and prioritize the primary threats to human and ecosystem health within the watershed. Consistent with the Agency's mission, EPA views ecosystems as the interactions of complex communities that include people; thus, healthy ecosystems provide for the health and welfare of humans as well as other living things.
- **Integrated actions** – The stakeholders and partners take corrective actions in a comprehensive and integrated manner, evaluate success, and refine actions if necessary. The watershed protection approach coordinates activities conducted by numerous government agencies and nongovernmental organizations to maximize efficient use of limited resources.

National Pollutant Discharge Elimination System (NPDES) program. Additional controls may be required if receiving waters are still affected by water quality problems after permit limits are met.

Total Maximum Daily Loads– The development of Total Maximum Daily Loads, or TMDLs, establishes the link between water quality standards and point/nonpoint source pollution control actions such as permits or Best Management Practices (BMPs). A TMDL calculates allowable loadings from the contributing point and nonpoint sources to a given waterbody and provides the quantitative basis for pollution reduction necessary to meet water quality standards. States, Tribes, and other jurisdictions develop and implement TMDLs for high-priority impaired or threatened waterbodies.

Permits and enforcement – All industrial and municipal facilities that discharge wastewater must have an NPDES permit and are responsible for monitoring and reporting levels of pollutants in their discharges. EPA issues these permits or can delegate that permitting authority to qualifying States or other jurisdictions. The States, other qualified jurisdictions, and EPA inspect facilities to determine if their discharges comply with permit limits. If dischargers are not in compliance, enforcement action is taken.

Grants – The EPA provides States with financial assistance to help support many of their pollution control programs. These programs include the State Revolving Fund program for construction and upgrading of municipal sewage treatment plants; water quality monitoring, permitting, and enforcement; and developing and implementing nonpoint source pollution controls, combined sewer and stormwater controls, ground water strategies, lake assessment, protection, and restoration activities, estuary and near coastal management programs, and wetlands protection activities.

Nonpoint source control – The EPA provides program guidance, technical support, and funding to help the States, Tribes, and other jurisdictions control nonpoint source pollution. The States, Tribes, and other jurisdictions are responsible for analyzing the extent and severity of their nonpoint source pollution problems and developing and implementing needed water quality management actions.

The CWA also established pollution control and prevention programs for specific waterbody categories, such as the Clean Lakes Program. Other statutes that also guide the development of water quality protection programs include:

- **The Safe Drinking Water Act**, under which States establish standards for drinking water quality, monitor wells and local water supply systems, implement drinking water protection programs, and implement Underground Injection Control (UIC) programs.

- **The Resource Conservation and Recovery Act**, which establishes State and EPA programs for ground water and surface water protection and cleanup and emphasizes prevention of releases through management standards in addition to other waste management activities.

- **The Comprehensive Environmental Response, Compensation, and Liability Act (Superfund Program)**, which provides EPA with the authority to clean up contaminated waters during remediation at contaminated sites.

- **The Pollution Prevention Act** of 1990, which requires EPA to promote pollutant source reduction rather than focus on controlling pollutants after they enter the environment.

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Protecting Lakes

Managing lake quality often requires a combination of in-lake restoration measures and pollution controls, including watershed management measures:

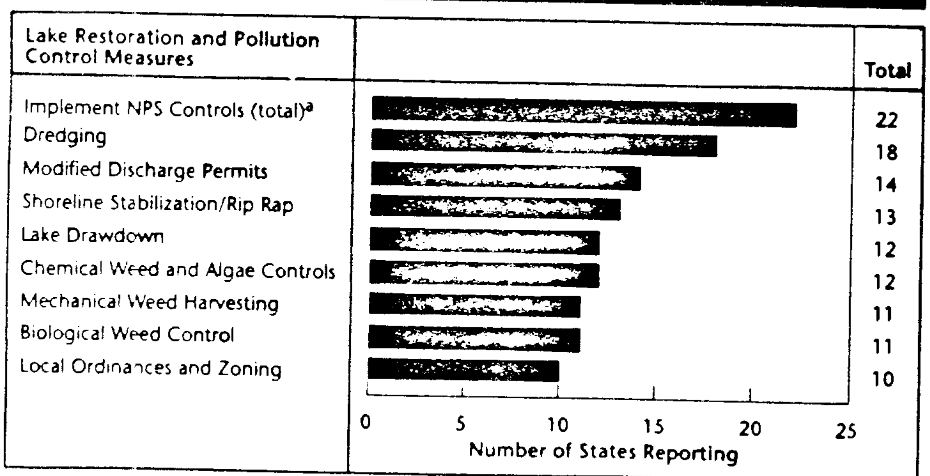
Restoration measures are implemented to reduce existing pollution problems. Examples of in-lake restoration measures include harvesting aquatic weeds, dredging sediment, and adding chemicals to precipitate nutrients out of the water column. Restoration measures focus on restoring uses of a lake and may not address the source of the pollution.

Pollution control measures deal with the sources of pollutants degrading lake water quality or threatening to impair lake water quality. Control measures include planning activities, regulatory actions, and implementation of BMPs to reduce nonpoint sources of pollutants.

During the 1980s, most States implemented chemical and mechanical in-lake restoration measures to control aquatic weeds and algae. In their 1994 Section 305(b) reports, the States and Tribes report a shift toward nonpoint source controls to reduce pollutant loads responsible for aquatic weed growth and algal blooms (Figure ES-18). Twenty-two States reported that they implemented best management practices to control nonpoint source pollution entering more than 171 lakes. The States reported that they implemented agricultural practices to control soil erosion, constructed retention and detention basins to control urban runoff, managed animal waste, revegetated shorelines, and constructed or restored wetlands to remove pollutants from runoff. Although the States reported that they still use in-lake treatments, the States recognize that source controls are needed in addition to in-lake treatments to restore lake water quality.

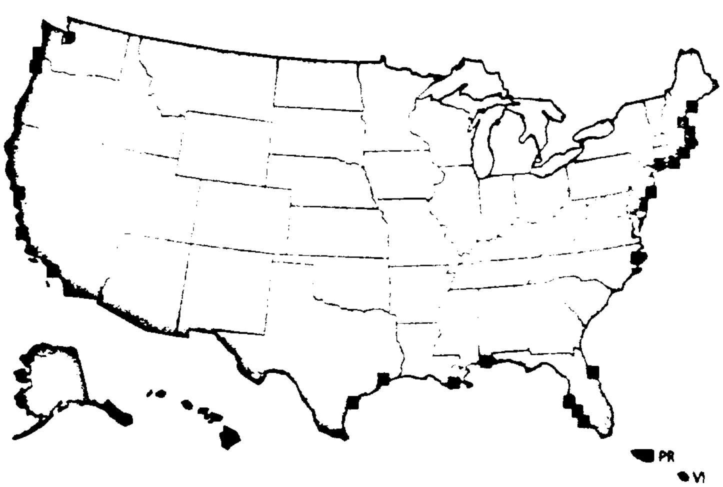
Successful lake programs require strong commitment from local citizens and cooperation from natural resource agencies at the local, State, and Federal levels.

Figure ES-18



[a]Includes best management practices, such as conservation tillage, sediment detention basins, vegetated buffers, and animal waste management.

Figure ES-19.--Locations of National Estuary Program Sites



The National Estuary Program

Section 320 of the Clean Water Act (as amended by the Water Quality Act of 1987) established the National Estuary Program (NEP) to protect and restore water quality and living resources in estuaries. The NEP adopts a geographic or watershed approach by planning and implementing pollution abatement activities for the estuary and its surrounding land area as a whole.

The NEP embodies the ecosystem approach by building coalitions, addressing multiple sources of contamination, pursuing habitat protection as a pollution control mechanism, and investigating cross-media transfer of pollutants from air and soil into specific estuarine waters. Under the NEP, a State governor nominates an estuary in his or her State for participation in the program. The State must demonstrate a likelihood of success in protecting candidate estuaries and provide evidence of institutional, financial, and political commitment to solving estuarine problems.

If an estuary meets the NEP guidelines, the EPA Administrator convenes a management conference of representatives from interested Federal, Regional, State, and local governments; affected industries; scientific and academic institutions; and citizen organizations. The management conference defines program goals and objectives, identifies problems, and designs strategies to control pollution and manage natural resources in the estuarine basin. Each management conference develops and initiates implementation of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect the estuary.

The NEP currently supports 28 estuary projects.

The NEP integrates science and policy by bringing water quality managers, elected officials, and stakeholders together with scientists from government agencies, academic institutions, and the private sector. Because the NEP is not a research program, it relies heavily on past and ongoing research of other agencies and institutions to support development of CCMPs.

With the addition of seven estuary sites in July of 1995, the NEP currently supports 28 estuary projects (see Figure ES-19). These 28 estuaries are nationally significant in their economic value as well as in their ability to support living resources. The project sites also represent a broad range of environmental conditions in estuaries throughout the United States and its Territories so that the lessons learned through the NEP can be applied to other estuaries.

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> Shortly after coming into office, the Clinton Administration convened an interagency working group to address concerns with Federal wetlands policy. After hearing from States, developers, farmers, environmental interests, members of Congress, and scientists, the working group developed a comprehensive 40-point plan for wetlands protection to make wetlands programs more fair, flexible, and effective. This plan was issued on August 24, 1993
>
> The Administration's Wetlands Plan emphasizes improving Federal wetlands policy by
>
> - Streamlining wetlands permitting programs
> - Increasing cooperation with private landowners to protect and restore wetlands
> - Basing wetlands protection on good science and sound judgment
> - Increasing participation by States, Tribes, local governments, and the public in wetlands protection.

Protecting Wetlands

A variety of public and private programs protect wetlands. Section 404 of the CWA continues to provide the primary Federal vehicle for regulating certain activities in wetlands. Section 404 establishes a permit program for discharges of dredged or fill material into waters of the United States, including **wetlands**.

The U.S. Army Corps of Engineers (COE) and EPA jointly implement the Section 404 program. The COE is responsible for reviewing permit applications and making permit decisions. EPA establishes the environmental criteria for making permit decisions and has the authority to review and veto Section 404 permits proposed for issuance by the COE. EPA is also responsible for determining geographic jurisdiction of the Section 404 permit program, interpreting statutory exemptions, and overseeing Section 404 permit programs assumed by individual States. To date, only two States (Michigan and New Jersey) have assumed the Section 404 permit program from the COE. The COE and EPA share responsibility for enforcing Section 404 requirements.

The COE issues **individual** Section 404 permits for specific projects or **general** permits (Table ES-5). Applications for individual permits go through a review process that includes opportunities for EPA, other Federal agencies (such as the U.S. Fish and Wildlife Service and the National Marine Fisheries Service), State agencies, and the public to comment. However, the vast majority of activities proposed in wetlands are covered by Section 404 general permits. For example, in FY94, over 48,000 people applied to the COE for a Section 404 permit. Eighty-two percent of these applications were covered by general permits and were processed in an average of 16 days. It is estimated that another 50,000 activities are covered by general permits that do not require notification of the COE at all.

General permits allow the COE to permit certain activities without performing a separate individual

Table ES-5 Federal Section 404 Permits

General Permits (streamlined permit review procedures)				Individual Permits
Nationwide Permits	Regional Permits	Programmatic Permits		
		State Programmatic Permits	Others	
• Cover 36 types of activities that the COE determines to have minimal adverse impacts on the environment	• Developed by COE District Offices to cover activities in a specified region	• COE defers permit decisions to State agency while reserving authority to require an individual permit	• Special Management Agencies • Watershed Planning Commissions	• Required for major projects that have the potential to cause significant adverse impacts • Project must undergo interagency review • Opportunity for public comment • Opportunity for 401 certification review

permit review. Some general permits require notification of the COE before an activity begins. There are three types of general permits:

- Nationwide permits (NWPs) authorize specific activities across the entire Nation that the COE determines will have only minimal individual and cumulative impacts on the environment, including construction of minor road crossings and farm buildings, bank stabilization activities, and the filling of up to 10 acres of isolated or headwater wetlands.

- Regional permits authorize types of activities within a geographic area defined by a COE District Office.

- Programmatic general permits are issued to an entity that the COE determines may regulate activities within its jurisdictional wetlands. Under a programmatic general permit, the COE defers its permit decision to the regulating entity but reserves its authority to require an individual permit.

Currently, the COE and EPA are promoting the development of State programmatic general permits (SPGPs) to increase State involvement in wetlands protection and minimize duplicative State and Federal review of activities proposed in wetlands. Each SPGP is a unique arrangement developed by a State and the COE to take advantage of the strengths of the individual State wetlands program. Several States have adopted comprehensive SPGPs that replace many or all COE-issued nationwide general permits. SPGPs simplify the regulatory process and increase State control over their wetlands resources. Carefully developed SPGPs can improve wetlands protection while reducing regulatory demands on landowners.

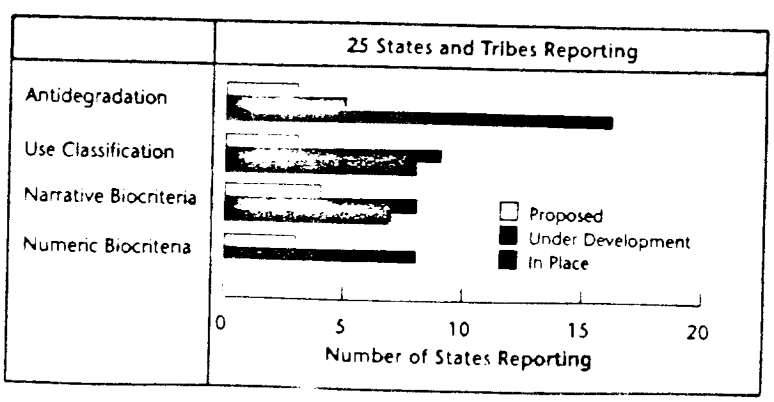
Water quality standards for wetlands ensure that the provisions of CWA Section 303 that apply to other surface waters are also applied to wetlands. In July 1990, EPA issued guidance to States for the development of wetlands water quality standards. Water quality standards consist of designated beneficial uses, numeric criteria, narrative criteria, and antidegradation statements. Figure ES-20 indicates the State's progress in developing these standards.

Standards provide the foundation for a broad range of water quality management activities under the CWA including, but not limited to, monitoring for the Section 305(b) report, permitting under Section 402 and 404, water quality certification under Section 401, and the control of nonpoint source pollution under Section 319.

States, Territories, and Tribes are well positioned between Federal and local government to take the lead in integrating and expanding wetlands protection and management programs. They are experienced in managing federally mandated environmental programs, and they are uniquely equipped to help resolve local and regional conflicts and identify the local economic and geographic factors that may influence wetlands protection.

Section 401 of the CWA gives States and eligible American Indian Tribes the authority to grant, condition, or deny certification of federally permitted or licensed activities that may result in a discharge to U.S. waters, including wetlands. Such activities include discharge of dredged or fill material permitted under CWA Section 404, point source discharges permitted under CWA Section 402, and Federal Energy Regulatory Commission's

Figure ES-20. Development of State Water Quality Standards for Wetlands



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hydropower licenses. States review these permits to ensure that they meet State water quality standards.

Section 401 certification can be a powerful tool for protecting wetlands from unacceptable degradation or destruction especially when implemented in conjunction with wetlands-specific water quality standards. If a State or an eligible Tribe denies Section 401 certification, the Federal permitting or licensing agency cannot issue the permit or license.

Until recently, many States waived their right to review and certify Section 404 permits because these States had not defined water quality standards for wetlands or codified regulations for implementing their 401 certification program into State law. Now, most States report that they use the Section 401 certification process to review Section 404 projects and to require mitigation if there is no alternative to degradation of wetlands. Ideally, 401 certification should be used to augment State programs because activities that do not require Federal permits or licenses, such as some ground water withdrawals, are not covered.

State Wetlands Conservation Plans (SWCPs) are strategies that integrate regulatory and cooperative approaches to achieve State wetlands management goals, such as no overall net loss of wetlands. SWCPs are not meant to create a new level of bureaucracy. Instead, SWCPs improve government and private-sector effectiveness and efficiency by identifying gaps in wetlands protection programs and identifying opportunities to improve wetlands programs.

States, Tribes, and other jurisdictions protect their wetlands with a variety of other approaches, including permitting programs, coastal management programs, wetlands acquisition programs, natural heritage programs, and integration with other programs. The following trends emerged from individual State and Tribal reporting:

- Most States have defined wetlands as waters of the State, which offers general protection through antidegradation clauses and designated uses that apply to all waters of a State. However, most States have not developed specific wetlands water quality standards and designated uses that protect wetlands' unique functions, such as flood attenuation and filtration.

- Without specific wetlands uses and standards, the Section 401 certification process relies heavily on antidegradation clauses to prevent significant degradation of wetlands.

- In many cases, the States use the Section 401 certification process to add conditions to Section 404 permits that minimize the size of wetlands destroyed or degraded by proposed activities to the extent practicable. States often add conditions that require compensatory mitigation for destroyed wetlands, but the States do not have the resources to perform enforcement inspections or followup monitoring to ensure that the wetlands are constructed and functioning properly.

- More States are monitoring selected, largely unimpacted wetlands to establish baseline conditions in healthy wetlands. The States will use this information to monitor the relative performance of constructed wetlands and to help establish biocriteria and water quality standards for wetlands.

Although the States, Tribes, and other jurisdictions report that they are making progress in protecting wetlands, they also report that the pressure to develop or destroy wetlands remains high. EPA and the States, Tribes, and other jurisdictions will continue to pursue new mechanisms for protecting wetlands that rely less on regulatory tools.

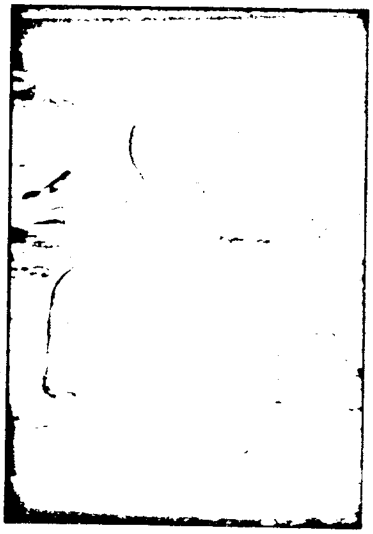
Protecting the Great Lakes

Restoring and protecting the Great Lakes requires cooperation from numerous organizations because the pollutants that enter the Great Lakes originate in both the United States and Canada, as well as in other countries. The International Joint Commission (IJC), established by the 1909 Boundary Waters Treaty, provides a framework for the cooperative management of the Great Lakes. Representatives from the United States and Canada, the Province of Ontario, and the eight States bordering the Lakes sit on the IJC's Water Quality Board. The Water Quality Board recommends actions for protecting and restoring the Great Lakes and evaluates the environmental policies and actions implemented by the United States and Canada.

The EPA Great Lakes National Program Office (GLNPO) coordinates Great Lakes management activities conducted by all levels of government within the United States. The GLNPO also works with nongovernmental organizations to protect and restore the Lakes. The GLNPO provides leadership through its annual *Great Lakes Program Priorities and Funding Guidance*. The GLNPO also serves as a liaison to the Canadian members of the IJC and the Canadian environmental agencies.

The 1978 Great Lakes Water Quality Agreement (as amended in 1987) lay the foundation for ongoing efforts to restore and protect the Great Lakes. The Agreement committed the United States and Canada to developing Remedial Action Plans (RAPs) for Areas of Concern and Lakewide Management Plans (LaMPs) for each Lake. Areas of Concern are specially designated waterbodies around the Great Lakes that show symptoms of serious water quality degradation. Most of the 42 Areas of Concern are located in harbors, bays, or river mouths entering the Great Lakes. RAPs identify impaired uses and examine management options for addressing degradation in an Area of Concern. LaMPs use an ecosystem approach to examine water quality issues that have more widespread impacts within each Great Lake. Public involvement is a critical component of both LaMP development and RAP development.

EPA advocates pollution prevention as the most effective approach for achieving the virtual elimination of persistent toxic discharges into the Great Lakes. The GLNPO has funded numerous pollution prevention grants throughout the Great



Julie Fountain, Youngsville, NC

Lakes Basin during the past 3 years. EPA and the States also implemented the 38/50 Program in the Great Lakes Basin, under which EPA received voluntary commitments from industry to reduce the emission of 17 priority pollutants by 50% by the end of 1995. In addition, EPA, the States, and Canada are implementing a virtual elimination initiative for Lake Superior. The first phase of the initiative seeks to eliminate new contributions of mercury.

The Great Lakes Water Quality Initiative is a key element of the environmental protection efforts undertaken by the United States in the Great Lakes Basin. The purpose of the Initiative is to provide a consistent level of protection in the Basin from the effects of toxic pollutants. In 1989, the Initiative was organized by EPA at the request of the Great Lakes States to promote consistency in their environmental programs in the Great Lakes Basin with minimum requirements.

Initiative efforts were well under way when Congress enacted the Great Lakes Critical Programs Act of 1990. The Act requires EPA to publish proposed and final water quality guidance that specifies minimum water quality criteria for the Great Lakes System. The Act also requires the Great Lakes States to adopt provisions that are consistent with the EPA final guidance within 2 years of EPA's publication. In addition, Indian Tribes authorized to administer an NPDES program in the Great Lakes Basin must also adopt provisions consistent with EPA's final guidance.

To carry out the Act, EPA proposed regulations for implementing the guidance on April 16, 1993, and invited the public to comment. The States and EPA conducted public meetings in all of the Great Lakes States during the comment period. As a result, EPA received over 26,500 pages of comments from over 6,000 commenters. EPA reviewed all of the comments and published the final guidance in March of 1995.

The final guidance prioritizes control of long-lasting pollutants that accumulate in the food web—bioaccumulative chemicals of concern (BCCs). The final guidance includes provisions to phase out mixing zones for BCCs (except in limited circumstances), more extensive data requirements to ensure that BCCs are not underregulated due to a lack of data, and water quality criteria to protect wildlife that feed on aquatic prey.

Publication of the final guidance is a milestone in EPA's move toward increasing stakeholder participation in the development of innovative and comprehensive programs for protecting and restoring our natural resources.

The Chesapeake Bay Program

In many areas of the Chesapeake Bay, the quality is not sufficient to support living resources year round. In the warmer months, large portions of the Bay contain little or no dissolved oxygen. Low oxygen conditions may cause fish eggs and larvae to die. The growth and reproduction of oysters, clams, and other bottom-dwelling animals are impaired. Adult fish find their habitat reduced and their feeding inhibited.

Many areas of the Bay also have cloudy water from excess sediment in the water or an overgrowth of algae (stimulated by excessive nutrients in the water). Turbid waters block the sunlight needed to support the growth and survival of Bay grasses, also known as submerged aquatic vegetation (SAV). Without SAV, critical habitat for fish and crabs is lost. Although there has been a recent resurgence of SAV in some areas of the Bay, most areas still do not support abundant populations as they once did.

The main causes of the Bay's poor water quality and aquatic habitat loss are elevated levels of the nutrients nitrogen and phosphorus. Both are natural fertilizers found in animal wastes, soil, and the atmosphere. These nutrients have always existed in the Bay, but not at the present elevated concentrations. When the Bay was surrounded primarily by forests and wetlands, very little nitrogen and phosphorus ran off the land into the water. Most of it was absorbed or held in place by the natural vegetation. As the use of the land has changed and the watershed's population has grown, the amount of nutrients entering the Bay has increased tremendously.

Now in its twelfth year, the Chesapeake Bay Program is a regional partnership of Federal, State, and local participants that has directed and coordinated restoration of the Bay since the signing of the historic 1983 Chesapeake Bay Agreement. Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission, EPA, and advisory groups form the partnership. The Chesapeake Executive Council provides leadership for the Bay Program and establishes program policies to restore and protect the Bay and its living resources. The Council consists of the governors of Maryland, Virginia, and Pennsylvania, the mayor of the District of Columbia, the administrator of EPA, and the chairperson of the Chesapeake Bay Commission.

Considered a national and international model for estuarine restoration and protection programs, the Chesapeake Bay Program is still a "work in progress." Since 1983, milestones in the evolution of the program include the 1987 Chesapeake Bay Agreement and the 1992 amendments to the Agreement. The 1987 Agreement set a goal to reduce the quantity of nutrients entering the Bay by 40% by the year 2000. In the 1992 amendments to the Agreement, the partners reaffirmed the 40% nutrient reduction goal, agreed to cap nutrient loadings beyond the year 2000, and agreed to attack nutrients at their source by applying the 40% reduction goal to the 10 major tributaries of the Bay. The amendments also stressed managing the Bay as a whole ecosystem. The amendments also spell out the importance of reducing atmospheric sources of nutrients and broadening regional interstate cooperation.

Protection and restoration of forests is a critical component of the Chesapeake Bay Program because scientific data clearly show that forests are the most beneficial land cover for maintaining clean water, especially forests alongside waterbodies in the riparian zone. Through the Chesapeake Bay Program, unique partnerships have been formed among the Bay region's forestry agencies, forest managers, and interested citizen groups. Since 1990, the U.S. Forest Service has assigned a Forestry Program Coordinator to the Chesapeake Bay Program to assist both the EPA and Bay Program committees in developing strategies and projects that will contribute to the Bay restoration goals. A Forestry Work Group, formed under the Nonpoint Source Subcommittee, raises and addresses issues related to forests and the practice of forestry in the watershed.

In addition, State foresters and local governments have developed and implemented numerous programs and projects aimed at the protection and restoration of forests.

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Forestry incentive programs in all of the Bay States have resulted in the planting of millions of trees, the restoration of nearly 50 miles of riparian forest, the development of stewardship plans, and forest enhancement projects on thousands of acres within the Bay watershed.

On the positive side, the extent of Bay grasses has increased by 75% since 1978. The current extent of SAV attains 64% of the goal established by the Chesapeake Bay Program. Striped bass, or rockfish, have made a remarkable recovery over the past decade due to improved reproduction and better control of the harvest. There has been a modest increase in the number of American shad returning to the Bay to spawn. Controls on the harvest of American shad, creation of fish passages at blockages, stocking programs, and habitat restoration are expected to yield increases in the American shad population and similar fish species that inhabit the Bay during part of their life cycle.

Phosphorus levels continue to decline and, after many years of increasing nitrogen concentrations, most of the Bay's tributaries are showing a leveling off of this trend. Some tributaries are showing declining trends in nitrogen concentrations. These trends indicate that both point and nonpoint source pollution abatement programs are working.

Despite the promising trends in nutrient concentrations, oxygen concentrations are still low enough to cause severe impacts or stressful conditions in the mainstem of the Bay and several larger tributaries. Prospects for the Bay's oyster populations remain poor. Overharvesting, habitat loss, and disease have severely depleted oyster stocks. New management efforts have been developed to improve this situation.

Chesapeake Bay Foundation, Richmond, VA

The blue crab is currently the most important commercial and recreational fishery in the Bay. There is growing concern about the health of the blue crab population due to increasing harvesting pressures and relatively low harvests in recent years. Both Maryland and Virginia have recently implemented new regulations on commercial and recreational crabbers to protect this important resource.

Overall, the Chesapeake Bay still shows symptoms of stress from an expanding population and changes in land use. However, conditions in the Chesapeake Bay have improved since the Chesapeake Bay Program was launched, and continuation of the Program promises an even brighter future for the Bay.

The Gulf of Mexico Program

The Gulf of Mexico Program (GMP) was established in 1988 with EPA as the lead Federal agency in response to signs of long-term environmental damage throughout the Gulf's coastal and marine ecosystem. The main purpose of the GMP is to develop and help implement a strategy to protect, restore, and maintain the health and productivity of the Gulf. The GMP is a grass roots program that serves as a catalyst to promote sharing of information, pooling of resources, and coordination of efforts to restore and reclaim wetlands and wildlife habitat, clean up existing pollution, and prevent future contamination and destruction of the Gulf. The GMP mobilizes State, Federal, and local government; business and industry; academia; and the community at large through public awareness and information dissemination programs, forum discussions, citizen committees, and technology applications.

A Policy Review Board and the Management Committee determine the scope and focus of GMP activities. The program also receives input from a Technical Advisory Committee and a Citizen's Advisory Committee. The GMP Office, eight technical issue committees, and the operations and support committees coordinate the collection, integration, and reporting of pertinent data and information. The issue committees are composed of individuals from Federal, State, and local agencies and from industry, science, education, business, citizen groups, and private organizations.

The issue committees are responsible for documenting environmental problems and management goals, available resources, and potential solutions for a broad range of issues, including habitat degradation, public health, freshwater inflow, marine debris, shoreline erosion, nutrient enrichment, toxic pollutants, and living aquatic resources. The issue committees publish their findings in Action Agendas.

On December 10, 1992, the Governors of Alabama, Florida, Louisiana, Mississippi, and Texas; EPA; the Chair of the Citizen's Advisory Committee; and representatives of 10 other Federal agencies signed the Gulf of Mexico Program Partnership for Action agreement for protecting, restoring, and enhancing the Gulf of Mexico and adjacent lands. The agreement committed the signatory agencies to pledge their efforts, over 5 years, to obtain the knowledge and resources to:

- Significantly reduce the rate of loss of coastal wetlands
- Achieve an increase in Gulf Coast seagrass beds
- Enhance the sustainability of Gulf commercial and recreational fisheries
- Protect human health and food supply by reducing input of nutrients, toxic substances, and pathogens to the Gulf
- Increase Gulf shellfish beds available for safe harvesting by 10%
- Ensure that all Gulf beaches are safe for swimming and recreational uses
- Reduce by at least 10% the amount of trash on beaches
- Improve and expand coastal habitats that support migratory birds, fish, and other living resources
- Expand public education/outreach tailored for each Gulf Coast county or parish
- Reduce critical coastal and shoreline erosion.

Beginning in 1992, the GMP also launched Take-Action Projects in each of the five Gulf States to demonstrate that program strategies and methods could achieve rapid results. The Take-Action Projects primarily address inadequate sewage treatment, pollution prevention, and habitat protection and restoration. Several projects aim to demonstrate the effectiveness of innovative sewage treatment technologies to control pathogenic contamination of shellfish harvesting areas. Other projects aim to restore wetlands, sea grass beds, and oyster reefs. The Take-Action Projects are designed to have Gulf-wide application.

Take-Action Projects in the five Gulf States primarily address sewage treatment, pollution prevention, and habitat protection and restoration.

Since 1992, EPA has streamlined and restructured its management scheme for the GMP to increase Regional involvement and better meet the needs of the 5-year environmental challenges. The GMP has also expanded efforts to integrate Mexico and the Caribbean Islands into management of the Gulf. These activities include technology transfer and development of international agreements that prohibit the discharge of ship-generated wastes and plastics into waters of the Gulf and Caribbean Sea.

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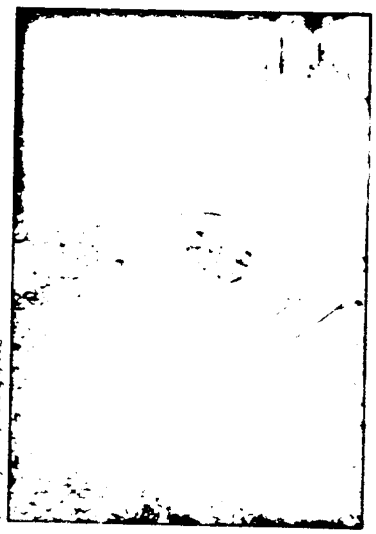


Jeff Reynolds, Raleigh, NC

Ground Water Protection Programs

The sage adage that "An ounce of prevention is worth a pound of cure" is being borne out in the field of ground water protection. Studies evaluating the cost of prevention versus the cost of cleaning up contaminated ground water have found that there are real cost advantages to promoting protection of our Nation's ground water resources.

Numerous laws, regulations, and programs play a vital role in protecting ground water. The following Federal laws and programs enable, or provide incentives for, EPA and/or States to regulate or voluntarily manage and monitor sources of ground water pollution:

- The Resource Conservation and Recovery Act (RCRA) addresses the problem of safe disposal of the huge volumes of solid and hazardous waste generated nationwide each year. RCRA is part of EPA's comprehensive program to protect ground water resources through the development of regulations and methods for handling, storing, and disposing of hazardous material and through the regulation of underground storage tanks—the most frequently cited source of ground water contamination.

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulates the restoration of contaminated ground water at abandoned hazardous waste sites.

- The Safe Drinking Water Act (SDWA) regulates subsurface injection of fluids that can contaminate ground water.

- The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) controls the use and disposal of pesticides, some of which have been detected in ground water wells in rural communities.

- The Toxic Substances Control Act (TSCA) controls the use and disposal of additional toxic substances, thereby minimizing their entry into ground water. Other Federal laws establish State grants that may be used to protect ground water.

- Clean Water Act Sections 319(h) and (i) and 518 provide funds to State agencies to implement EPA-approved nonpoint source

Comprehensive State Ground Water Protection Programs

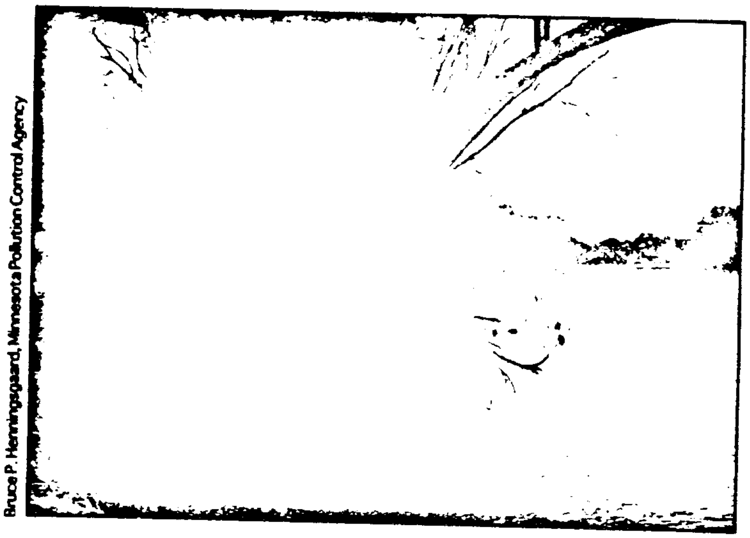
A Comprehensive State Ground Water Protection Program (CSGWPP) is composed of six "strategic activities." They are:

- Establishing a prevention-oriented goal
- Establishing priorities, based on the characterization of the resource and identification of sources of contamination
- Defining roles, responsibilities, resources, and coordinating mechanisms
- Implementing all necessary efforts to accomplish the State's ground water protection goal
- Coordinating information collection and management to measure progress and reevaluate priorities
- Improving public education and participation

management programs that include ground water protection activities. Several States have developed programs that focus on ground water contamination resulting from agriculture and septic tanks.

- The Pollution Prevention Act of 1990 allows grants for research projects to demonstrate agricultural practices that emphasize ground water protection and reduce the excessive use of fertilizers and pesticides.

Comprehensive State Ground Water Protection Programs (CSGWPPs) attempt to combine all of the above efforts and emphasize contamination prevention.



Bruce P. Henningsgaard, Minnesota Pollution Control Agency

Comprehensive State ground water protection programs support State-directed priorities in resource protection.

CSGWPPs improve coordination of Federal, State, Tribal, and local ground water programs and enable distribution of resources to established priorities.

Another means of protecting our Nation's ground water resources is through the implementation of Wellhead Protection Plans. EPA's Office of Ground Water and Drinking Water is supporting the development and implementation of Wellhead Protection Plans at the local level through many efforts. For example, EPA-funded support is provided through the National Rural Water Association Ground Water/Wellhead Protection programs. At the conclusion of the first 4 years of this program, over 2,000 communities in 26 States were actively involved in protecting their water supplies by implementing wellhead protection programs. These 2,000 communities represent almost 4 million people in the rural areas of the United States who will have better-protected water supplies.

Recognizing the importance and cost-effectiveness of protecting our Nation's ground water resources, States are participating in numerous activities to prevent future impairments of the resource. These activities include enacting legislation aimed at the development of comprehensive State ground water protection programs and promulgating protection regulations. More than 80% of the States indicate that they have current or pending legislation geared specifically to ground water protection. Generally, State legislation focuses on the need for program development, increased data collection, and public education programs. In addition, States also may mandate strict technical controls such as discharge permits, underground storage tank registrations, and protection standards.

All of these programs are intended to provide protection to a valuable, and often vulnerable, resource. Through the promotion of ground water protection on both State and Federal levels, our Nation's ground water resources will be safeguarded against contamination, thereby protecting human health and the environment.

What You Can Do

Federal and State programs have helped clean up many waters and slow the degradation of others. But government alone cannot solve the entire problem, and water quality concerns persist. Nonpoint source pollution, in particular, is everybody's problem, and everybody needs to solve it.

Examine your everyday activities and think about how you are contributing to the pollution problem. Here are some suggestions on how you can make a difference.

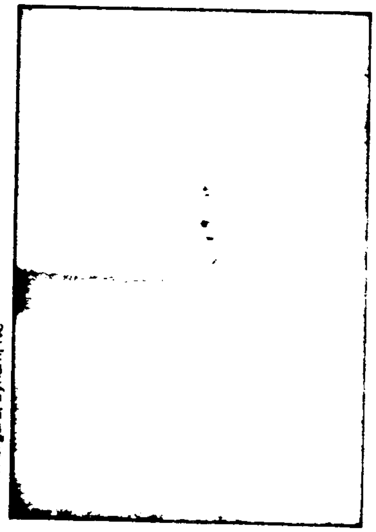
Be Informed

You should learn about water quality issues that affect the communities in which you live and work. Become familiar with your local water resources. Where does your drinking water come from? What activities in your area might affect the water you drink or the rivers, lakes, beaches, or wetlands you use for recreation?

Learn about procedures for disposing of harmful household wastes so they do not end up in sewage treatment plants that cannot handle them or in landfills not designed to receive hazardous materials.

Be Responsible

In your yard, determine whether additional nutrients are needed before you apply fertilizers, and look for alternatives where fertilizers might run off into surface waters. Consider selecting plants and grasses that have low maintenance requirements. Water your lawn conservatively. Preserve existing trees and plant new trees



John Theilgard, Bynum, NC

and shrubs to help prevent erosion and promote infiltration of water into the soil. Restore bare patches in your lawn to prevent erosion. If you own or manage land through which a stream flows, you may wish to consult your local county extension office about methods of restoring stream banks in your area by planting buffer strips of native vegetation.

Around your house, keep litter, pet waste, leaves, and grass clippings out of gutters and storm drains. Use the minimum amount of water needed when you wash your car. Never dispose of any household, automotive, or gardening wastes in a storm drain. Keep your septic tank in good working order.

Within your home, fix any dripping faucets or leaky pipes and install water-saving devices in shower heads and toilets. Always follow directions on labels for use and disposal of household chemicals. Take used motor oil, paints, and other hazardous household materials to proper disposal sites such as approved service stations or designated landfills.

Be Involved

As a citizen and a voter there is much you can do at the community level to help preserve and protect our Nation's water resources. Look around. Is soil erosion being controlled at construction sites? Is the community sewage plant being operated efficiently and correctly? Is the community trash dump in or along a stream? Is road deicing salt being stored properly?

Become involved in your community election processes. Listen and respond to candidates' views on water quality and environmental issues. Many communities have recycling programs; find out about them, learn how to recycle, and volunteer to help out if you can. One of the most important things you can do is find out how your community protects water quality, and speak out if you see problems.

Volunteer Monitoring: You Can Become Part of the Solution

In many areas of the country, citizens are becoming personally involved in monitoring the quality of our Nation's water. As a volunteer monitor, you might be involved in taking ongoing water quality measurements, tracking the progress of protection and restoration projects, or reporting special events, such as fish kills and storm damage.

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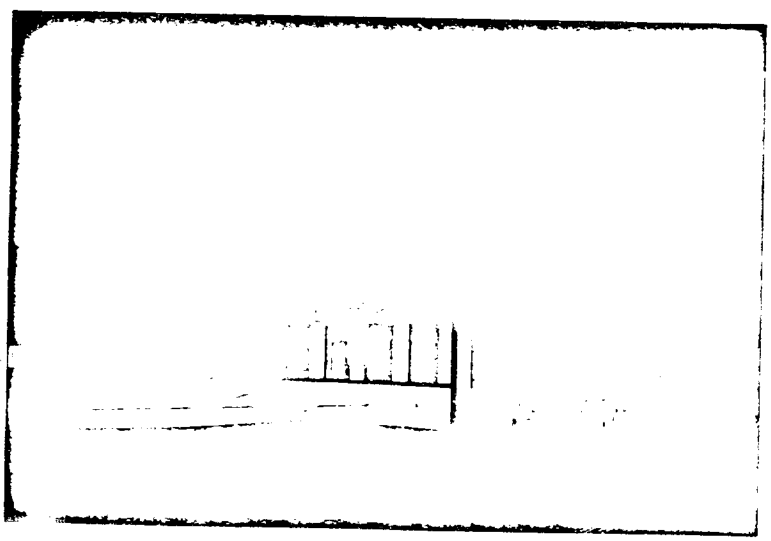
Volunteer monitoring can be of great benefit to State and local governments. Some States stretch their monitoring budgets by using data collected by volunteers, particularly in remote areas that otherwise might not be monitored at all. Because you are familiar with the water resources in your own neighborhood, you are also more likely to spot unusual occurrences such as fish kills.

The benefits to you of becoming a volunteer are also great. You will learn about your local water resources and have the opportunity to become personally involved in a nationwide campaign to protect a vital, and mutually shared, resource. If you would like to find out more about organizing or joining volunteer monitoring programs in your State, contact your State department of environmental quality, or write to:

Alice Mayio
Volunteer Monitoring
Coordinator
U.S. EPA (4503F)
401 M St. SW
Washington, DC 20460
(202) 260-7018

For further information on water quality in your State or other jurisdiction, contact your Section 305(b) coordinator listed in Chapters 9, 10, and 11. Additional water quality information may be obtained from the Regional offices of the U.S. Environmental Protection Agency (see inside front cover).



Jimmy Crawford, Raleigh, NC

For Further Reading

Volunteer Monitoring. EPA-800-F-93-008. September 1993. A brief fact sheet about volunteer monitoring, including examples of how volunteers have improved the environment.

Starting Out in Volunteer Water Monitoring. EPA-841-B-92-002. August 1992. A brief fact sheet about how to become involved in volunteer monitoring.

National Directory of Citizen Volunteer Environmental Monitoring Programs, Fourth Edition. EPA-841-B-94-001. January 1994. Contains information about 519 volunteer monitoring programs across the Nation.

Volunteer Stream Monitoring: A Methods Manual. EPA-841-D-95-001. 1995. Presents information and methods for volunteer monitoring of streams.

Volunteer Estuary Monitoring: A Methods Manual. EPA-842-B-93-004. December 1993. Presents information and methods for volunteer monitoring of estuarine waters.

Volunteer Lake Monitoring: A Methods Manual. EPA-440/4-91-002. December 1991. Discusses lake water quality issues and methods for volunteer monitoring of lakes.

Many of these publications can also be accessed through EPA's Water Channel on the Internet. From the World Wide Web or Gopher, enter http://www.epa.gov/OWOW to enter WIN and locate documents. See page 380 for additional information about EPA's Water Channel.

Fish Consumption Advisories

States issue fish consumption advisories to protect the public from ingesting harmful quantities of toxic pollutants in contaminated fish and shellfish. Fish may accumulate dangerous quantities of pollutants in their tissues by ingesting many smaller organisms, each contaminated with a small quantity of pollutant. This process is called bioaccumulation or biomagnification. Pollutants also enter fish and shellfish tissues through the gills or skin.

Fish consumption advisories recommend that the public limit the quantity and frequency of consumption of fish caught in specific waterbodies. The States tailor individual advisories to minimize health risks based on contaminant data collected in their fish tissue sampling programs. Advisories may completely ban fish consumption in severely polluted waters, or limit fish consumption to several meals per month or year in cases of less severe contamination. Advisories may target a subpopulation at risk (such as children, pregnant women, and nursing mothers), specific fish species, or larger fish that may have accumulated high concentrations of a pollutant over a longer lifetime than a smaller, younger fish.

The EPA fish consumption advisory database tracks advisories issued by each State. For 1994, the database listed 1,531 fish consumption advisories in effect in 49 States. Fish consumption advisories are unevenly distributed among the

Chesapeake Bay Foundation, Richmond, VA

States because the States use their own criteria to determine if fish tissue concentrations of toxics pose a health risk that justifies an advisory. States also vary the amount of fish tissue monitoring they conduct and the number of pollutants analyzed. States that conduct more monitoring and use strict criteria will issue more advisories than States that conduct less monitoring and use weaker criteria. For example, 62% of the advisories active in 1994 were issued by the States surrounding the Great Lakes, which support extensive fish sampling programs and follow strict criteria for issuing advisories.

Most of the fish consumption advisories (73%) are due to mercury. The other pollutants most commonly detected in elevated concentrations in fish tissue samples are polychlorinated biphenyls (PCBs), chlordane, dioxins, and DDT (with its byproducts).

Many coastal States report restrictions on shellfish harvesting in estuarine waters. Shellfish–particularly oysters, clams, and mussels–are filter-feeders that extract their food from water. Waterborne bacteria and viruses may also accumulate on their gills and mantles and in their digestive systems. Shellfish contaminated by these microorganisms are a serious human health concern, particularly if consumed raw.

States currently sample water from shellfish harvesting areas to measure indicator bacteria, such as total coliform and fecal coliform bacteria. These bacteria serve as indicators of the presence of potentially pathogenic microorganisms associated with untreated or undertreated sewage. States restrict shellfish harvesting to areas that maintain these bacteria at concentrations in sea water below established health limits.

In 1994, 15 States reported that shellfish harvesting restrictions were in effect for more than 6,052 square miles of estuarine and coastal waters during the 1992-1994 reporting period. Six States reported that urban runoff and storm sewers, municipal wastewater treatment facilities, nonpoint sources, marinas, industrial discharges, CSOs, and septic tanks restricted shellfish harvesting.

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Part I

Introduction

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Introduction

Purpose

The *National Water Quality Inventory Report to Congress* is the primary vehicle for informing Congress and the public about general water quality conditions in the United States. This document characterizes whether waters are meeting water quality standards, identifies widespread water quality problems of national significance, and describes various programs implemented to restore and protect our waters.

This document, the tenth in a series published since 1975, satisfies reporting requirements in Section 305(b) of the Clean Water Act (CWA), formally known as the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). Section 305(b) requires that States and other jurisdictions survey the health of their surface waters every 2 years and submit biennial reports describing their water quality conditions to the U.S. Environmental Protection Agency (EPA). Section 305(b) also requires that EPA summarize the reports submitted by the States, Tribes, and other jurisdictions and convey the information to Congress on a biennial schedule.

The *National Water Quality Inventory Report to Congress* is a compilation of information reported by States, Tribes, and other jurisdictions. As such, this report identifies water quality issues of concern to the States, Tribes, and other jurisdictions, not just the issues of concern to EPA. This report summarizes the water quality assessment information submitted by 61 States, American Indian Tribes, Territories, Interstate Water Commissions, and the District of Columbia in their 1994 Section 305(b) reports. Most of the survey information in the 1994 Section 305(b) reports is based on water quality information collected and evaluated during 1992 and 1993.

It is important to note that the States, Tribes, and other jurisdictions do not use identical survey methods and criteria to rate their water quality. They favor flexibility in the 305(b) process to accommodate natural variability in their waters, but there is a tradeoff between flexibility and consistency. Without consistent survey methods in place, EPA cannot compare data submitted by different States and jurisdictions or determine the quality and accuracy of their data. Also, EPA must use caution when comparing water quality information submitted during different 305(b) reporting periods because States and other jurisdictions may modify their criteria or survey different waterbodies from one reporting period to the next.

For more than 10 years, EPA has pursued a balance between flexibility and consistency in the Section 305(b) process that could generate data of known quality and accuracy. Recent joint actions by EPA, the States, Tribes, and other

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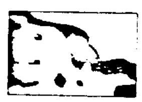
jurisdictions include implementing the recommendations of the National 305(b) Consistency Workgroup and the Intergovernmental Task Force for Monitoring Water Quality, revising EPA's *Guidelines for Preparation of the 305(b) Reports*, and beginning to implement monitoring recommendations in the *State Section 106 Grant Guidelines*. The 1996 305(b) Guidelines recommend moving toward a goal of comprehensively characterizing waters of every State every 5 years using a variety of monitoring techniques targeted to the condition of, and goals for, the water. These actions will improve consistency and accuracy in the Section 305(b) data, which will enable States and other jurisdictions to share data across political boundaries as they develop watershed protection strategies.

The Section 305(b) information, which focuses on attainment of water quality standards adopted by States, Tribes, and other jurisdictions, complements the water quality data contained in the *National Water Summary 1990-91 – Hydrologic Events and Stream Water Quality*, in which the U.S. Geological Survey (USGS) applied statistical analysis methods to a nationally consistent water database. Congress, EPA, and the public can use the summary information in this report and the *National Water Summary* to develop national goals and strategies for restoring and protecting our waters.

EPA recognizes that national initiatives alone cannot clean up our waters; water quality protection and restoration must happen at the local watershed level, in conjunction with State and Federal activities. Similarly, this document alone cannot provide the detailed information needed to manage water quality at all levels. This document should be used together with the individual Section 305(b) reports (see the inside back cover for information on obtaining Section 305(b) reports), watershed management plans, and other local documents to develop integrated water quality management options.

Background

Integrated water quality management begins with a basic understanding of how water moves through the environment, comes into contact with pollutants, and transports and deposits pollutants. The water cycle depicted in the highlight on page 15 illustrates the general links between the atmosphere, soil, surface waters, ground waters, and plants. Additional links between surface waters and ground waters are described below.



Rivers and Streams

Rivers and streams are characterized by flow. **Perennial** rivers and streams flow continuously, all year round. **Nonperennial** rivers and streams stop flowing for some period of time, usually due to dry conditions or upstream withdrawals. Many rivers and streams originate in nonperennial headwaters that flow only during snowmelt or heavy showers. Nonperennial streams provide critical habitats for nonfish species, such as amphibians and dragonflies, as well as safe havens for juvenile fish to escape from predation by larger fish. (See note on page 25 regarding the national estimate of total stream miles almost doubling from 1.8 million miles in 1990 to more than 3.5 million miles in 1994.)

The health of rivers and streams is directly linked to habitat integrity on shore and in adjacent wetlands. Stream quality will deteriorate if activities damage shoreline (i.e., riparian) and wetlands vegetation, which filter pollutants from runoff and bind soils. Removal of vegetation also eliminates shade that moderates stream temperature as well as the land temperature that can warm runoff entering surface waters. Stream temperature, in turn, affects the availability of dissolved oxygen in the water column for fish and other aquatic organisms.

Lakes, Reservoirs, and Ponds

Lakes, reservoirs, and ponds are depressions that hold water for extended periods of time. These waterbodies may receive water carrying pollutants from rivers and streams, melting snow, runoff, or ground water discharge areas. Lakes may also receive pollution directly from the air.

Pollutants become trapped in lakes, reservoirs, and ponds because water exits these waterbodies at a slow rate. Therefore, they are especially vulnerable to additional inputs of pollutants from human activities in lake watersheds. Even under natural conditions, sediment, nutrients, and organic materials accumulate in lakes and ponds as part of a natural aging process called eutrophication. Unnatural sources of nutrients (such as point source discharges and agricultural runoff) overload lake systems and accelerate eutrophication. Algae blooms, depressed oxygen concentrations, and aquatic weeds are symptoms of cultural eutrophication from unnatural sources of nutrients.

The Great Lakes

The Great Lakes—Superior, Michigan, Huron, Erie, and Ontario—are the largest system of fresh surface water on earth, by area. They contain approximately 18% of the world's fresh water supply. The Great Lakes basin is currently home to one-tenth of the population in the United States and one-quarter of the population of Canada.

Despite their large size, the Great Lakes are sensitive to the effects of a broad range of contaminants that enter the Lakes from polluted air, ground water, surface water, and overland runoff. Even dilute quantities of toxic chemicals can have adverse effects on water quality in the Great Lakes because many toxic chemicals persist in the environment and concentrate in organisms, including fish.

Overall, scientists estimate that atmospheric deposition contributes 35% to 50% of current annual inputs of a variety of chemicals entering the Great Lakes. In wet deposition, precipitation events (such as rain or snow) remove pollutants from the atmosphere. Dry deposition occurs when particles settle out of the air directly on a lake surface or within the extensive land basin draining into a lake. It is difficult to manage atmospheric sources of pollutants entering the Great Lakes because these pollutants

> Lakes are vulnerable to inputs of pollutants from human activities because water exits lakes at a very slow rate.

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may originate in the Great Lakes basin or hundreds of miles away.

For Lake Superior, the largest of the Great Lakes, available data indicate that volatilization (i.e., evaporation) and other processes remove far greater quantities of polychlorinated biphenyls (PCBs) than are introduced to it from atmospheric deposition and river inflow combined. Atmospheric deposition, nevertheless, is the largest source of new PCBs to the lake system and serves to significantly retard the PCB stripping process. Meanwhile, contributions from the reservoir of already contaminated sediments remains the overwhelming source of total PCBs to the water column and biota.

Estuaries

Rivers meet the oceans, Gulf of Mexico, and the Great Lakes in coastal waters called estuaries. Estuarine waters include bays and tidal rivers that serve as nursery areas for many commercial fish and most shellfish populations, including shrimp, oysters, crabs, and scallops. Most of our Nation's fish and shellfish industry relies on productive estuarine waters and their adjacent wetlands to provide healthy habitat for some stage of fish and shellfish development. Recreational anglers also enjoy harvesting fish that reproduce or feed in estuaries, such as striped bass and flounder.

Pollutants from both local and distant sources tend to accumulate in estuaries. Most pollutants that enter rivers migrate toward the coast. As rivers approach the coast, their mouths broaden and flow decreases. The low flow and fluctuating tides, typical of estuarine waters, reduce flushing and trap nutrients and pollutants in estuarine waters. This natural trapping process lays the foundation for rich estuarine ecosystems but also makes estuaries vulnerable to excessive loads of nutrients and pollutants.

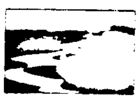
Historic development patterns have amplified natural trapping functions and overloaded estuaries on all our coasts. Historically, industrial development and population centers clustered around estuarine bays with access to shipping and an adjacent waterbody for waste disposal. Now, many coastal cities must address contaminated sediments and develop alternative disposal systems for their outdated combined sewer systems.

Wetlands

In general, wetlands are a transition zone between land and water where the soil is occasionally or permanently saturated with water. Wetlands are populated by plants that are specially adapted to grow in standing water or saturated soils. There are many different types of wetlands, including marshes, bogs, fens, swamps, mangroves, prairie potholes, and bottomland hardwood forests. Wetlands may not always appear to be wet. Many wetlands dry out for extended periods of time. Other wetlands may appear dry on the surface but be saturated beneath the surface.

Saltwater wetlands fringe estuaries; freshwater wetlands border rivers, lakes, and the Great Lakes or occur in isolation. In general, wetlands improve water quality, provide critical habitat for a wide variety of fish and wildlife, provide storage for flood waters, and stabilize shorelines. Wetlands filter sediment and nutrients (from both natural and unnatural sources) out of the water before they enter adjacent waterbodies and underlying ground water aquifers. Wetlands also provide storage for floodwaters and reduce the velocity of overland runoff. Reduced velocity translates into less damage from flood waters.

Wetlands can be physically destroyed by filling, draining, and dewatering, or wetlands can be damaged by the same pollutants that degrade other waterbodies, such as toxic chemicals and oxygen-demanding substances.



Ocean Shoreline Waters

Our ocean shoreline waters provide critical habitat for various life stages of commercial fish and shellfish (such as shrimp), provide habitat for endangered species (such as sea turtles), and support popular recreational activities, including sport fishing and swimming. Despite their vast size and volume, oceans are vulnerable to impacts from pollutants, especially in nearshore waters that receive inputs from adjoining waterbodies, ground water seeps, and land surfaces. Beach closures due to elevated bacterial concentrations are one of the most visible symptoms of water quality degradation in ocean shoreline waters resulting from activities onshore. Wastes disposed of offshore may also impact nearshore waters, as was demonstrated in the late 1980s when trash and medical wastes disposed of at sea washed ashore on the East Coast. Oil spills from tankers or offshore extraction facilities can also generate persistent adverse impacts on ocean shoreline waters.

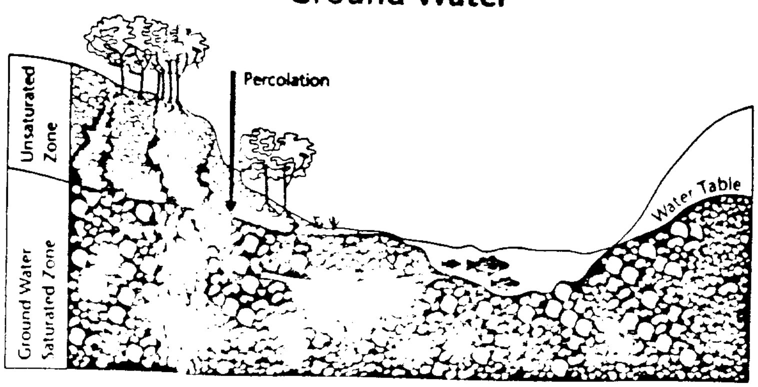
Ground Water

Beneath the land's surface, water resides in two general zones, the saturated zone and the unsaturated zone (Figure 1-1). The unsaturated zone lies directly beneath the land surface, where air and water fill in the pore spaces between soil and rock particles. Water saturates the pore spaces in the saturated zone beneath the unsaturated zone in most cases. The term "ground water" applies to water in the saturated zone. Surface water replenishes (or recharges) ground water by percolating through the unsaturated zone. Therefore, the unsaturated zone plays an important role in ground water hydrology and may act as a pathway for ground water contamination.

Ground water can move laterally and emerge at discharge sites, such as springs on hillsides or seeps

Figure 1-1

Ground Water



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The Clean Water Act of 1972

. . . it is the national goal that, wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water, be achieved by July 1, 1983 . . .

Water quality standards consist of:

- *Designated beneficial uses*
- *Numeric criteria for biological, chemical, and physical parameters*
- *Narrative criteria for biological, chemical, and physical parameters*
- *Antidegradation policy*

in the bottoms of streams, lakes, wetlands, and oceans. Therefore, ground water affects surface water quantity and quality because polluted ground water can contaminate surface waters. Conversely, some surface waters, such as wetlands, contain flood waters and replenish ground waters. Loss of wetlands reduces ground water recharge.

The Clean Water Act

The Clean Water Act still guides Federal, State, and some Tribal water pollution control programs more than 20 years after it was enacted by Congress. In 1972, the CWA launched a national objective to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Act set two goals to achieve this objective:

- Eliminate the discharge of pollutants into navigable waters by 1985

- Achieve an interim water quality level that protects and propagates fish, shellfish, and wildlife and supports recreation in and on the water, where attainable.

As it became evident that the Nation could not eliminate pollutant discharges by 1985, Congress amended the CWA to stress achieving the interim water quality levels, which came to be known as "the fishable and swimmable goals of the Act."

The EPA measures national progress in achieving the CWA interim water quality levels by summarizing attainment of State and Tribal water quality standards. Water quality standards consist of designated beneficial uses, numeric and narrative criteria sufficient to protect each use, and an antidegradation statement:

- **Designated beneficial uses** are the desirable uses that water quality should support. Examples are drinking water supply, primary contact recreation (such as swimming), and aquatic life support. Each designated use has a unique set of water quality requirements or criteria that must be met for the use to be realized. States, Tribes, and other jurisdictions may designate an individual waterbody for multiple beneficial uses.

- **Numeric water quality criteria** establish the minimum physical, chemical, and biological parameters required to support a beneficial use. Physical and chemical numeric criteria may set maximum concentrations of pollutants, acceptable ranges of physical parameters such as flow, and minimum concentrations of desirable parameters, such as dissolved oxygen. Numeric biological criteria describe the expected attainable community attributes and establish values based on measures such as species richness, presence or absence of indicator taxa, and distribution of classes of organisms.

- **Narrative water quality criteria** define, rather than quantify, conditions and attainable goals that must be maintained to support a designated use. Narrative biological criteria establish a positive statement about aquatic community characteristics expected to occur within a waterbody. For example, "Aquatic life shall be as it naturally occurs," or "Ambient water quality shall be sufficient to support life stages of all

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indigenous aquatic species." Narrative criteria may also describe conditions that are desired in a waterbody, such as, "Waters must be free of substances that are toxic to humans, aquatic life, and wildlife."

- Antidegradation statements, where possible, protect existing uses and prevent waterbodies from deteriorating even if their water quality is better than the fishable and swimmable goals of the Act.

The CWA allows States, Tribes, and other jurisdictions to set their own standards but requires that all beneficial uses and their criteria comply with the goals of the Act. At a minimum, beneficial uses must provide for "the protection and propagation of fish, shellfish, and wildlife" and provide for "recreation in and on the water" (i.e., the fishable and swimmable goals of the Act), where attainable. The Act prohibits States and other jurisdictions from designating waste transport or waste assimilation as a beneficial use, as some States did prior to 1972.

Survey Methodology

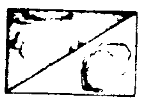
Section 305(b) of the CWA requires that the States biennially survey their water quality for attainment of the fishable and swimmable goals of the Act and report the results to EPA. The States, participating Tribes, and other jurisdictions measure attainment of the CWA goals by determining how well their waters support their designated beneficial uses. EPA encourages States, Tribes, and other jurisdictions to survey waterbodies for support of the following individual beneficial uses:

Aquatic Life Support

The waterbody provides suitable habitat for protection and propagation of desirable fish, shellfish, and other aquatic organisms.

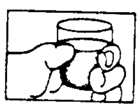
Fish Consumption

The waterbody supports fish free from contamination that could pose a human health risk to consumers.



Shellfish Harvesting

The waterbody supports a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.



Drinking Water Supply

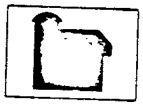
The waterbody can supply safe drinking water with conventional treatment.

Primary Contact Recreation - Swimming

People can swim in the waterbody without risk of adverse human health effects (such as catching waterborne diseases from raw sewage contamination).

Secondary Contact Recreation

People can perform activities on the water (such as boating) without risk of adverse human health effects from ingestion or contact with the water.



Agriculture

The water quality is suitable for irrigating fields or watering livestock.

States, Tribes, and other jurisdictions may also define their own individual uses to address special concerns. For example, many Tribes and States designate their waters for the following beneficial uses:

Ground Water Recharge

The surface waterbody plays a significant role in replenishing ground water, and surface water supply and quality are adequate to protect existing or potential uses of ground water.

Wildlife Habitat

Water quality supports the waterbody's role in providing habitat and resources for land-based wildlife as well as aquatic life.

Tribes may designate their waters for special cultural and ceremonial uses:

Culture

Water quality supports the waterbody's role in Tribal culture and preserves the waterbody's religious, ceremonial, or subsistence significance.

The States, Tribes, and other jurisdictions assign one of five levels of use support categories to each of their waterbodies (Table 1-1).

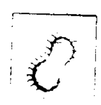
If possible, the States, Tribes, and other jurisdictions determine the level of use support by comparing monitoring data with numeric criteria for each use designated for a particular waterbody. If monitoring data are not available, the State, Tribe, or other jurisdiction may determine the level of use support with qualitative information. Valid qualitative information includes land use data, fish and game surveys, and predictive model results. **Monitored assessments** are based on recent monitoring data collected during the past 5 years. **Evaluated assessments** are based on qualitative information or monitored information more than 5 years old.

Overall Use Support

For waterbodies with more than one designated use, the States, Tribes, and other jurisdictions consolidate the individual use support information into a single overall use support determination:

Good/Fully Supporting Overall Use – All designated beneficial uses are fully supported.

Good/Threatened Overall Use – One or more designated beneficial uses are threatened and the remaining uses are fully supported.



Fair/Partially Supporting Overall Use – One or more designated beneficial uses are partially supported and the remaining uses are fully supported or threatened. These waters are considered impaired.

Poor/Not Supporting Overall Use – One or more designated beneficial uses are not supported. These waters are considered impaired.

Poor/Not Attainable – The State, Tribe, or other jurisdiction has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six biological, chemical, physical, or economic/social conditions specified in the *Code of Federal Regulations* (40 CFR Section 131.10). These conditions include naturally high concentrations of pollutants (such as metals); other natural physical features that create unsuitable aquatic life habitat (such as inadequate substrate, riffles, or pools); low flows or water levels; dams and other hydrologic modifications that permanently alter waterbody characteristics; poor water quality resulting from human activities that cannot be reversed without causing further environmental degradation; and poor water quality that cannot be improved without imposing more stringent controls than those required in the CWA that would result in widespread economic and social impacts.

- **Impaired Waters** – The sum of waterbodies partially supporting uses and not supporting uses.

Total Surveyed Waters

Most States do not assess all of their waterbodies during the 2-year reporting cycle required under CWA Section 305(b). Thus, the surveyed waters reported in Figure 1-2 are a subset of the Nation's total waters. In addition, the summary information based on surveyed waters may not represent general conditions in the Nation's total waters because States, Tribes, and other jurisdictions often focus on surveying major perennial rivers, estuaries, and public lakes with suspected pollution

Table [illegible] Levels of Use Support

Symbol	Use Support Level	Water Quality Condition	Definition
	Fully Supporting	Good	Water quality meets designated use criteria.
	Threatened	Good	Water quality supports beneficial uses now but may not in the future unless action is taken.
	Partially Supporting	Fair (Impaired)	Water quality fails to meet designated use criteria at times.
	Not Supporting	Poor (Impaired)	Water quality frequently fails to meet designated use criteria.
	Not Attainable	Poor	The State, Tribe, or other jurisdiction has performed a use-attainability analysis and demonstrated that use support is not attainable due to one of six biological, chemical, physical, or economic/social conditions specified in the *Code of Federal Regulations*

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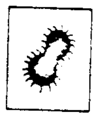
problems in order to direct scarce resources to areas that could pose the greatest risk. Many States, Tribes, and other jurisdictions lack the resources to collect use support information for nonperennial streams, small tributaries, and private ponds. This report does not predict the health of these unassessed waters, which include an unknown ratio of pristine waters to polluted waters.

SAMPLE


Little River

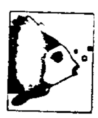
Little River is designated for aquatic life use and primary contact recreation. The State examines dissolved oxygen data and notes that 15% of the samples contain dissolved oxygen concentrations below the aquatic life use criterion of 5 parts per million (ppm). Bacterial indicators do not exceed the contact recreation criterion. Therefore, the waterbody partially supports aquatic life use and fully supports contact recreation use. The waterbody partially supports overall uses based on monitored data.




SAMPLE


Turkey Lake

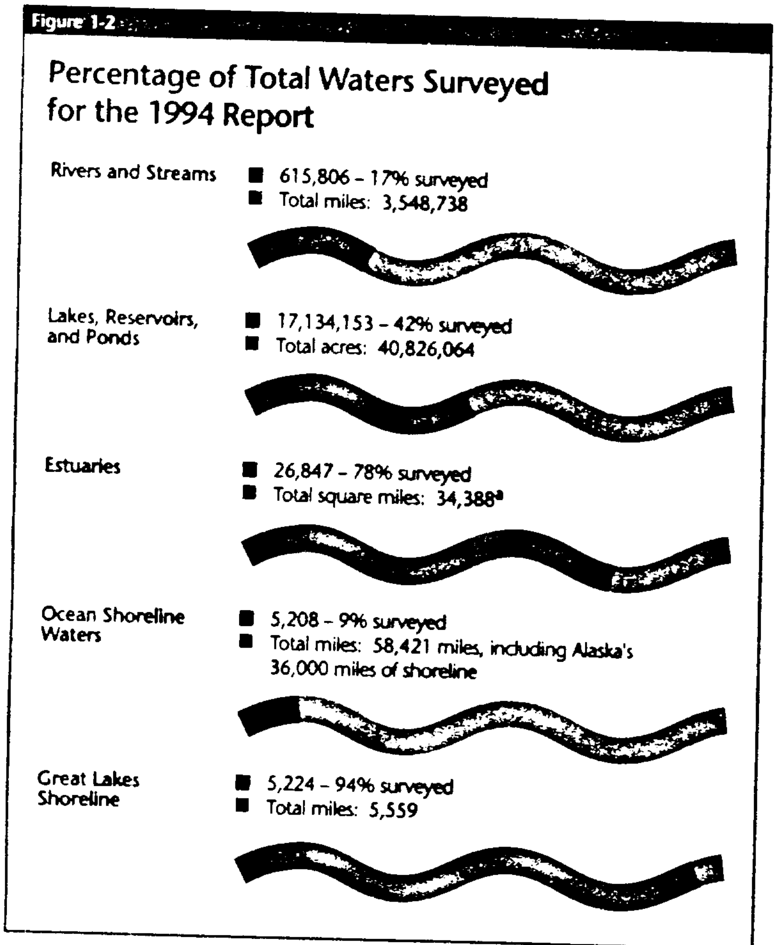
Turkey Lake is also designated for aquatic life use and primary contact recreation. However, the State has never sampled chemical and physical parameters, such as dissolved oxygen, in the lake. The State did perform a biological survey of the lake and noted the presence of desirable fish species and insect larvae. The survey also revealed a probable source of sewage contamination upstream. The lake appears to fully support aquatic life use but may only partially support contact recreation use due to sewage contamination. The waterbody partially supports overall uses based on evaluated information (the suspected source of sewage contamination).




Pollutants That Degrade Water Quality and Sources of Impairment

Where possible, States, Tribes, and other jurisdictions identify the pollutants causing water quality impairments and the sources of pollutants degrading their waterbodies. **Causes of impairment** are pollutants or processes that violate numeric or narrative use support criteria. Causes of impairment include chemical contaminants (such as PCBs, dioxins, and metals), physical parameters (such as temperature), and biological parameters (such as aquatic weeds) (see Highlight on page 16).

Sources of impairment generate the pollutants that violate use support criteria (Table 1-2). Point sources discharge pollutants directly into surface waters from a conveyance. Point sources include industrial facilities, municipal sewage treatment plants, and combined sewer overflows. Nonpoint sources deliver pollutants to surface waters from diffuse origins. Nonpoint sources include urban runoff, agricultural runoff, and atmospheric deposition of contaminants in air pollution. Habitat alterations, such as hydromodification, dredging, and streambank destabilization, can also degrade water quality.



Source: 1994 Section 305(b) reports submitted by the States, Tribes, Territories, and Commissions.

[a]Excluding estuarine waters in Alaska because no estimate was available.

Throughout this document, EPA rates the significance of causes and sources of pollution by the percentage of surveyed waters impaired by each individual cause or source (obtained from the Section 305(b) reports submitted by the States, Tribes, and other jurisdictions). Note that the cause and source rankings do not describe the condition of all waters in the United States because the States identify the causes and sources degrading some of their impaired waters, which are a small subset of surveyed waters, which, in turn, are a subset of the Nation's total waters. For example, the States identified sources degrading some of the 224,236 impaired river miles, which represent 36% of the surveyed river miles and only 6% of the Nation's total stream miles.

Table 1-2. Pollution Source Categories Used in This Report

Category	Examples
Industrial	Pulp and paper mills, chemical manufacturers, steel plants, metal process and product manufacturers, textile manufacturers, food processing plants
Municipal	Publicly owned sewage treatment plants that may receive indirect discharges from industrial facilities or businesses
Combined Sewers	Single facilities that treat both stormwater and sanitary sewage, which may become overloaded during storm events and discharge untreated wastes into surface waters.
Storm Sewers/ Urban Runoff	Runoff from impervious surfaces including streets, parking lots, buildings, lawns, and other paved areas
Agricultural	Crop production, pastures, rangeland, feedlots, other animal holding areas
Silvicultural	Forest management, tree harvesting, logging road construction
Construction	Land development, road construction
Resource Extraction	Mining, petroleum drilling, runoff from mine tailing sites
Land Disposal	Leachate or discharge from septic tanks, landfills, and hazardous waste sites
Hydrologic Modification	Channelization, dredging, dam construction, streambank modification

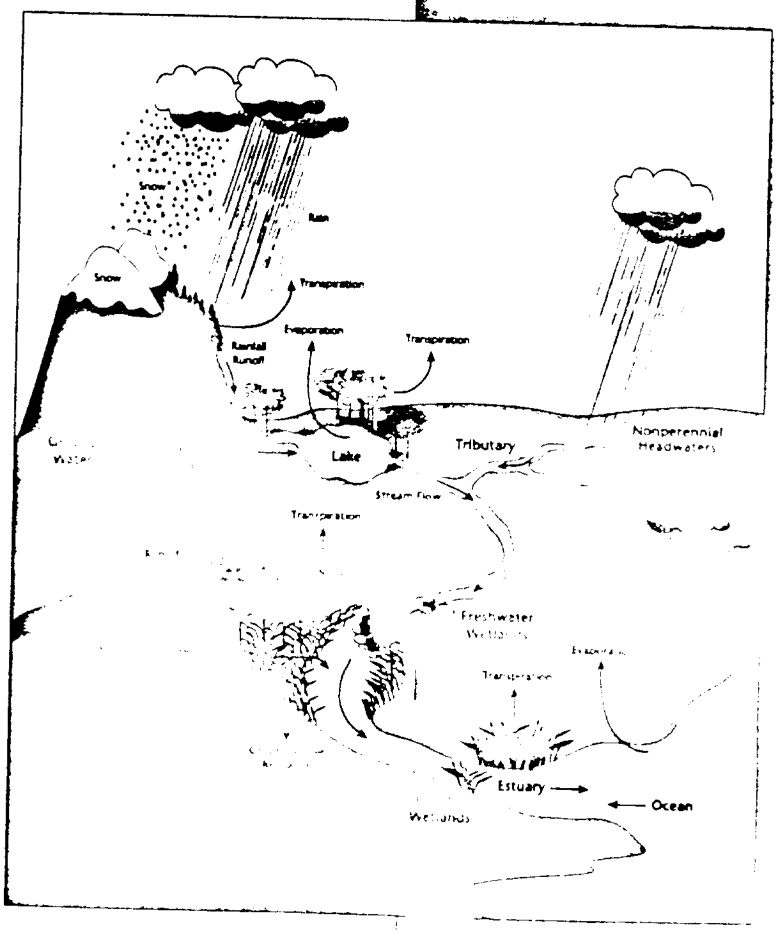
HIGHLIGHT HI HIGHLIGHT

The Water Cycle

The water cycle describes how water moves through the environment and identifies the links between ground water, surface water, and the atmosphere (see figure). For convenience, discussions of the water cycle usually begin and end in the atmosphere. Water in the atmosphere condenses and falls onto the earth in the form of rain or snow. The rain or snow can contain contaminants from air pollution. The rain and snow may fall directly onto surface waters, be intercepted by plants or structures, or fall onto the ground. Intercepted water evaporates directly back into the atmosphere or drips onto the ground.

On the ground, rainfall and melting snow percolate deeper into the ground, saturating the soil and recharging ground water aquifers. Trees and other plants take up water in the upper soil zone through their roots and return the water to the atmosphere in a process called transpiration. Ground water below the root zone may migrate many miles and emerge (or discharge) into a distant surface water.

When rainfall or melting snow saturates soils, water runs off the ground into surface waterbodies (such as lakes, streams, wetlands, and coastal waters). Runoff may dislodge soil particles and pollutants and carry them into surface waterbodies. Surface waters may evaporate back into the atmosphere, percolate into the underlying ground water, or flow into other surface waters until reaching the ocean. From the ocean, water evaporates back into the atmosphere, completing the cycle.



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Pollutants and Processes That Damage Water Quality

This highlight describes individual pollutants and processes separately. In reality, water quality usually suffers from the combined effects of several pollutants and processes. EPA encourages water quality managers and the public to use a holistic approach to managing our integrated water quality problems.

Low Dissolved Oxygen

Dissolved oxygen is a basic requirement for a healthy aquatic ecosystem. Most fish and beneficial aquatic insects "breathe" oxygen dissolved in the water column. Some fish and aquatic organisms (such as carp and sludge worms) are adapted to low oxygen conditions, but most desirable fish species (such as trout and salmon) suffer if dissolved oxygen concentrations fall below 3 to 4 mg/L (3 to 4 milligrams of oxygen dissolved in 1 liter of water, or 3 to 4 parts of oxygen per million parts of water). Larvae and juvenile fish are more sensitive and require even higher concentrations of dissolved oxygen, ranging from 5 to 8 mg/L.

Many fish and other aquatic organisms can recover from short periods of low dissolved oxygen availability. However, prolonged episodes of depressed dissolved oxygen concentrations of 2 mg/L or less can result in "dead" waterbodies. Prolonged exposure to low dissolved oxygen conditions can suffocate adult fish or reduce their reproductive survival by suffocating sensitive eggs and larvae or can starve fish by killing aquatic insect larvae and other prey. Low dissolved oxygen concentrations also favor anaerobic bacterial activity that produces noxious gases or foul odors often associated with polluted waterbodies.

Oxygen concentrations in the water column fluctuate under natural conditions, but severe oxygen depletion usually results from human activities that introduce large quantities of biodegradable organic materials into surface waters. Biodegradable organic materials contain plant, fish, or animal matter. Leaves, lawn clippings, sewage, manure, shellfish processing waste, milk solids, and other food processing wastes are examples of biodegradable organic materials that enter our surface waters.

In both pristine and polluted waters, beneficial bacteria use oxygen to break apart (or decompose) organic materials. Pollution-containing organic wastes provide a continuous glut of food for the bacteria, which accelerates bacterial activity and population growth. In polluted waters, bacterial consumption of oxygen can rapidly outpace oxygen

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replenishment from the atmosphere and photosynthesis performed by algae and aquatic plants. The result is a net decline in oxygen concentrations in the water.

Often, water quality managers measure the biological oxygen demand (or BOD) of pollution or natural organic materials in water. BOD is a measure of how much oxygen is consumed by bacteria while they decompose different mixtures of organic materials. Toxic pollutants can indirectly elevate BOD by killing algae, aquatic weeds, or fish, which provides an abundance of food for oxygen-consuming bacteria. Oxygen depletion can also result from chemical reactions that do not involve bacteria. Some pollutants trigger chemical reactions that place a chemical oxygen demand (or COD) on receiving waters.

Other factors, such as temperature and salinity, influence the amount of oxygen dissolved in water. Prolonged hot weather will depress oxygen concentrations and may cause fish kills even in clean waters because warm water cannot hold as much oxygen as cold water. Warm conditions further aggravate oxygen depletion by stimulating bacterial activity and respiration in fish, which consumes oxygen. Removal of streamside vegetation eliminates shade, thereby raising water temperatures, and accelerates runoff of organic debris. Under such conditions, minor additions of pollution-containing organic materials can severely deplete oxygen.

Nutrients

Nutrients are essential building blocks for healthy aquatic communities, but excess nutrients (especially nitrogen and phosphorus compounds) overstimulate the growth of aquatic weeds and algae. Excessive growth of these organisms, in turn, can clog navigable waters, interfere with swimming and boating, outcompete native submerged aquatic vegetation (SAV), and lead to oxygen depletion. Oxygen concentrations can fluctuate daily during algae blooms, rising during the day as algae perform photosynthesis, and falling at night as algae continue to respire, which consumes oxygen. Beneficial bacteria also consume oxygen as they decompose the abundant organic food supply in dying algae cells.

Lawn and crop fertilizers, sewage, manure, and detergents contain nitrogen and phosphorus, the nutrients most often responsible for water quality degradation. Rural areas are vulnerable to ground water contamination from nitrates (a compound containing nitrogen) found in fertilizer and manure.

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Very high concentrations of nitrate (>10 mg/L) in drinking water cause methemoglobinemia, or blue baby syndrome, an inability to fix oxygen in the blood.

Nutrients are difficult to control because lake and estuarine ecosystems recycle nutrients. Rather than leaving the ecosystem, the nutrients cycle among the water column, algae and plant tissues, and the bottom sediments. For example, algae may temporarily remove all the nitrogen from the water column, but the nutrients will return to the water column when the algae die and are decomposed by bacteria. Therefore, gradual inputs of nutrients tend to accumulate over time rather than leave the system.

Sediment and Siltation

In a water quality context, sediment usually refers to soil particles that enter the water column from eroding land. Sediment consists of particles of all sizes, including fine clay particles, silt, sand, and gravel. Water quality managers use the term "siltation" to describe the suspension and deposition of small sediment particles in waterbodies.

Sediment and siltation can severely alter aquatic communities. Sediment may clog and abrade fish gills, suffocate eggs and aquatic insect larvae on the bottom, and fill in the pore space between bottom cobbles where fish lay eggs. Silt and sediment interfere with recreational activities and aesthetic enjoyment at waterbodies by reducing water clarity and filling in waterbodies.

Sediment may also carry other pollutants into waterbodies. Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or detach and become soluble in the water column.

Rain washes silt and other soil particles off of plowed fields, construction sites, logging sites, urban areas, and strip-mined lands into waterbodies. Eroding streambanks also deposit silt and sediment in waterbodies. Removal of vegetation on shore can accelerate streambank erosion.

Bacteria and Pathogens

Some waterborne bacteria, viruses, and protozoa cause human illnesses that range from typhoid and dysentery to minor respiratory and skin diseases. These organisms may enter waters through a number of routes, including inadequately treated sewage, storm water drains, septic systems, runoff from livestock pens, and sewage dumped overboard from recreational boats. Because it is impossible to test waters for every possible disease-causing organism, States and other jurisdictions usually measure indicator bacteria that are found in great numbers in the stomachs and intestines of warm-blooded animals and people. The presence of indicator bacteria suggests that the waterbody may be contaminated with untreated sewage and that other, more dangerous, organisms may be present. The States, Tribes, and

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other jurisdictions use bacterial criteria to determine if waters are safe for recreation and shellfish harvesting.

Toxic Organic Chemicals and Metals

Toxic organic chemicals are synthetic compounds that contain carbon, such as PCBs, dioxins, and DDT. These synthesized compounds often persist and accumulate in the environment because they do not readily break down in natural ecosystems. Many of these compounds cause cancer in people and birth defects in other predators near the top of the food chain, such as birds and fish.

Metals occur naturally in the environment, but human activities (such as industrial processes and mining) have altered the distribution of metals in the environment. In most reported cases of metals contamination, high concentrations of metals appear in fish tissues rather than the water column because the metals accumulate in greater concentrations in predators near the top of the food chain.

pH

Acidity, the concentration of hydrogen ions, drives many chemical reactions in living organisms. The standard measure of acidity is pH, and a pH value of 7 represents a neutral condition. A low pH value (less than 5) indicates acidic conditions; a high pH (greater than 9) indicates alkaline conditions. Many biological processes, such as reproduction, cannot function in acidic or alkaline waters. Acidic conditions also aggravate toxic contamination problems because sediments release toxicants in acidic waters. Common sources of acidity include mine drainage, runoff from mine tailings, and atmospheric deposition.

Habitat Modification/ Hydrologic Modification

Habitat modifications include activities in the landscape, on shore, and in waterbodies that alter the physical structure of aquatic ecosystems and have adverse impacts on aquatic life. Examples of habitat modifications include:

- Removal of streamside vegetation that stabilizes the shoreline and provides shade, which moderates instream temperatures
- Excavation of cobbles from a stream bed that provide nesting habitat for fish
- Burying streams
- Excessive development sprawl that alters the natural drainage patterns by increasing the intensity, magnitude, and energy of runoff waters.

Hydrologic modifications alter the flow of water. Examples of hydrologic modifications include channelization, dewatering, damming, and dredging.

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Tribal Water Quality

Tribal lands span the United States and are diverse in climate, habitat, and water usage. Water quality is one of the top environmental priorities for the majority of Tribes throughout the United States. Over the past 7 years, approximately 100 Tribes have developed or have begun developing water quality programs, including water quality criteria and standards, through grants from Section 106 of the Clean Water Act. This number represents close to 40% of all Tribes in the contiguous United States that are eligible for Section 106 grants, a number that reflects the importance of this effort by Tribes. Tribes are also establishing water quality programs with General Assistance Program (GAP) grants, which can be used to develop general multimedia environmental programs on reservations.

Phil Johnson, EPA Region 8

As Tribes expand their interest in administering water quality programs on Tribal lands, their technical capabilities and desire to monitor those waters over which they have jurisdiction also grows. Some Tribes have special concerns about water quality because they acquire a large portion of their food or income from water resources and/or water plays a significant role in their traditional ceremonies and cultural heritage.

Tribes are interested in developing water quality management options and assessments in all of the areas described in this report. Some Tribes are conducting water quality monitoring programs for surface and ground waters and assembling databases of biological, chemical, physical, and bacteriological analyses. Others are working toward adopting standards involving biological criteria and ecosystem preservation. Still others are developing nonpoint source assessment and management programs and establishing their own laboratory capability for monitoring waters and

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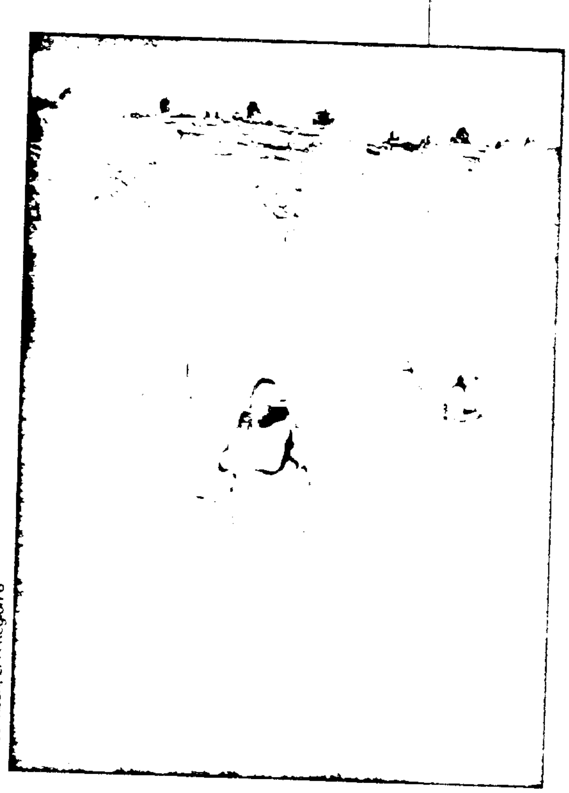
training staff to perform monitoring. Joint Tribal consortia, intertribal councils, and other collaborative efforts have been established to examine entire watersheds. All of these efforts reiterate the common goal shared by communities throughout the country to acquire the data needed to preserve and restore water quality for generations to come. Tribes will continue to make water quality a priority as they develop and expand their capacity to contribute information to the *National Water Quality Inventory Report to Congress.*

EPA's Office of Wetlands, Oceans, and Watersheds (OWOW), in conjunction with the Section 305(b) Consistency Workgroup (which includes 3 Tribal members and 25 State members), developed flexible guidance to assist Tribes in reporting water quality information for inclusion in the 1996 *National Water Quality Inventory Report to Congress.* This guidance describes a level of reporting that may be appropriate for most Tribes' first 305(b) reports.

In 1995, OWOW also produced a booklet, *Knowing Our Waters: Tribal Reporting Under Section 305(b),* to encourage all Tribes to monitor, assess, and report on their water quality. The goal of Tribal reporting is to document the status of water quality and identify water quality improvements needed on Tribal lands. The 305(b) report is a good vehicle for recommending actions to EPA to protect Tribal waterbodies and achieve the objectives of the Clean Water Act. EPA encourages Tribes to use the 305(b) process as a mechanism for sharing their ideas, concerns, and information with State and Federal water quality managers.



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Part II

Water Quality Assessments

Barry Burgan, U.S. EPA

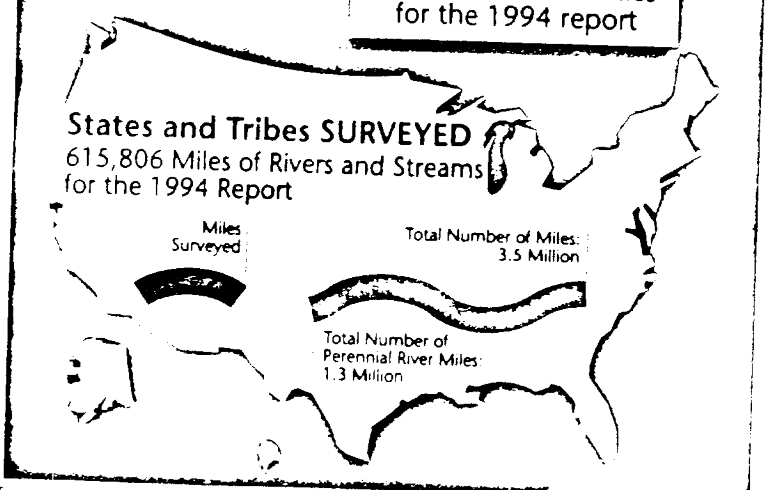
Rivers and Streams

Forty-eight States, three Interstate River Commissions, one Territory, and the District of Columbia (hereafter collectively referred to as States), and six American Indian Tribes rated river water quality in their 1994 Section 305(b) reports (see Appendix A, Table A-1, for individual State and Tribal information). These States and Tribes surveyed conditions in 615,806 miles of rivers and streams; most of the surveyed rivers and streams are perennial waterbodies that flow all year. The surveyed rivers and streams represent 48% of the 1.3 million miles of perennial rivers and streams in the lower 48 States, or 17% of the estimated 3.5 million miles of all rivers and streams in the country, including nonperennial streams that flow only during wet periods (Figure 2-1).

Altogether, the States and Tribes surveyed 27,075 fewer river miles in 1994 than in 1992. Individually, most States reported that they surveyed more river miles in 1994, but their increases were offset by a decline of 85,000 surveyed river miles reported by Montana, Mississippi, and Maryland. For 1994, these States reported use support status for only those river miles that they surveyed in direct monitoring

States and Tribes
SURVEYED
17%
of their total river miles[a]
for the 1994 report

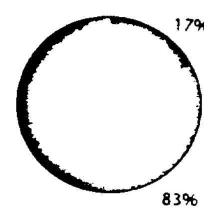
Figure 2-1



Based on data contained in Appendix A, Table A-1.

River Miles Surveyed by States and Tribes

1994 ■ 615,806 miles = 17% surveyed
■ Total miles: 3,548,738[a]



1992 ■ 642,881 miles = 18% surveyed
■ Total miles: 3,551,247[b]

1990 ■ 647,066 miles = 36% surveyed
■ Total miles: 1,800,000[c]

[a]Source: 1994 State and Tribal Section 305(b) reports.
[b]Source: 1992 State and Tribal Section 305(b) reports.
[c]Source: *National Water Quality Inventory, 1990 Report to Congress*, U.S. EPA, 1992.

Note: In comparison to 1990, it appears that the States and Tribes assessed a smaller percentage of the Nation's rivers in 1994. However, in 1994, most States and Tribes included intermittent streams, canals, and ditches that were excluded from the 1990 estimates of total stream miles. As a result, the national estimate of total stream miles almost doubled from 1.8 million miles in 1990 to more than 3.5 million miles in 1994.

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rivers have g...
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programs or evaluations rather than using inferences for unsurveyed waters. Previously, Montana and Maryland assumed that rivers of unknown quality were surveyed and in good condition. Mississippi assumed that conditions in evaluated rivers represented conditions in upstream tributaries.

The changes made by Montana, Mississippi, and Maryland are examples of the numerous modifications the States made to their water quality survey methods between 1992 and 1994 as a result of the many Federal and State partnership efforts to improve monitoring in the Nation. Due to these changes, the summary data presented herein should not be compared with summary data presented in the 1992 Report to Congress.

The summary information presented in this chapter applies strictly to the portion of the Nation's rivers surveyed by the States and Tribes. EPA cannot make generalizations about the health of all of our Nation's rivers based on data extracted from the 305(b) reports because most States and Tribes rate their waters with information obtained from water monitoring programs designed to detect degraded waterbodies. Very few States or Tribes select water sampling sites with a statistical design to represent a cross section of water quality conditions in their jurisdiction. Instead, many States and Tribes direct their limited monitoring resources toward waters with suspected problems. As a result, the surveyed rivers reflect conditions of targeted waters rather than a representative sampling of all waters.

In the future, increased use of statistically based programs will enable EPA and the States and Tribes to report more comprehensively on the general health of the Nation's waters. Examples of statistically based programs include probability designs implemented by Delaware and Maryland, EPA's Environmental Monitoring and Assessment Program (EMAP), and EPA's Regional Environmental Monitoring and Assessment Program (R-EMAP). EMAP is a long-term monitoring program with a unique approach that combines a probability-based sampling strategy with ecological indicators (quantifiable expressions of an environmental value) to assess the overall condition of ecological resources. R-EMAP applies the concepts, methods, and approach developed by EMAP to resolve specific environmental issues of importance to the EPA Regions and the States.

National data from other Federal agencies, such as the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), and private organizations, such as the Nature Conservancy, will also clarify national water quality trends. (See Chapter 13 for additional information about monitoring and assessment programs.)

Overall Water Quality

The States and Tribes rate whether their water quality is good enough to fully support a healthy community of aquatic organisms and human activities, such as swimming, fishing, and drinking. The States designate individual rivers for specific activities, termed "individual designated uses." EPA and the

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States use the following terminology to rate their water quality:

■ **Good/Fully Supporting**: Good water quality supports a diverse community of fish, plants, and aquatic insects, as well as the array of human activities assigned to a river by the State.

■ **Good/Threatened**: Good water quality currently supports aquatic life and human activities in and on the river, but changes in factors such as land use threaten water quality, or data indicate a trend of increasing pollution in the river.

■ **Fair/Partially Supporting**: Fair water quality supports aquatic communities with fewer species of fish, plants, and aquatic insects, and/or occasional pollution interferes with human activities. For example, runoff during severe thunderstorms may temporarily elevate fecal coliform bacteria densities and indicate that swimming is not safe immediately following storms.

■ **Poor/Not Supporting**: Poor water quality does not support a healthy aquatic community and/or prevents some human activities on the river. For example, persistent PCB contamination in river sediments (originating from discontinued industrial discharges) may contaminate fish and make the fish inedible for years.

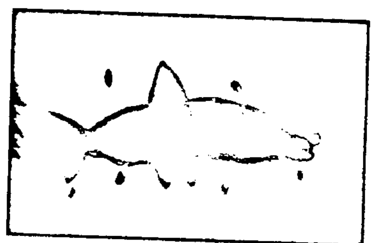
■ **Poor/Not Attainable**: The State has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six specific biological, chemical, physical, or economic/social conditions (see Chapter 1 for additional information).

Most States and Tribes rate how well a river supports individual uses (such as swimming and aquatic life habitat) and then consolidate individual use ratings into a general water quality rating termed "overall use support." A river receives a poor overall rating if water quality consistently fails to support any one human activity or a healthy aquatic community (see Chapter 1 for a complete discussion of use support).

Forty-three States, six Tribes, three Interstate Commissions, Puerto Rico, and the District of Columbia reported overall use support status for rivers and streams in their 1994 Section 305(b) reports (see Appendix A, Table A-2, for individual State and Tribal information). Another five States reported individual use support status but did not report overall use support status. In such cases, EPA used aquatic life use support status to represent overall water quality conditions in the State's rivers and streams.

Altogether, 64% of the 615,806 surveyed river miles have good water quality. Of these waters, 57% fully support designated uses and 7% have good water quality that fully supports uses but is threatened and might deteriorate if we fail to manage potential sources of pollution (Figure 2-2).

Some form of pollution or habitat degradation prevents the remaining 36% of the surveyed river miles from fully supporting a healthy aquatic community or human activities all year round. Twenty-two percent of the surveyed river miles have fair water quality that partially supports designated



Krista Rose, age 8, Bruner Elementary, North Las Vegas, NV

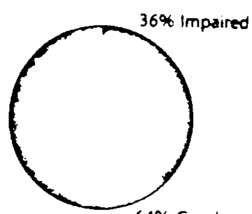
Surveyed Waters

Total rivers = 3.5 million miles[a]
Total surveyed = 615,806 miles

Of the surveyed miles:

- 40% were monitored
- 42% were evaluated
- 18% were not specified

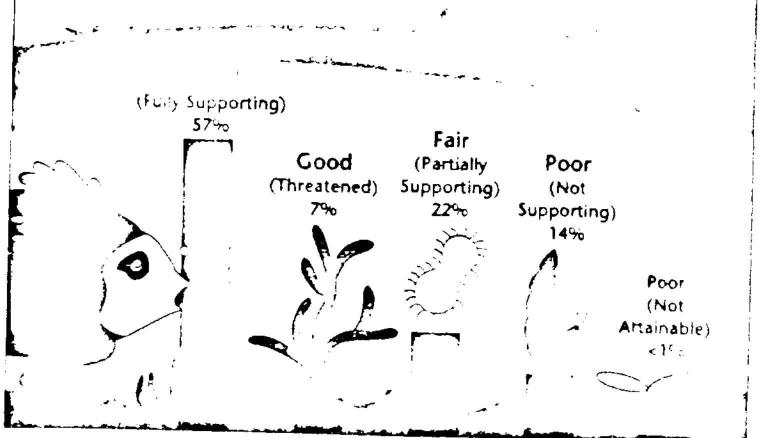
Overall Surveyed Water Quality



[a]Source: 1994 State and Tribal Section 305(b) reports.

Figure 2-2

Overall Use Support
in Surveyed Rivers and Streams



Based on data contained in Appendix A, Table A-2.

uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Fourteen percent of the surveyed river miles suffer from poor water quality that consistently stresses aquatic life and/or prevents people from using the river for activities such as swimming and fishing.

Individual Use Support

Individual use support information provides additional detail about water quality problems in our Nation's surface waters. The States are responsible for designating their rivers and streams for State-specific uses, but EPA requests that the States rate how well their rivers support six standard uses so that EPA can summarize the State data.

- **Aquatic life support** – Is water quality good enough to support a balanced community of aquatic organisms, including fish, plants, insects, and algae?
- **Fish consumption** – Can people eat fish caught in the river or stream?
- **Primary contact recreation (swimming)** – Can people make full body contact with the water without risking their health?
- **Secondary contact recreation** – Is there a risk to public health from recreational activities on the water, such as boating, that expose the public to minor contact with the water?
- **Drinking water supply** – Can the river or stream provide a safe water supply with standard treatment?
- **Agricultural uses** – Can the water be used for irrigating fields and watering livestock?

Only eight States did not report individual use support status of their rivers and streams (see Appendix A, Table A-3, for individual State and Tribal information). The reporting States and Tribes surveyed the status of aquatic life and swimming uses most frequently and identified more impacts on aquatic life and swimming uses than on the other individual uses (Figure 2-3). These States and Tribes reported that fair or poor water quality impacts aquatic life in 161,367 stream miles (31% of the 527,269 miles surveyed for aquatic life support). Fair or poor water quality conditions also impair

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swimming activities in 92,058 miles (23% of the 394,528 miles surveyed for swimming use support).

Many States and Tribes did not rate fish consumption use support because they have not codified fish consumption as a use in their standards. Some of these States consider fishing use as a component of aquatic life use–rivers and streams that provide a healthy habitat for fish support fishing activities even though anglers may not be able to eat their catch in these States. EPA encourages the States to designate fish consumption as a use in their waterbodies to promote consistency in future reporting.

Water Quality Problems Identified in Rivers and Streams

Figures 2-4 and 2-5 identify the pollutants and sources of pollutants that impair (i.e., prevent from fully supporting designated uses) the most river miles, as reported by the States and Tribes. The two figures are based on the same data (contained in Appendix A, Tables A-4 and A-5), but each figure provides a different perspective on the extent of impairment attributed to individual pollutants and sources. Figure 2-4 compares the impacts of the leading pollutants and sources in all surveyed rivers. Figure 2-5 presents the relative impact of the leading pollutants and sources in impaired rivers, a subset of surveyed rivers with identified water quality problems.

The following sections describe the leading pollutants and sources of impairment identified in rivers. It is important to note that the information about pollutants and sources is incomplete because the States cannot identify the pollutant or source of pollutants responsible for every impaired river segment. In some cases, a State may recognize that water quality does not fully support a designated use, but the State may not have adequate data to document that a specific

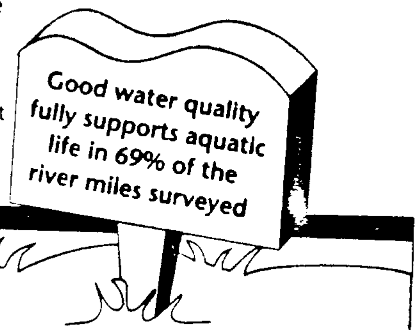

Figure 2-3

Individual Use Support in Rivers and Streams

Designated Use	Miles Surveyed	Percent: Good (Fully Supporting)	Percent: Good (Threatened)	Percent: Fair (Partially Supporting)	Percent: Poor (Not Supporting)	Percent: Poor (Not Attainable)
Aquatic Life Support	527,269	62	7	21	10	<1
Fish Consumption	310,013	94	1	3	2	<1
Primary Contact - Swimming	394,528	74	3	10	13	<1
Secondary Contact	229,522	85	2	7	6	<1
Drinking Water Supply	192,660	80	3	8	9	<1
Agriculture	306,763	91	<1	4	4	<1

Based on data contained in Appendix A, Table A-3

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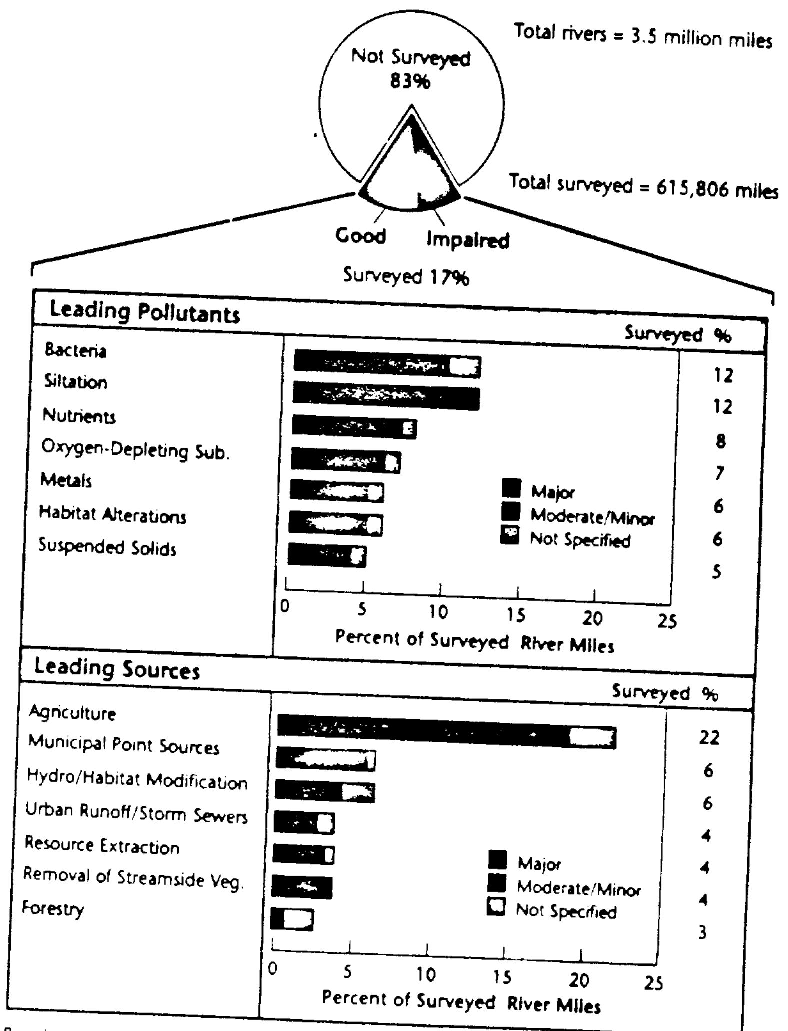
Figure 2-4

SURVEYED River Miles: Pollutants and Sources



Based on data contained in Appendix A, Tables A-4 and A-5.

Note. Percentages do not add up to 100% because more than one pollutant or source may impair a river segment.

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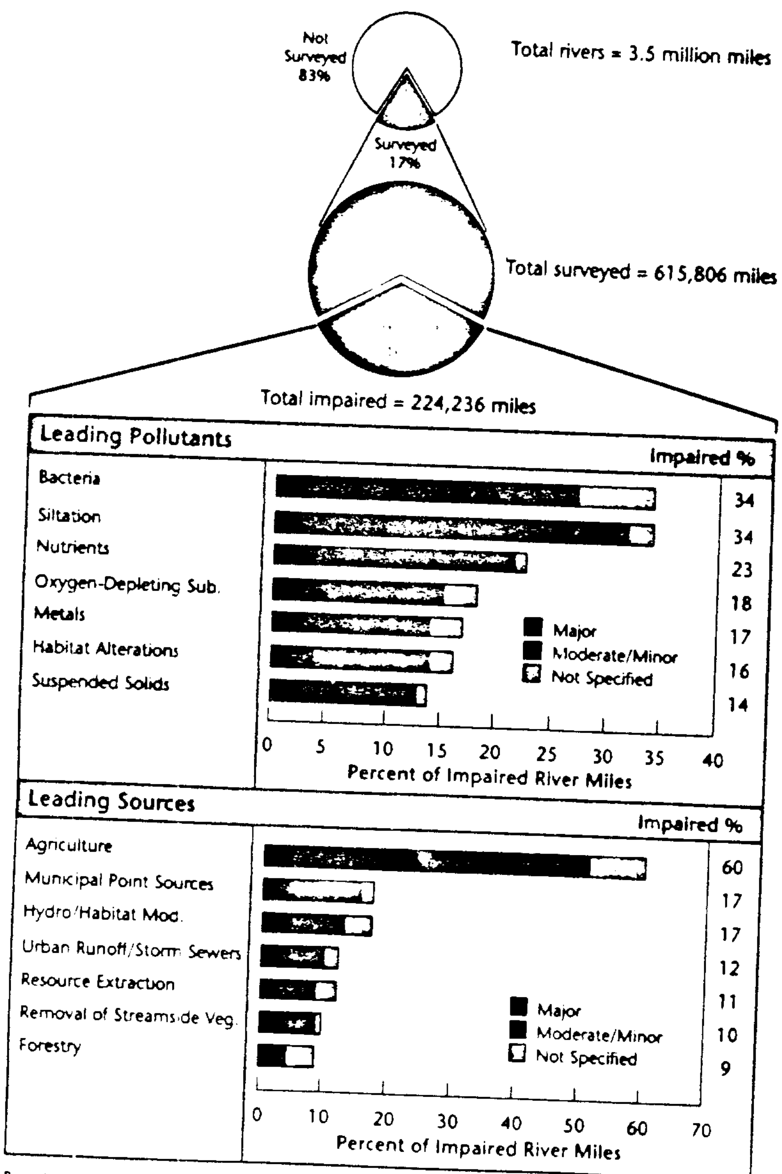
Figure 2-5

IMPAIRED River Miles: Pollutants and Sources



Based on data contained in Appendix A, Tables A-4 and A-5.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a river segment.

pollutant or process is responsible for the impairment. Sources are even more difficult to identify than pollutants and processes.

Pollutants Impacting Rivers and Streams

Fifty-five States and Tribes reported the number of river miles impacted by individual pollutants and processes, such as invasions by exotic species (see Appendix A, Table A-4, for individual State and Tribal information). EPA ranks the pollutants and processes by the geographic extent of their impacts on aquatic life and human activities (i.e., the number of river miles impaired by each pollutant or process) rather than actual pollutant loads in rivers and streams. This approach targets the pollutants and processes causing the most harm to aquatic life and public use of our waters, rather than the most abundant pollutants in our rivers and streams.

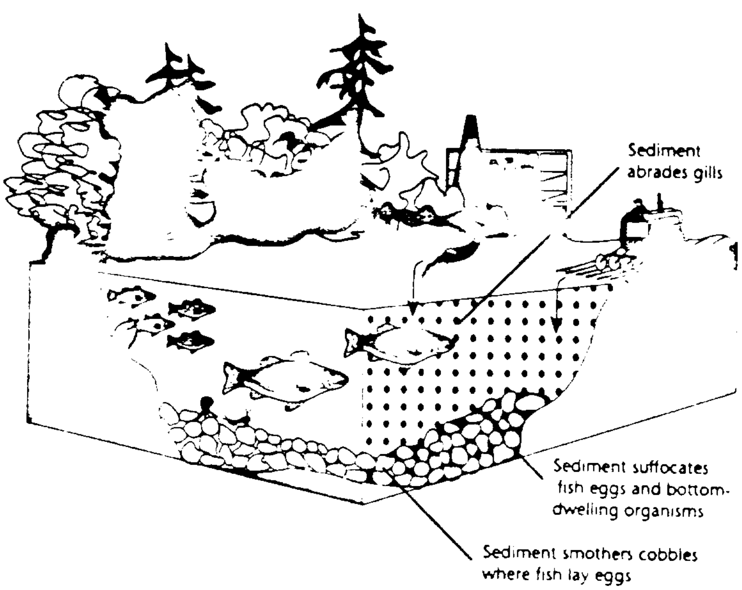
The States and Tribes report that bacteria pollute 76,397 river miles (which equals 12% of the surveyed river miles). Bacteria provide evidence of possible fecal contamination that may cause illness if the public ingests the water. States use bacterial indicators to determine if rivers are safe for swimming and drinking. Bacteria commonly enter surface waters in inadequately treated sewage, fecal material from wildlife, and runoff from pastures, feedlots, and urban areas.

Siltation, composed of tiny soil particles, remains one of the most widespread pollutants impacting rivers and streams (Figure 2-6). The States and Tribes reported that siltation impairs 75,792 river miles (which equals 12% of the surveyed river miles). Siltation alters aquatic habitat and suffocates fish eggs and bottom-dwelling organisms. Aquatic insects live in the spaces between cobbles, but their habitat is destroyed when silt fills in these spaces. The loss of aquatic insects adversely impacts fish and other wildlife that eat these insects. Excessive siltation can also interfere with drinking water treatment processes and recreational use of a river. Sources of siltation include agriculture, urban runoff, construction, and forestry.

In addition to siltation and bacteria, the States and Tribes also

Figure 2-6

The Effects of Siltation in Rivers and Streams



Siltation is one of the leading pollution problems in the Nation's rivers and streams. Over the long term, unchecked siltation can alter habitat with profound adverse effects on aquatic life. In the short term, silt can kill fish directly, destroy spawning beds, and increase water turbidity resulting in depressed photosynthetic rates.

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reported that nutrients, oxygen-depleting substances, metals, and habitat alterations impact more miles of rivers and streams than other pollutants and processes. Often, several pollutants and processes impact a single river segment. For example, a process, such as removal of shoreline vegetation, may accelerate erosion of sediment and nutrients into a stream. In such cases, the States and Tribes count a single mile of river under each pollutant and process category that impacts the river mile. Therefore, the river miles impaired by each pollutant or process do not add up to 100%.

Most States and Tribes also rate pollutants and processes as major or moderate/minor contributors to impairment. A major pollutant or process is solely responsible for an impact or predominates over other pollutants and processes. A moderate/minor pollutant or process is one of multiple pollutants and processes that degrade aquatic life or interfere with human use of a river.

Currently, EPA ranks pollutants and processes by the geographic extent of their impacts (i.e., the number of miles impaired by each pollutant or process). However, less abundant pollutants or processes may have more severe impacts on short stream reaches. For example, a toxic chemical spill can eliminate aquatic life in a short stream while widely distributed bacteria do not affect aquatic life but occasionally indicate a potential human health hazard from swimming. The individual State and Tribal 305(b) reports provide more detailed information about the severity of pollution in specific locations.

Sources of Pollutants Impacting Rivers and Streams

Fifty-two States and Tribes reported sources of pollution related to human activities that impact some of their rivers and streams (see Appendix A, Table A-5, for individual State and Tribal information). These States and Tribes reported that agriculture is the most widespread source of pollution in the Nation's surveyed rivers. Agriculture generates pollutants that degrade aquatic life or interfere with public use of 134,557 river miles (which equals 22% of the surveyed river miles) in 49 States and Tribes (Figures 2-4 and 2-5).

Twenty-one States reported the size of rivers impacted by specific types of agricultural activities:

- Nonirrigated Crop Production – crop production that relies on rain as the sole source of water.

- Irrigated Crop Production – crop production that uses irrigation systems to supplement rainwater.

- Rangeland – land grazed by animals that is seldom enhanced by the application of fertilizers or pesticides, although land managers sometimes modify plant species to a limited extent.

- Pastureland – land upon which a crop (such as alfalfa) is raised to feed animals, either by grazing the animals among the crops or harvesting the crops. Pastureland is actively managed to encourage selected plant species to grow, and fertilizers or pesticides may be applied more often on pastureland than rangeland.

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Kings Park Elementary. 3rd Grade, Springfield, VA

■ Feedlots are generally facilities where animals are fattened. By EPA's definition, feedlots are large sites where many animals are confined at high densities.

■ Animal Holding Areas – facilities for confining animals briefly before slaughter. By EPA's definition, animal holding areas confine fewer animals than feedlots.

Nonirrigated crop production leads the list of agricultural activities impacting rivers and streams, followed by irrigated crop production, rangeland, feedlots, pastureland, and animal holding areas (Figure 2-7). Runoff from irrigated and nonirrigated cropland may introduce commercial fertilizers (that contain nitrogen and phosphorus), pesticides, and soil particles into rivers and streams. Manure applied to cropland as a fertilizer may also wash off of irrigated and nonirrigated fields and prevent rivers and streams from fully supporting designated uses.

Animal waste runoff from feedlots and animal holding areas can introduce pathogens, nutrients (including phosphorus and nitrogen), and organic material to nearby rivers and streams. Rangeland may generate both soil erosion and animal waste runoff. Pastureland usually has good ground cover that protects the soil from eroding, but pastureland can become a source of animal waste runoff if animals graze on impermeable frozen pastureland during winter.

The States and Tribes also report that municipal sewage treatment plants pollute 37,443 river miles (6% of the surveyed river miles), hydrologic modifications and habitat alterations degrade 37,080 river miles (6% of the surveyed river miles), urban runoff and storm sewers pollute 26,862 river miles (4% of the surveyed river miles), resource extraction pollutes 24,059 river miles (4% of the surveyed river miles), and industrial discharges pollute 16,348 river miles (3% of the surveyed river miles).

The States and Tribes also report that "natural" sources impair many miles of rivers and streams in the absence of human activities. "Natural" sources include soils with natural deposits of arsenic or salts that leach into waterbodies, waterfowl (a source of nutrients), and low-flow conditions and elevated water temperatures caused by drought. The total size of rivers impaired by "natural" sources is probably exaggerated because some States may automatically attribute water quality impairments to "natural" sources if the State cannot identify a human activity responsible for a water quality problem.

Other sources, such as mining and forestry activities, can play a more significant role in degrading water quality at a regional or local level than at the national level. For example, resource extraction (including acid mine drainage) contributes to the degradation of 39% of the impaired river miles in the coal belt States of Kentucky, Maryland, Ohio, Pennsylvania, and West Virginia. These States report that resource extraction impairs about 7,590 miles of rivers and streams. Yet, at the national level, resource extraction contributes to the degradation of only 11% of all the impaired river miles in the Nation. At the local level, streams impacted by acid mine drainage are devoid of fish and other aquatic life due to low pH levels and the smothering effects of iron and other metals deposited on stream beds. The primary sources of acid mine drainage are abandoned coal refuse disposal sites and surface and underground mines.

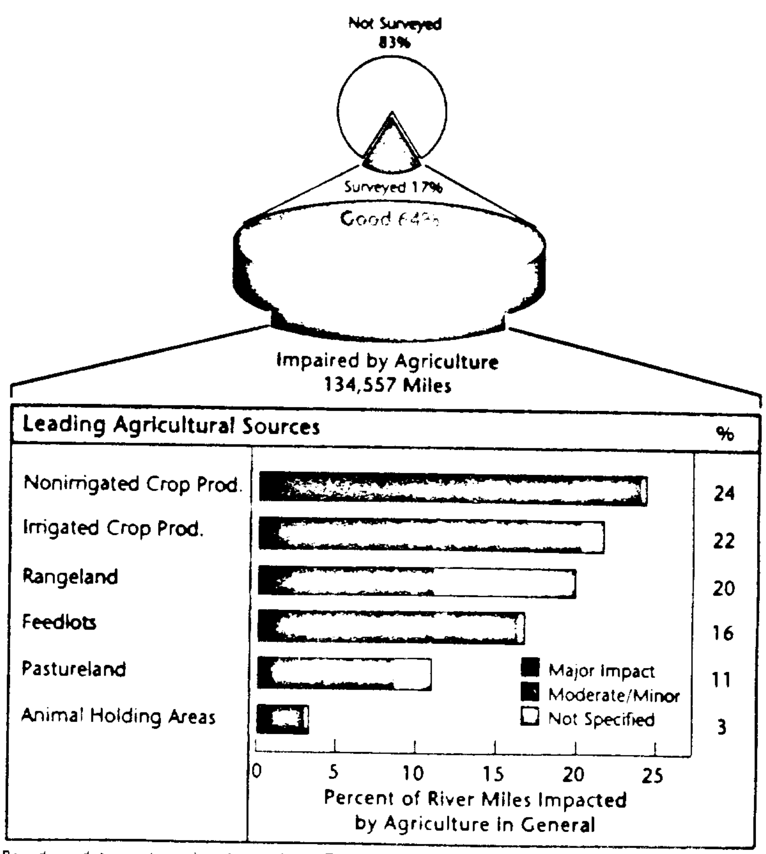
In the Pacific Northwest States of Oregon and Washington, States identify forestry activities as responsible for almost half (46%) of the impaired river miles, but, at the national level, States report that forestry activities contribute to the degradation of only 9% of the Nation's total impaired river miles. Forestry activities include harvesting timber, constructing logging roads, and stand maintenance. California, Florida, Montana, and Wisconsin also report that forestry activities degrade over 1,000 miles of streams in each State.

Many States reported declines in pollution from sewage treatment plants and industrial discharges since enactment of the Clean Water Act in 1972. The States attributed improvements in water quality conditions to sewage treatment plant construction and upgrades and permit controls on industrial discharges. Despite the improvements, municipal sewage treatment plants remain the second most common source of pollution in rivers because population growth increases the burden on our municipal facilities.

Several States reported that they detected more subtle impacts from nonpoint sources, hydrologic modifications, and habitat alterations as they reduced conspicuous pollution from point sources. Hydrologic modifications and habitat alterations are a growing concern to the States. Hydrologic modifications include activities that alter the flow of water in a stream, such as channelization, dewatering, and damming of streams. Habitat alterations include removal of streamside vegetation that protects the stream from high temperatures and scouring of stream bottoms. Additional gains in water quality conditions will be more subtle and require innovative management strategies that go beyond point source controls.

Figure 2-7

Agricultural Impairment: Rivers and Streams
(21 States Reporting)



Based on data contained in Appendix A, Table A-6.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a river segment.

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Habitat Quality of Delaware Nontidal Streams

Delaware has fewer than 10 municipal or industrial point sources that discharge to nontidal waters. Nonpoint sources, including agriculture and urbanization activities, have the major impact on its nontidal streams. Delaware has the capacity to produce over 250 million chickens per year, has over 50% of its land area in crop production, and has an urban population that is increasing annually by 10%.

Delaware uses water quality monitoring to assess the condition of its surface waters for inclusion in its Section 305(b) report. Delaware designed the biological and habitat measures to assess the condition of nontidal streams and evaluate the impact of nonpoint source pollution. Biological and habitat assessments conducted by Delaware during the fall of 1991 and 1993 used a modified version of the EMAP-Estuaries probability-based statistical sampling design. The key to the modified approach involved selecting conveniently accessible sites adjacent to Delaware's roads as a cost-effective means of selecting sampling sites.

Results of these assessments impact decisions related to stormwater controls and the management of streams and ditches and their riparian areas. Stormwater controls are needed throughout the State, and existing sediment and stormwater control regulations must be aggressively adhered to in order to prevent further deterioration of habitat quality from urbanization. Data documenting the poor condition of ponds and the Inland Bays indicate the need for maintenance and restoration of streamside and riparian vegetation to attain the ecological and water quality potential of Delaware's surface waters.

Objectives

The primary objective of this monitoring approach was to provide an assessment of the biological and habitat condition of nontidal streams throughout Delaware. The data were intended for use in the 305(b) report and to support the establishment of biological criteria in the development of State Water Quality Standards. A secondary objective was to quantify the relationship between biological quality,

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using aquatic macroinvertebrates, and habitat quality. This information will be used to evaluate habitat degradation as a biological stressor in nontidal streams and to assess the effect of nonpoint source pollution on stream ecological health.

Sampling Design

The probability-based statistical sampling design developed by EMAP-Estuaries was modified for nontidal streams and used for these assessments. This design allowed for the assessment of conditions over larger geographic areas by sampling a set of randomly selected sites.

The number of sites selected was based on the areal extent of the length of river and stream miles in each of 35 subbasins. The State took samples from a list of 3,311 randomly selected road crossings identified with a geographic information system (GIS).

The distance between road crossings in Delaware averages 1.1 miles. Assessments were made 100 to 150 meters (approximately 330-500 feet) upstream of the road crossing to ensure that the results were minimally affected by the cultural activities near the road.

Using road crossings as sample sites in Delaware is believed to be an acceptable approach because the road crossings occur frequently and are fairly evenly distributed, so they are representative of the nontidal streams; the conditions just upstream from Delaware's small country roads (as opposed to major interstate roads) are not significantly different from those between roads; and the stratification using 35 subbasins overcomes any patchiness in distribution. The statistical certainty of this approach is being further investigated by funding from EMAP-Surface Waters (SW) to compare the statistical validity of the road-crossing design with the standard EMAP-SW statistical sampling design.

The study design enabled the data collected from these sites to be extrapolated with confidence to the entire State. The results from the 189 sampling sites represent a database of sufficient size and statistical certainty to provide a comprehensive assessment of the biological and habitat conditions of nontidal streams throughout the State and in individual counties.

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Biological Monitoring

Chemical monitoring is particularly complex and expensive when applied to diffuse and intermittent pollution sources, and criteria do not exist for such major nonpoint source pollutants as sediment and nutrients. Biological monitoring may provide, therefore, a cost-effective monitoring tool for identifying nonpoint source problems and tracking the progress of control programs.

Measurements associated with the aquatic macroinvertebrate community were used as the basis for determining the biological quality of the nontidal streams. There is considerable variability in the community of organisms found in the aquatic environment. This variability must be accounted for in order to detect differences among sites and among time periods. In this study, to minimize temporal variability, data were collected only during the fall of 2 years. Site variability was further reduced by defining groups of waterbodies with such similar characteristics as salinity, depth, width, and ecoregion. In Delaware nontidal streams, this categorization resulted in two distinct ecoregions: the Piedmont Ecoregion, characterized by gently rolling terrain, and the Coastal Plain Ecoregion, characterized by flat terrain. Biological monitoring was conducted solely in the Coastal Plain Ecoregion.

Standardization of collection and sample processing methods is also important to minimize biological and habitat data variability. The Mid Atlantic-Coastal Stream Workgroup, consisting of biologists from four States and two EPA Regions, developed and tested standard methods for collecting data. Delaware used the methods developed by this workgroup.

Habitat Measurements

Measurements to define the quality of the physical habitat were used to evaluate the relationship between habitat and biology in both ecoregions. The habitat parameters used to score the habitat quality of each site are as follows:

Northern Piedmont Ecoregion

- Channel modification
- Instream habitat
- Bank stability
- Bank vegetative type
- Shading
- Riparian zone width
- Velocity or depth ratio
- Sediment deposition
- Embeddedness (the percent of a rock "stuck" in the substrate)
- Riffle quality
- Riffle quantity

Coastal Plain Ecoregion

- Channel modification
- Instream habitat
- Bank stability
- Bank vegetative type
- Shading
- Riparian zone width
- Pools

Available reports:

Habitat Quality of Delaware Nontidal Streams

Biological Integrity and Habitat Quality of Nontidal Streams of Kent and Sussex Counties, Delaware

For further information:

John Maxted
Delaware Department of Natural Resources and Environmental Control
PO Box 1401
Dover, DE 19903
(302) 739-4590

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Mid-Atlantic Highlands Assessment (MAHA)

In 1992, aquatic biologists in Pennsylvania, Maryland, Virginia, and West Virginia, EPA Region 3, and EPA's Office of Research and Development (ORD) began to explore the feasibility of developing biocriteria for the Mid-Atlantic Highlands and using ecoregions as a management tool. Three years later, this modest effort has evolved into a multistate, multiagency effort known as MAHA (Mid-Atlantic Highlands Assessment). The Mid-Atlantic Highlands, covering some 65,000 square miles, is comprised of many unique terrestrial and aquatic ecosystems, extending east to west from the Blue Ridge Mountains to Ohio and north to south from New York to North Carolina/Tennessee (Figure 1). It includes six major watersheds: West Susquehanna, Upper Susquehanna, Potomac, Kanawa, Monongahela, and Allegheny.

The natural features of this region illustrate both the complexity and the interconnection of ecological systems. The streams are inhabited by the greatest variety of freshwater mussels in the United States. The surrounding landscapes contain some of the most diverse deciduous forests in the world, as well as geographically restricted species that are on the edge of their range or are isolated genetically. The Shenandoah National Park is world renowned for its beauty and variety of animal and plant life. This region also includes extensive and unique cave ecosystems.

In 1995, nine Federal agencies formed the Mid-Atlantic Highlands Coordinating Council to foster and promote cooperation among these entities in carrying out their responsibilities in the Mid-Atlantic Highlands. An interagency Memorandum of Understanding (The Highlands Accord) was signed during the summer of 1995 in the Nation's Capital by and between the U.S. Department of the Interior's Office of Surface Mining, the National Park Service, the National Biological Service, the Fish and Wildlife Service, the U.S. Geological Survey, the U.S. Forest Service, the U.S. Department of Agriculture's Natural Resources Conservation Service, the Agricultural Research Service, and the U.S. Environmental Protection Agency.

The purpose of the Memorandum of Understanding is to establish a framework for regional cooperation and participation among the Federal cooperators and with the States and other parties toward a collective and more holistic approach to the management, conservation, and protection of the Mid-Atlantic Highlands' natural resources. It is anticipated that another three to five Federal agencies and relevant States will join the Council over the next year. The Council will conduct an ecological

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assessment of the condition of the aquatic resources in the Mid-Atlantic Highlands, their associated watersheds, and the factors that affect them. The protection and sustainability of these valuable natural resources can be enhanced through cooperation among the Federal, State, and local agencies and citizens groups involved in managing the area's ecosystems.

Field studies began during 1993. This was the first step toward building a joint monitoring and assessment effort that will ultimately be used to characterize the ecological condition of the Highlands. The field efforts in MAHA are an integration of the base EMAP-Surface Waters stream pilot, the Region 3 R-EMAP project (biological criteria in streams of the Ridge and Valley region), and the TIME project (assessment of streams sensitive to acidic deposition in response to the Clean Air Act Amendments).

First Survey

During the Spring of 1993, field crews from Pennsylvania, Maryland, Virginia, West Virginia, EPA Region 3, EPA's ORD, and the U.S. Fish and Wildlife Service visited 256 stream locations across the four-state area. Using common protocols, they sampled these sites for fish, benthic invertebrates, attached algae, physical habitat, riparian habitat, and water chemistry. Additionally, information from satellite images and aerial photography were collected for the watersheds sampled. Of these sites, 41 had been specifically selected as being representative of either minimally disturbed sites or sites known to be highly impacted. The remainder of the sites had been selected using a statistical process, similar to election

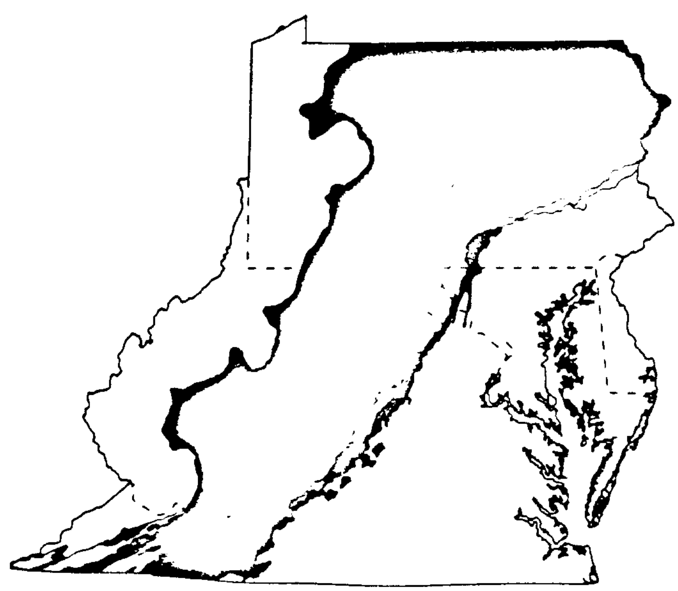

Figure 1. Ecological Regions of the Mid-Atlantic Highlands.

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polls, so that information from these sites could be used to estimate the conditions found across all small streams within the region.

The information presented here represents just the initial findings of the first year's survey, yet significant information about the chemical, biological, and habitat conditions of streams in the mid-Atlantic was uncovered. Additional analyses are ongoing by the Region, States, ORD, and local universities to more fully describe the stream conditions in MAHA. This first survey only addressed small, "wadeable" streams (first- to third-order streams). Although small, these streams account for approximately 80% of the total stream length in the region. Thus, impacts or alterations in these systems can have a significant effect on the region's fisheries and a cumulative impact on the larger streams and rivers with which people are more familiar.

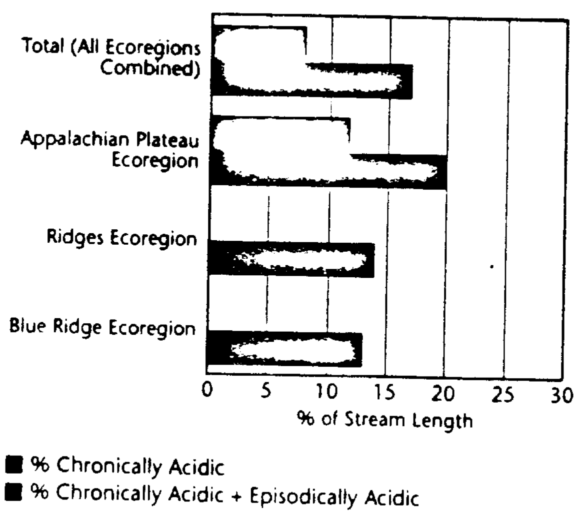

Figure 2. The Extent of Acidification of Streams in the Mid-Atlantic Highlands Regions.

Chemical Quality of MAHA Streams

Previous studies have identified streams in the Mid-Atlantic Highlands as very sensitive to acidification from sources such as acid rain or acid mine drainage. Previous 305(b) reports from States in the mid-Atlantic identified resource extraction, predominantly coal mining, as one of the major impacts on streams. This study looked at impacts from acidification in the Appalachian Plateau, the Ridges, and the Blue Ridge ecoregions. From measures of acid neutralizing capacity (ANC) in streams, it was estimated that 32% of the stream length in the Appalachian Plateau is either chronically acidic (12%) or chronically and episodically acidic (20%) (Figure 2). For this analysis, ANC ≤ 0 was the criterion for chronically acidic streams and ANC ≤ 50 was the criterion for episodically acidic systems.

Given the high impact in the Appalachian Plateau, there was interest in determining how much of the acidification impact was from deposition, mine drainage, or a mixture of impacts. Figure 3 shows the relative magnitude of different chemical impacts in streams of the Appalachian Plateau. Mixed impacts affect 29,000 km (18,021 miles) of stream while mine drainage impact

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is seen in 11,000 km (6,835 miles) of stream. Acidic deposition appears to account for approximately 8,000 km (about 4,971 miles) of impacted streams in the Appalachian Plateau. Within this ecoregion, approximately 21,000 km (13,049 miles) of the small streams showed little or no chemical impact. The stream benthic community shows a response to these impacts, with the response being most severe in streams showing impacts from acid mine drainage (Figure 3).

Riparian Condition

Historically, alteration to the riparian system has not been of concern in water quality studies. But as our concern spread to encompass the protection of aquatic life, it became apparent that alterations to other facets of the riverine system, besides the water itself, could significantly impact the system. Alterations to the strip of land bordering the stream, the riparian corridor, have been shown to have potentially important implications to aquatic life. This riparian vegetation

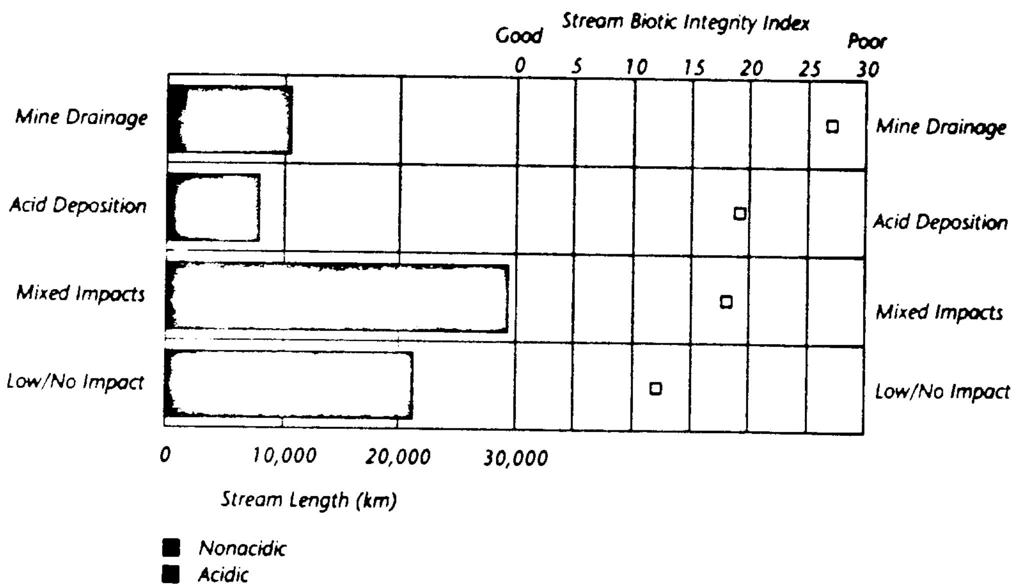

Figure 3. Extent of Chemical Impacts in Streams of the Appalachian Plateau Ecoregion and Resulting Condition of Aquatic Insects (Measured as Biotic Integrity).

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provides shade, cover, and a constant supply of vegetative material for use by aquatic insects. Previous 305(b) reports for the region estimated that less than 1% of the assessed stream length was impacted by hydrologic or habitat alterations. The current study suggests that this number might be much higher, ranging from 73% of the stream length in the Western Allegheny Plateau to 17% in the Ridges of the Mid-Atlantic Region (Figure 4).

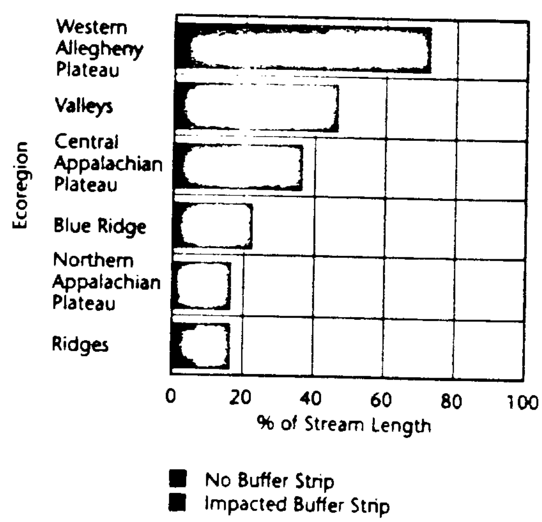

Figure 4. Percent of Riparian Buffer Impacted or Destroyed Along Streams in the Mid-Atlantic Highlands Region.

Biotic Integrity

The presence of healthy, diverse, and sustainable biological communities in streams reflects a strong biotic integrity. The State and Regional biologists continue to evaluate the best indicators of biotic integrity and establish biological criteria based on these indicators. Much was learned, however, during this first survey about the region's biological stream resources. In the smallest streams (first-order), 21% of the stream length (18,900 km or 11,744 miles) contained no fish (Figure 5). It is not known at present whether the absence of fish is due to natural causes or to anthropogenic alterations. However, the first-order streams contain as much stream length (26,000 km or 16,156 miles) with game fish as the second- and third-order streams combined (~25,000 km or 15,535 miles). Clearly this very small stream resource should be an important part of any management efforts to sustain sport fish. When this same information about fish presence is analyzed by ecoregion, the Ridge, Valley, and Western Allegheny ecoregions show significant portions of the stream resource with no fish present–39%, 18%, and 26%, respectively. It is uncertain whether the lack of fish is a natural condition or results from disturbances to the ecosystem.

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The Mid-Atlantic Highlands provide habitat for one of the most diverse fish communities in the country. Thus the introduction of exotic species, intentional or accidental, presents a significant threat to native fishes. Results from the first year of the MAHA survey provide an initial estimate of the extent of nonnative fish in the streams of the region. Overall, approximately 12% of the stream length in the mid-Atlantic contains nonnative (exotic) fish species. This is a result of both intentional introductions by fish stocking programs and accidental releases or invasions by nonnative fishes. The presence of exotic species is greatest in the third-order streams where approximately 49% of the stream length contains exotic fish species. In contrast, only 2% of the first-order stream length appears to contain nonnative fish species.

Future analyses of the MAHA data will refine the estimates provided here as well as present additional information on the condition and related causes of impacts to the stream resource of the Mid-Atlantic Highlands.

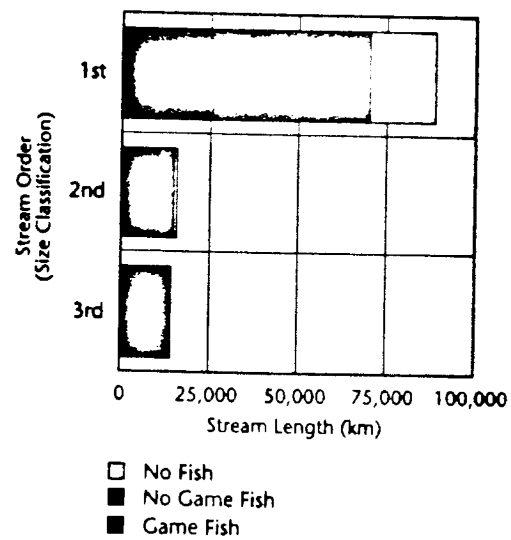


Figure 5. Occurrence of Fish by Stream Order in the Mid-Atlantic Highlands.

John Theilgard, Bynum, NC

Lakes, Reservoirs, and Ponds

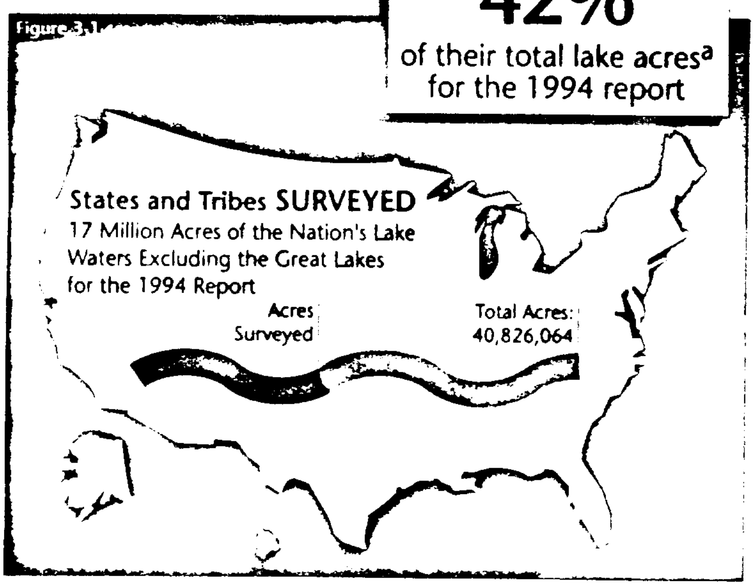
Forty-four States, Puerto Rico, and the District of Columbia (hereafter collectively referred to as States), and two Tribes rated lake water quality in their 1994 Section 305(b) reports (see Appendix B, Table B-1, for individual State and Tribal data). These States and Tribes surveyed over 17.1 million acres of lakes, reservoirs, and ponds, which equals 42% of the 40.8 million acres of lakes in the Nation (Figure 3-1). The States and Tribes based 66% of their survey on monitored data and evaluated 18% of the surveyed lake acres with qualitative information (including best professional judgment by water quality managers). The States and governments did not specify whether 16% of the surveyed lake acres were monitored or evaluated.

The number of surveyed lake acres declined between 1992 and 1994 because several States chose not to use their fish tissue data to help determine overall use support. Some of these States, such as Minnesota, have established massive databases of fish tissue contamination information (which is used to establish fish consumption

THE STATES SURVEYED more than 17 million acres of lakes for 1994.

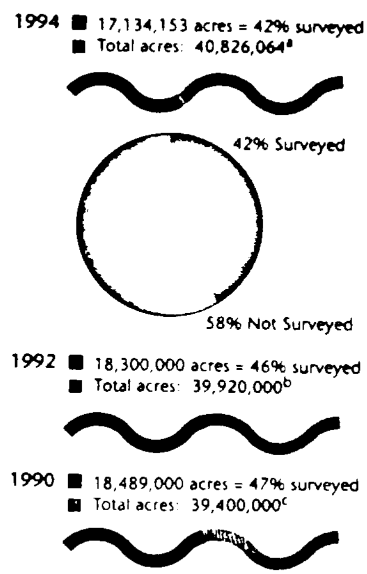
States and Tribes
SURVEYED
42%
of their total lake acres[a] for the 1994 report

Figure 3-1



Based on data contained in Appendix B, Table B-1.

Lake, Reservoir, and Pond Acres Surveyed by the States and Tribes



[a]Source: 1994 State and Tribal Section 305(b) reports.
[b]Source: 1992 State and Tribal Section 305(b) reports.
[c]Source: *National Water Quality Inventory: 1990 Report to Congress*, U.S. EPA, 1992

advisories) but lack other types of water quality data for many of their lakes. In 1994, these States chose not to assess overall use support entirely with fish tissue data alone, which is a very narrow indicator of water quality. In general, fish tissue data do not measure the health of a lake's aquatic community or swimming conditions although they do, of course, affect fish consumption. These States determined that it would be more useful to incorporate their fish tissue data into their discussions of public health concerns (see Chapter 7).

These changes are just one example of the numerous modifications the States made to their water quality survey methods between 1992 and 1994 as a result of many Federal, State, and Tribal partnerships implemented to improve monitoring in the Nation. Due to these changes, the summary data presented herein should not be compared with summary data presented in the 1992 Report to Congress.

Discrepancies in State survey methods also undermine comparisons of lake information submitted by individual States. Lake data should not be compared among States, which devote varying resources to monitoring biological integrity, water chemistry, and toxic pollutants in fish tissues. The discrepancies in State monitoring and survey methods, rather than actual differences in water quality, often account for the wide range in water quality ratings reported by individual States.

The summary information presented in this chapter applies strictly to the portion of the Nation's lakes surveyed by the States and Tribes. EPA cannot make generalizations about the health of all of our Nation's lakes based on data extracted from the 305(b) reports because most States and Tribes rate their waters with information obtained from water monitoring programs designed to detect degraded waterbodies. Very few States or Tribes randomly select water sampling sites to represent a cross section of water quality conditions in their jurisdiction. Instead, many States and Tribes direct their limited monitoring resources toward waters with suspected problems. As a result, the surveyed lakes probably contain a higher percentage of polluted waters than all of the Nation's lakes.

General Water Quality

The States and Tribes rate whether their water quality is good enough to fully support a healthy community of aquatic organisms and human activities, such as swimming, fishing, and drinking water use. The States and Tribes designate individual lakes for specific activities, termed "individual designated uses." EPA and the States use the following terminology to rate their water quality:

- **Good/Fully Supporting**: Good water quality supports a diverse community of fish, plants, and aquatic insects, as well as the array of human activities assigned to a lake by the State.

- **Good/Threatened**: Good water quality currently supports aquatic life and human activities in and on the lake, but changes in such factors as land use threaten water quality, or data indicate a trend of increasing pollution in the lake.

■ **Fair/Partially Supporting**: Fair water quality supports aquatic communities with fewer species of fish, plants, and aquatic insects, and/or occasional pollution interferes with human activities. For example, runoff during severe thunderstorms may temporarily elevate fecal coliform bacteria densities and indicate that swimming is not safe immediately following summer storms.

■ **Poor/Not Supporting**: Poor water quality does not support a healthy aquatic community and/or prevents some human activities on the lake. For example, lake waters may be devoid of fish for more than a month each summer because excessive nutrients from runoff initiate algal blooms that deplete oxygen concentrations.

■ **Poor/Not Attainable**: The State has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six specific biological, chemical, physical, or economic/social conditions (see Chapter 1 for additional information).

Most States and Tribes rate how well a lake supports individual uses (such as swimming and aquatic life habitat) and then consolidate individual use ratings into an overall water quality rating. A lake receives a poor overall rating if water quality consistently fails to support any one human activity or a healthy aquatic community (see Chapter 1 for a complete discussion of use support).

Forty-one States, two Tribes, Puerto Rico, and the District of Columbia reported overall use support status for lakes in their 1994 Section 305(b) reports (see Appendix B, Table B-2, for individual State and Tribal information). Another three States reported individual use support status but did not report overall use support status. In such cases, EPA used aquatic life use support status to represent general water quality conditions in the State's lakes.

The States and Tribes reported that 63% of their surveyed 17.1 million lake acres have good water quality (Figure 3-2). Waters with good quality include 50% of the surveyed lake acres fully supporting uses and 13% of the surveyed lake acres that are threatened and might deteriorate if we fail to manage potential sources of pollution.

Surveyed Waters

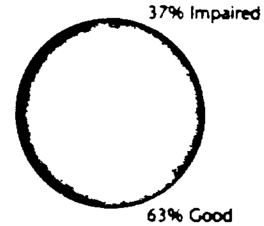
Total lakes = 40,826,064 acres[a]
Total surveyed = 17,134,153 acres

■ 42% surveyed
■ 58% not surveyed

Of the surveyed acres:

- 66% were monitored
- 18% were evaluated
- 16% were not specified

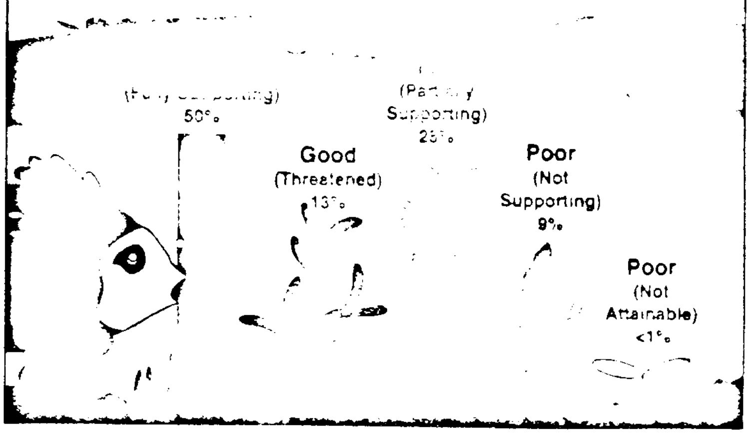
Overall Surveyed Water Quality



[a]Source: 1994 State and Tribal Section 305(b) reports.

Figure 3-2

Overall Use Support
in Surveyed Lakes, Reservoirs, and



Based on data contained in Appendix B, Table B-2 water quality.

Some form of pollution or habitat degradation impairs the remaining 37% of the surveyed lake acres. Twenty-eight percent of the surveyed lake acres have fair water quality that partially supports designated uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Nine percent of the surveyed lake acres suffer from poor water quality that consistently stresses aquatic life and/or prevents people from using the lake for activities such as swimming and fishing.

Individual Use Support

Individual use support information provides additional detail about water quality problems in our Nation's surface waters. The States and Tribes are responsible for designating their lakes for specific uses, but EPA requests that the States and Tribes rate how well their lakes support six standard uses so that EPA can summarize the State and Tribal data. The standard uses consist of aquatic life support, fish consumption, primary contact recreation (such as swimming and diving), secondary contact recreation (such as boating), drinking water supply, and agricultural use (see Chapter 1 for a description of each individual use).

Forty-one States, one Tribe, Puerto Rico, and the District of Columbia reported individual use support status of their lakes, reservoirs, and ponds (see Appendix B, Table B-3, for individual State and Tribal information). The reporting States and Tribes rated aquatic life use and swimming use in more lakes and identified more impacts on aquatic life use and swimming use than the other individual uses (Figure 3-3). These States and governments reported that fair or poor water quality impacts aquatic life in over 4.4 million lake acres (31% of the 14.5 million acres surveyed for aquatic life support), and swimming criteria violations impact 2.9 million lake acres (19% of the 14.8 million acres surveyed for swimming use support).

Many States and Tribes did not rate fish consumption use support because they have not codified fish consumption as a use in their standards. Some of these States consider fishing use as a component of aquatic life use—lakes that provide a healthy habitat for fish support fishing activities even though anglers may not be able to eat their catch in these States. EPA encourages the States to designate fish consumption as a use in their waterbodies to promote consistency in future reporting.

Water Quality Problems Identified in Lakes, Reservoirs, and Ponds

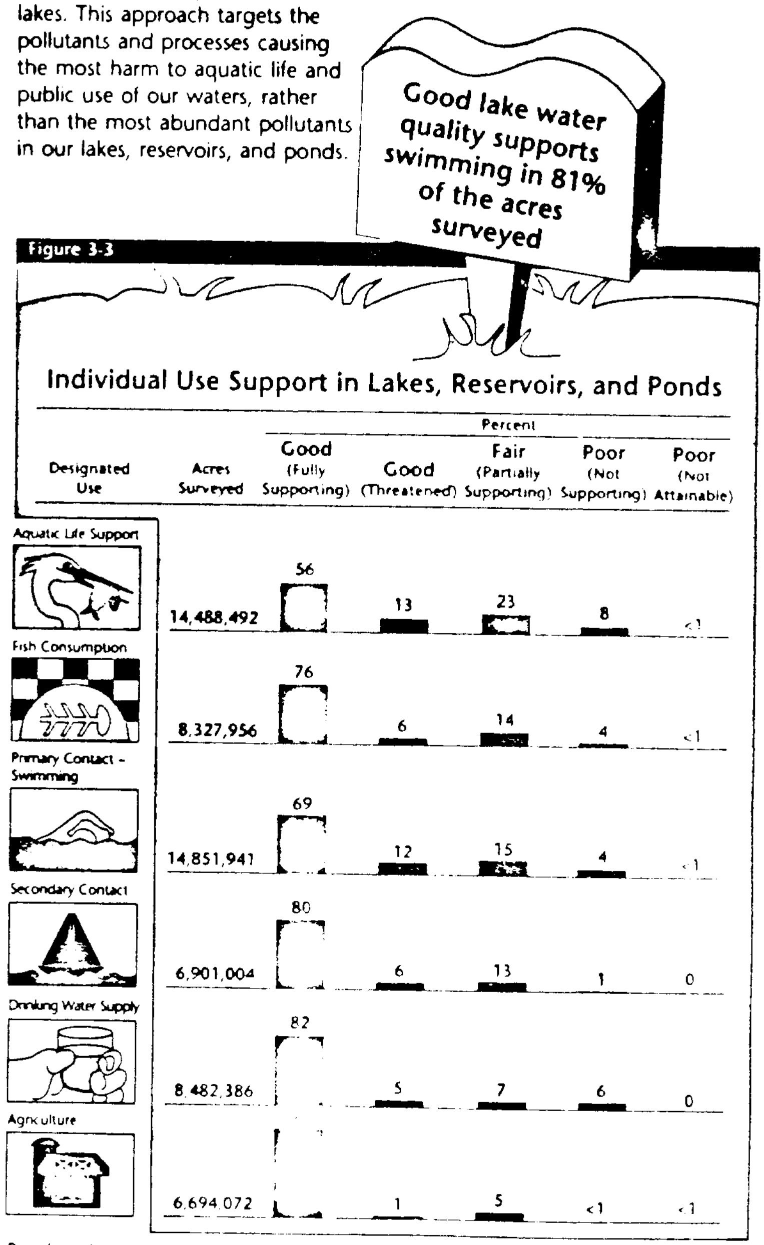
Figures 3-4 and 3-5 identify the pollutants and sources of pollutants that impair (i.e., prevent from fully supporting designated uses) the most acres of lakes, as reported by the States. The two figures are based on the same data (contained in Appendix B, Tables B-4 and B-5), but each figure provides a different perspective on the extent of impairment attributed to individual pollutants and sources. Figure 3-4 shows the relative impact of the leading pollutants and sources in surveyed lakes. Figure 3-5 presents the relative impact of the leading pollutants and sources in lakes with identified problems (i.e., impaired lakes), a subset of surveyed lakes.

The following sections describe the leading pollutants and sources of impairment identified in lakes. It is important to note that the information about pollutants and sources is incomplete because the States cannot identify the pollutant or source of pollutants impairing every impaired lake. In some cases, a State may recognize that water quality does not fully support a designated use, but the State may not have adequate data to document that a specific pollutant or process is responsible for the impairment. Sources are even more difficult to identify than pollutants and processes.

Pollutants Impacting Lakes, Reservoirs, and Ponds

Forty-one States, the District of Columbia, and Puerto Rico reported the number of lake acres impacted by individual pollutants and processes, such as invasions by noxious aquatic plants (see Appendix B, Table B-4, for individual State and Tribal information). EPA measures the impact of each pollutant or process by summing the total lake acres impaired (i.e., not fully supporting designated uses) by each pollutant or process. EPA ranks the pollutants and processes by the extent of their impacts on aquatic life and human activities rather than actual pollutant loads in lakes. This approach targets the pollutants and processes causing the most harm to aquatic life and public use of our waters, rather than the most abundant pollutants in our lakes, reservoirs, and ponds.

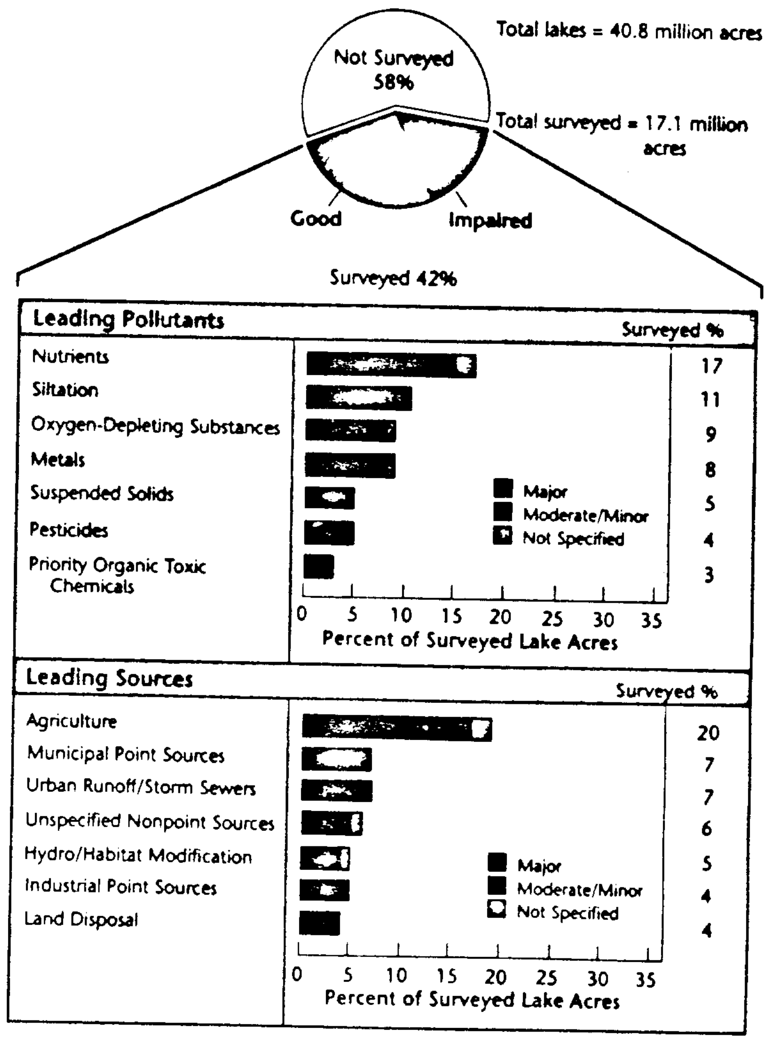
Figure 3-3



Based on data contained in Appendix B, Table B-3

Figure 3-4

SURVEYED Lake Acres: Pollutants and Sources



Based on data contained in Appendix B, Tables B-4 and B-5.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a lake.

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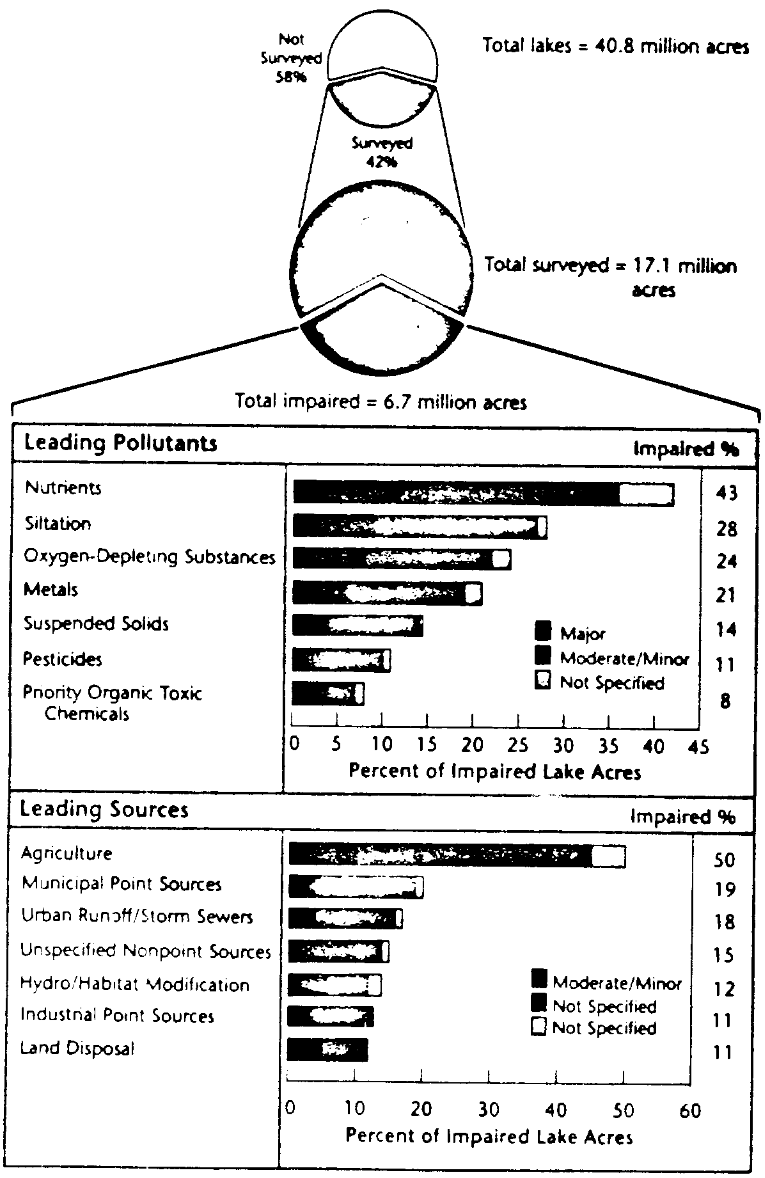
Figure 3-5

IMPAIRED Lake Acres: Pollutants and Sources



Based on data contained in Appendix B, Tables B-4 and B-5.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a lake.

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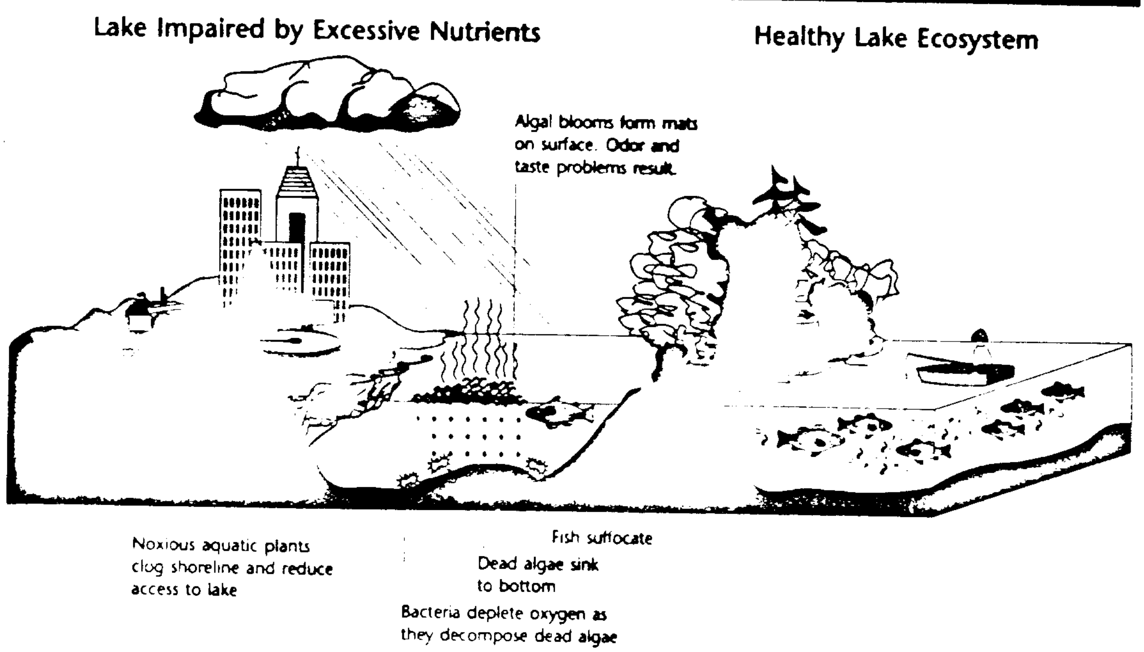
Thirty-seven States and Puerto Rico identified more lake acres polluted by nutrients than any other pollutant or process (Figures 3-4 and 3-5). The States and Puerto Rico reported that extra nutrients pollute 2.8 million lake acres (which equals 17% of the surveyed lake acres). Healthy lake ecosystems contain nutrients in small quantities, but extra inputs of nutrients (primarily nitrogen and phosphorus) from human activities unbalance lake ecosystems (Figure 3-6). When temperature and light conditions are favorable, excessive nutrients stimulate population explosions of undesirable algae and aquatic weeds. The algae sink to the lake bottom after they die, where bacteria consume the available dissolved oxygen as the bacteria decompose the algae. Fish kills and foul odors may result if the bacteria deplete the dissolved oxygen.

In addition to nutrients, the States, Puerto Rico, and the District of Columbia report that siltation pollutes 1.9 million lake acres (which equals 11% of the surveyed lake acres), enrichment by organic wastes that deplete oxygen impacts 1.6 million lake acres (which equals 9% of the surveyed lake acres), and

Figure 3-6



Nutrients cause nuisance overgrowth of algae as well as noxious aquatic plants, which leads to oxygen depletion via plant respiration and microbial decomposition of plant matter. If not properly managed and controlled, sources such as agriculture, industrial activities, municipal sewage, and atmospheric deposition can contribute to excessive nutrients in lakes.

metals pollute 1.4 million acres (which equals 8% of the surveyed lake acres).

Metals declined from the most widespread pollutant impairing lakes in the 1992 305(b) reporting cycle to the fourth leading pollutant impairing lakes in 1994. The decline is due to changes in State reporting and assessment methods rather than a measured decrease in metals contamination. In 1994, several States chose to no longer assess overall use support with fish contamination data alone. Much of that data consisted of measurements of metals in fish tissue. As a result of excluding these fish tissue data, the national estimate of lake acres impaired by metals fell by over 2 million acres in 1994.

Often, several pollutants and processes impact a single lake. For example, a process, such as removal of shoreline vegetation, may accelerate erosion of sediment and nutrients into a lake. In such cases, the States and Tribes count a single lake acre under each pollutant and process category that impacts the lake acre. Therefore, the lake acres impaired by each pollutant and process do not add up to 100%.

Most States and Tribes also rate pollutants and processes as major or moderate/minor contributors to impairment. A major pollutant or process is solely responsible for an impact or predominates over other pollutants and processes. A moderate/minor pollutant or process is one of multiple pollutants and processes that degrade aquatic life or interfere with human use of a lake. The States report that nutrients are the most widespread major cause of impairment in lakes.

Currently, EPA ranks pollutants and processes by the geographic extent of their impacts (i.e., the number of lake acres impaired by each pollutant or process). However, less abundant pollutants or processes may have more severe impacts than the leading pollutants listed above. For example, extreme acidity (also known as low pH) can eliminate fish in isolated lakes, but acid impacts on lakes are concentrated in northeastern lakes and mining States and are not widespread across the country as a whole. The individual State 305(b) reports provide more detailed information about the severity of pollution in specific locations.

Sources of Pollutants Impacting Lakes, Reservoirs, and Ponds

Forty-two States and Puerto Rico reported sources of pollution related to human activities that impact some of their lakes, reservoirs, and ponds (see Appendix B, Table B-5, for individual State information). These States and Puerto Rico reported that agriculture is the most widespread source of pollution in the Nation's surveyed lakes (Figures 3-4 and 3-5). Agriculture generates pollutants that degrade aquatic life or interfere with public use of 3.3 million lake acres (which equals 20% of the surveyed lake acres).

The States and Puerto Rico also reported that municipal sewage treatment plants pollute 1.3 million lake acres (7% of the surveyed lake acres), urban runoff and storm sewers pollute 1.2 million lake acres (7% of the surveyed lake acres),

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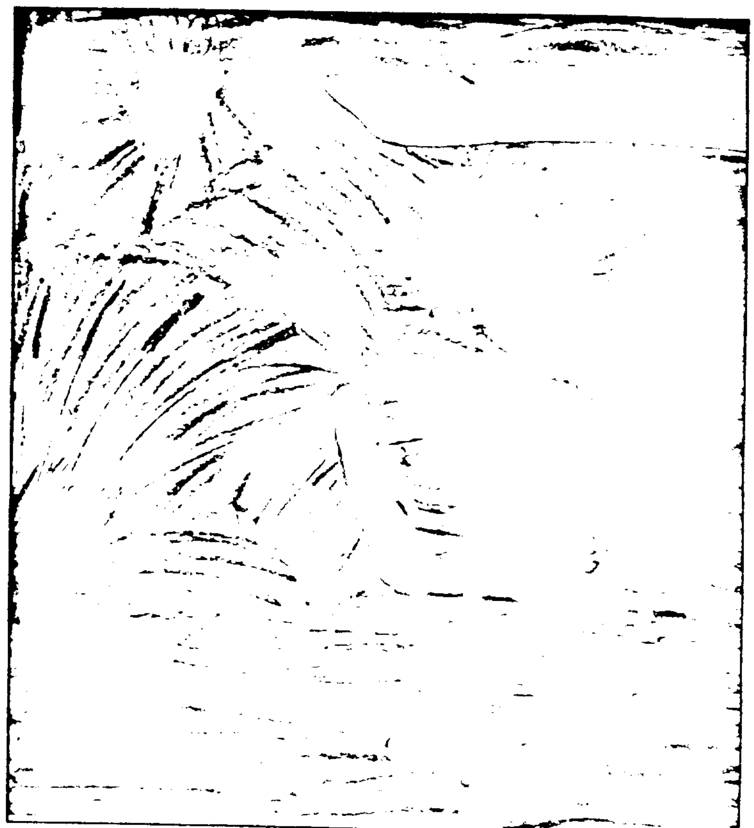
unspecified nonpoint sources impair 989,000 lake acres (6% of the surveyed lake acres), hydrologic modifications and habitat alterations degrade 832,000 lake acres (5% of the surveyed lake acres), and industrial point sources pollute 759,000 lake acres (4% of the surveyed lake acres). Many States prohibit new point source discharges into lakes, but existing municipal sewage treatment plants remain a leading source of pollution entering lakes. Effluent from sewage treatment plants may include nutrients and ammonia, as well as oxygen-depleting wastes and chemicals from industrial facilities that discharge into the municipal plant.

The States and Puerto Rico listed numerous sources that impact several hundred thousand lake acres, including land disposal of wastes, construction, flow regulation, highway maintenance and runoff, contaminated sediments, atmospheric deposition of pollutants, and onsite wastewater systems (including septic tanks).



Le[illegible] [illegible], 3rd grade, Kings Park Elementary, Springfield, VA

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Paul Goetz, Cary, NC

Tidal Estuaries and Ocean Shoreline Waters

Rivers meet the oceans, Gulf of Mexico, and the Great Lakes in coastal waters called estuaries. This chapter describes conditions in tidal estuaries, where tides mix fresh water from rivers with saline water from the oceans and the Gulf of Mexico. Fresh water estuaries around the Great Lakes are discussed in Chapter 12.

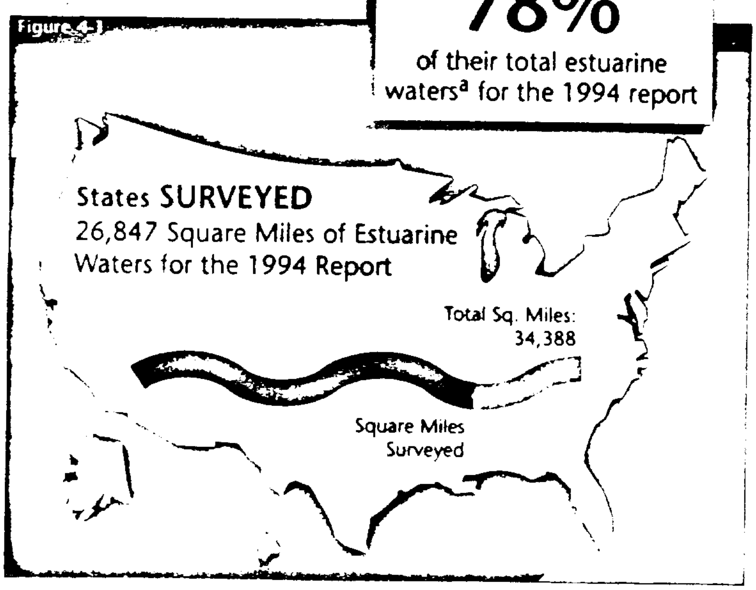
Estuarine waters include bays and tidal rivers that serve as nursery areas for many commercial fish and most shellfish populations, including shrimp, oysters, crabs, and scallops. Most of our Nation's fish and shellfish industry relies on productive estuarine waters and their adjacent wetlands to provide healthy habitat for some stage of fish and shellfish development. Recreational anglers also enjoy harvesting fish that reproduce or feed in estuaries, such as striped bass and flounder.

Estuaries

Twenty-three of the 27 coastal States and other government entities (hereafter collectively referred to as States) rated general water quality conditions in some of their

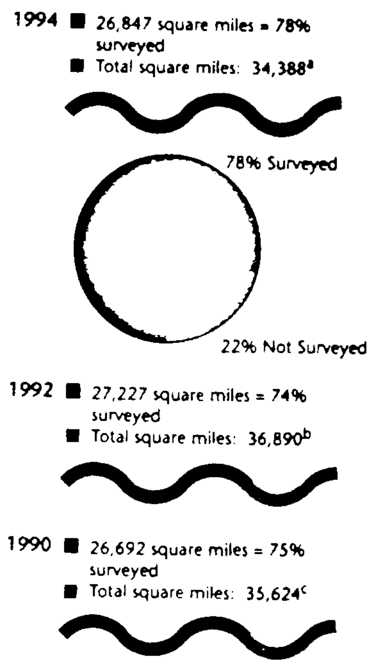
States SURVEYED 78% of their total estuarine waters[a] for the 1994 report

Figure 4-1



Based on data contained in Appendix C, Table C-1.

Estuaries Surveyed by States and Territories



[a] Source: 1994 State Section 305(b) reports.
[b] Source: 1992 State Section 305(b) reports.
[c] Source: 1990 State Section 305(b) reports.

estuarine waters (Appendix C, Table C-2, contains individual State data). In addition, California and New Jersey reported individual use support status in estuarine waters but did not summarize general water quality conditions. The EPA used aquatic life use support status to represent general water quality conditions in California's estuarine waters and shellfish use support status to represent general water quality conditions in New Jersey's estuarine waters.

Altogether, these States surveyed 26,847 square miles of estuarine waters, which equals 78% of the 34,388 square miles of estuarine waters in the Nation (Figure 4-1). The States based 42% of their survey on monitored data and evaluated 31% of the surveyed estuarine waters with qualitative information (including best professional judgment by water quality managers). The States did not specify whether 27% of the surveyed estuarine waters were monitored or evaluated.

The States constantly revise their survey methods in an effort to improve their accuracy and precision. These changes limit the comparability of summary data presented herein and summary data presented in previous Reports to Congress. Similarly, discrepancies in State survey methods undermine comparisons of estuarine information submitted by individual States. Estuarine data should not be compared among States, which devote varying resources to monitoring biological integrity, water chemistry, and toxic pollutants in fish tissues. The discrepancies in State monitoring and survey methods, rather than actual differences in water quality, often account for the wide range in water quality ratings reported by individual States.

General Water Quality

EPA directs the States to rate whether their water quality is good enough to fully support a healthy community of aquatic organisms and human activities, such as swimming, fishing, and drinking. The States designate individual estuaries for specific activities, termed "individual designated uses." EPA and the States use the following terminology to rate their water quality:

- **Good/Fully Supporting**: Good water quality supports a diverse community of fish, plants, and aquatic insects, as well as the array of human activities assigned to an estuary by the State.

- **Good/Threatened**: Good water quality currently supports aquatic life and human activities on the estuary, but changes in such things as land use threaten water quality, or data indicate a trend of increasing pollution in the estuary.

- **Fair/Partially Supporting**: Fair water quality supports aquatic communities with fewer species of fish, plants, and aquatic insects, and/or occasional pollution interferes with human activities. For example, runoff during severe thunderstorms may temporarily elevate fecal coliform bacteria densities and indicate that shellfish are not safe to harvest and eat immediately after summer storms.

■ **Poor/Not Supporting**: Poor water quality does not support a healthy aquatic community and/or prevents some human activities on the estuary. For example, estuarine waters may be devoid of fish for more than a month each summer because excessive nutrients from runoff initiate algal blooms that deplete oxygen concentrations.

■ **Poor/Not Attainable**: The State has performed a use-attainability analysis and demonstrated that use support of one or more designated beneficial uses is not attainable due to one of six specific biological, chemical, physical, or economic/social conditions (see Chapter 1 for additional information).

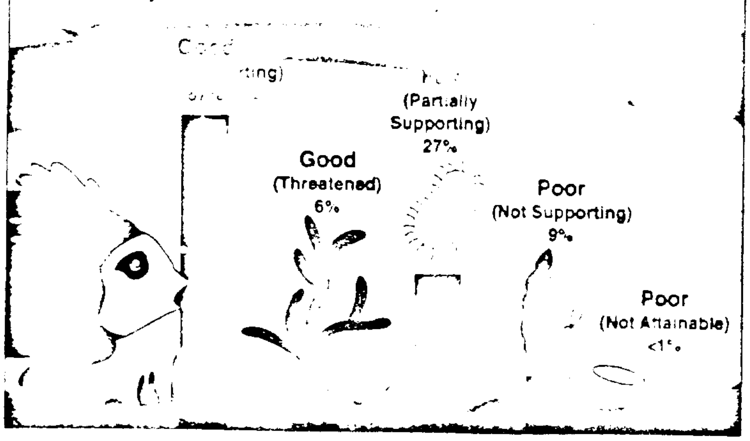
Most States rate how well an estuary supports individual uses (such as swimming and aquatic life habitat) and then consolidate individual use ratings into an overall water quality rating. An estuary receives a poor overall rating if water quality consistently fails to support any one human activity or a healthy aquatic community (see Chapter 1 for a complete discussion of use support).

The States reported that 63% of the surveyed estuarine waters have good water quality that fully supports designated uses (Figure 4-2). Of these waters, 6% are threatened and might deteriorate if we fail to manage potential sources of pollution.

Some form of pollution or habitat degradation impairs the remaining 37% of the surveyed estuarine waters. Twenty-seven percent of the surveyed estuarine waters have fair water quality that partially supports designated uses. Most of the time these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution

Figure 4-2

Overall Use Support
in Surveyed Estuaries



Based on data contained in Appendix C, Table C-2.

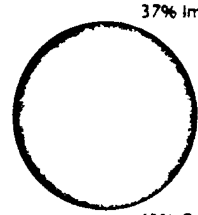
Surveyed Waters

Total estuaries = 34,388 square miles*
Total surveyed = 26,847 square miles

■ 78% surveyed
■ 22% not surveyed

Of the surveyed estuarine waters:
- 42% were monitored
- 31% were evaluated
- 27% were not specified

Overall Surveyed Water Quality



*Source: 1994 State Section 305(b) reports.

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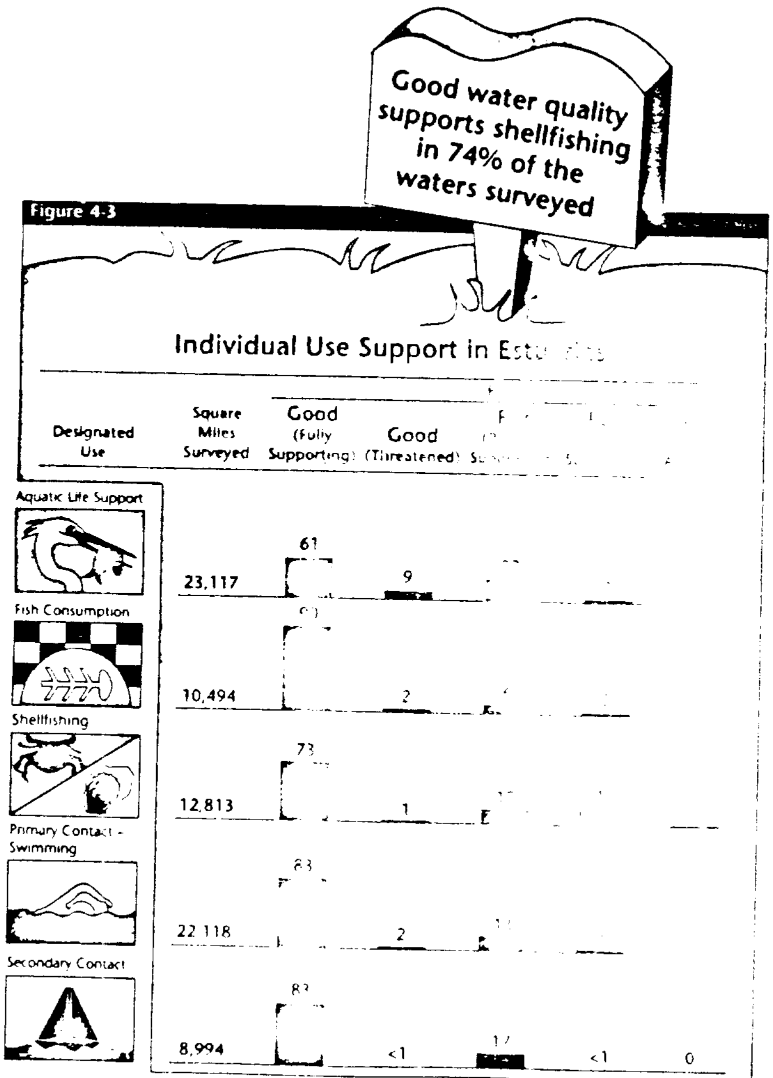
interferes with these activities and/or stresses aquatic life. Nine percent of the surveyed estuarine waters suffer from poor water quality that consistently stresses aquatic life and/or prevents people from using the estuarine waters for activities such as swimming and shellfishing.

Figure 4-3



Based on data contained in Appendix C, Table C-3.

Individual Use Support

Individual use support information provides additional detail about water quality problems in our Nation's surface waters. The States are responsible for designating their estuaries for State-specific uses, but EPA requests that the States rate how well their estuaries support five standard uses so that EPA can summarize the State data. The standard uses are aquatic life support, fish consumption, shellfish harvesting, primary contact recreation (such as swimming and diving), and secondary contact recreation (such as boating) (see Chapter 1 for a description of each individual use). Few States designate saline estuarine waters for drinking water supply use and agricultural use because of high treatment costs.

Twenty-one States reported the individual use support status of their estuarine waters (see Appendix C, Table C-3, for individual State information). Most often, these States examined aquatic life conditions and swimming use in their estuarine waters (Figure 4-3). The States reported that pollutants impact aquatic life in 6,945 square miles of estuarine waters (30% of the 23,117 square miles surveyed for aquatic life support) and violate shellfish harvesting criteria in 3,302 square miles of estuarine waters (26% of the 12,813 square miles surveyed for shellfishing use support). Pollutants also violate swimming criteria in 3,263 square miles of estuarine waters (15% of the 22,118 square miles surveyed for swimming use support).

Water Quality Problems Identified in Estuaries

Figures 4-4 and 4-5 identify the pollutants and sources of pollutants that impair (i.e., prevent from fully supporting designated uses) the most square miles of estuarine waters, as reported by the States. The two figures are based on the same data (contained in Appendix C, Tables C-4 and C-5), but each figure provides a different perspective on the extent of impairment attributed to individual pollutants and sources. Figure 4-4 shows the relative impact of the leading pollutants and sources in surveyed estuarine waters. Figure 4-5 presents the relative impact of the leading pollutants and sources in estuaries with identified problems (i.e., impaired estuaries), a subset of surveyed estuarine waters.

The following sections describe the leading pollutants and sources of impairment identified in estuaries. It is important to note that the information about pollutants and sources is incomplete because the States cannot identify the pollutant or source of pollutants impairing every estuarine waterbody. In some cases, a State may recognize that water quality does not fully support a designated use, but the State may not have adequate data to document that a specific pollutant or process is responsible for the impairment. Sources are even more difficult to identify than pollutants and processes.

Pollutants and Processes Impacting Estuaries

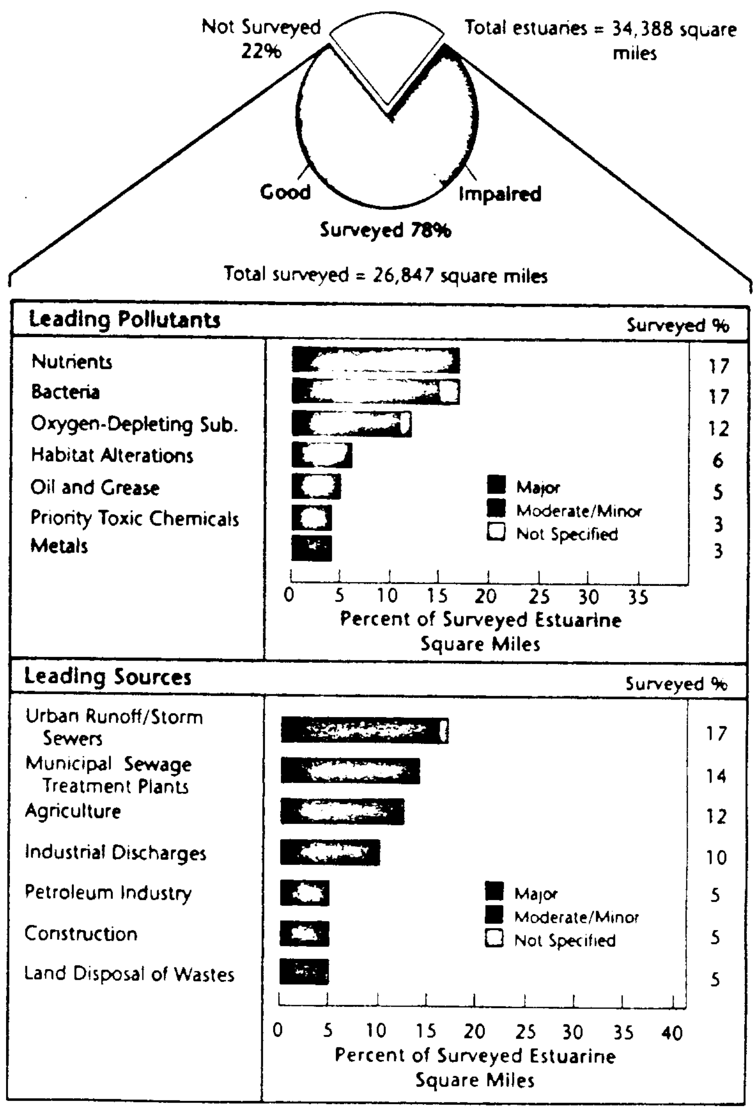
Twenty-five States reported the number of estuarine waters impacted by individual pollutants and processes, such as habitat alterations (see Appendix C, Table C-4, for individual State information). EPA ranks the pollutants and processes by the geographic extent of their impacts on aquatic life and human activities (measured as estuarine square miles impaired by each pollutant or process) rather than actual pollutant loads entering estuaries. This approach targets the pollutants and processes causing the most harm to aquatic life and public use of our waters, rather than the most abundant pollutants in our estuaries.

Often, more than one pollutant or process impacts a single estuarine waterbody. In such cases, the States and other jurisdictions count a single square mile of estuary under each pollutant or process category that impacts the estuary. Therefore, the percentages of estuarine waters impaired by all the pollutant and process categories do not add up to 100%.

The States identified more square miles of estuarine waters polluted by nutrients and bacteria than any other pollutant or process (Figures 4-4 and 4-5). Fifteen States reported that extra nutrients pollute 4,548 square miles of estuarine waters (which equals 17% of the surveyed estuarine waters). As in lakes, extra inputs of nutrients from human activities destabilize estuarine ecosystems. When temperature

Figure 4-4

SURVEYED Estuaries: Pollutants and Sources



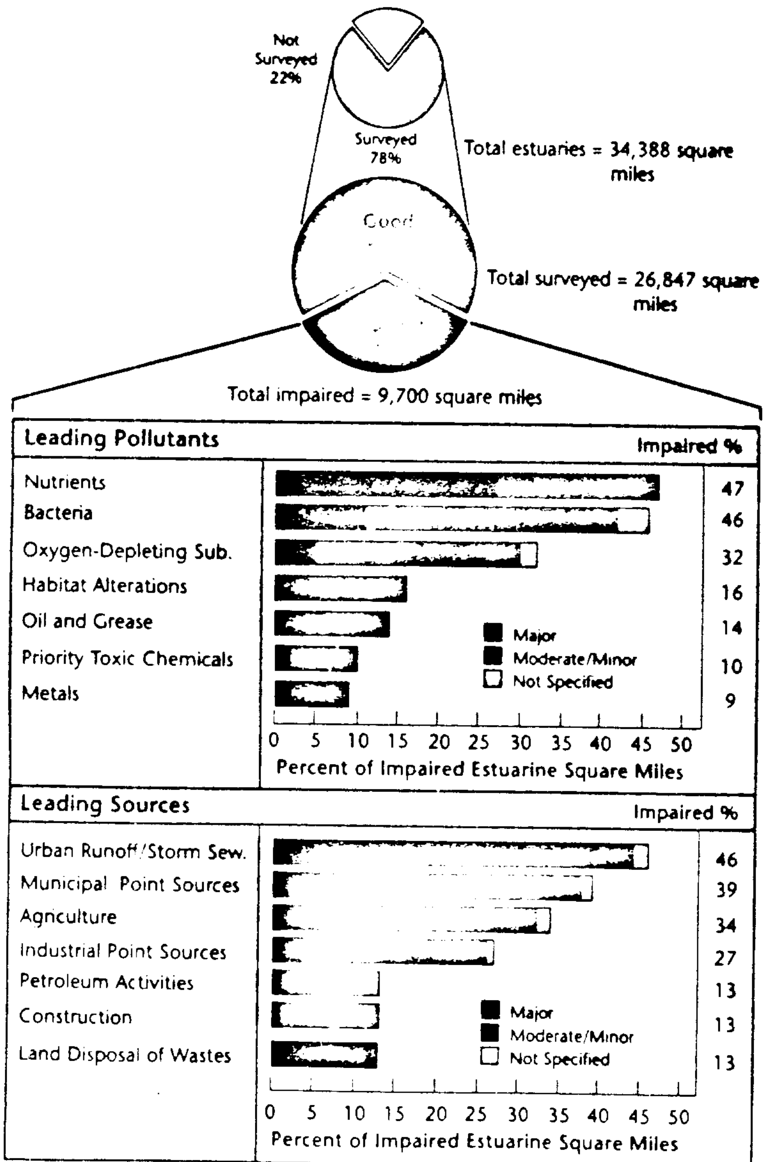
Based on data contained in Appendix C, Tables C-4 and C-5.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair an estuary.

NUTRIENTS AND

Figure 4-5

IMPAIRED Estuaries: Pollutants and Sources



Based on data contained in Appendix C, Tables C-4 and C-5.

URBAN RUNOFF AND STORM SEWERS are the leading source of pollution in surveyed estuaries. According to the States, urban runoff and storm sewers

- affect 17% of all estuaries surveyed (see Figure 4-4), and
- constitute 46% of all water quality problems identified.

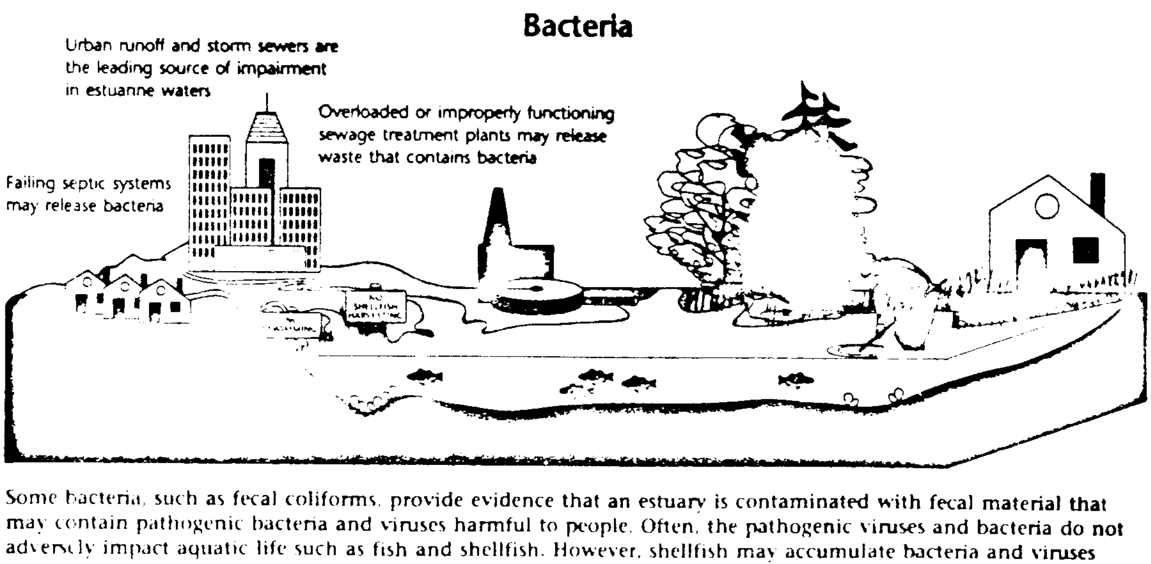
Note: Percentages do not add up to 100% because more than one pollutant or source may impair an estuary.

and light conditions are favorable, excessive nutrients stimulate population explosions of undesirable algae. Decomposition of dead algae depletes oxygen, which may trigger fish kills and foul odors. Explosive growth of algae populations can reduce light penetration and inhibit growth of beneficial aquatic plants. Submerged aquatic plants provide critical habitat for desirable shellfish, such as scallops.

Twenty-five States reported that bacteria pollute 4,479 square miles of estuarine waters (which equals 17% of the surveyed estuarine waters). Most States monitor harmless bacteria, such as *Escherichia coli*, that inhabit the digestive tracts of humans and other warm-blooded animals and populate sewage in high densities. Bacteria provide evidence that an estuary is contaminated with sewage that may contain numerous viruses and bacteria that cause illness in people. Most States monitor the indicator bacteria rather than run multiple tests to detect the numerous harmful viruses and bacteria in sewage.

Pathogenic viruses and bacteria seldom impact aquatic organisms such as fish and shellfish. However, shellfish can accumulate bacteria and viruses from contaminated water and cause illness when ingested. Therefore, the Food and Drug Administration and the States restrict the harvest and sale of shellfish grown in waters polluted with indicator bacteria. Bacteria also interfere with recreational activities because some pathogens can be transmitted by contact with

Figure 4-6



Some bacteria, such as fecal coliforms, provide evidence that an estuary is contaminated with fecal material that may contain pathogenic bacteria and viruses harmful to people. Often, the pathogenic viruses and bacteria do not adversely impact aquatic life such as fish and shellfish. However, shellfish may accumulate bacteria and viruses that cause human diseases when ingested. Therefore, officials restrict shellfish harvesting in contaminated waters to protect public health. Bacteria also impair swimming uses because some pathogenic bacteria and viruses can be transmitted by contact with contaminated water.

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contaminated water or ingestion during swimming (Figure 4-6).

The States also report that oxygen depletion from organic wastes impacts 3,127 square miles (which equals 12% of the surveyed estuarine waters), habitat alterations impact 1,564 square miles (which equals 6% of the surveyed estuarine waters), and oil and grease pollute 1,344 square miles (which equals 5% of the surveyed estuarine waters). Dissolved oxygen depletion is a widespread problem reported by 21 States. In contrast, only one State (Maryland) reported extensive impacts from habitat alterations, and only one State (Louisiana) reported extensive impacts from oil and grease.

Most States rate pollutants and processes as major or moderate/minor contributors to impairment. A major pollutant or process is solely responsible for an impact or predominates over other pollutants and processes. A moderate/minor pollutant or process is one of multiple pollutants and processes that degrade aquatic life or interfere with human use of estuarine waters.

The States report that nutrients have a major impact on more estuarine waters than any other pollutant or process. The individual State 305(b) reports provide more detailed information about the severity of pollution in specific locations.

Sources of Pollutants Impacting Estuaries

Twenty-three States reported sources of pollution related to human activities that impact some of their estuarine waters (see Appendix C, Table C-5, for individual State information). These States reported that urban runoff and storm sewers are the most widespread source of pollution in the Nation's surveyed estuarine waters. Pollutants in urban runoff and storm sewer effluent degrade aquatic life or interfere with public use of 4,508 square miles of estuarine waters (which equals 17% of the surveyed estuarine waters) (Figure 4-4).

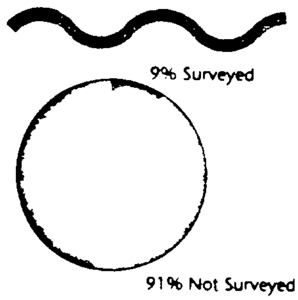
The States also reported that municipal sewage treatment plants pollute 3,827 square miles of estuarine waters (14% of the surveyed estuarine waters), agriculture pollutes 3,321 square miles of estuarine waters (12% of the surveyed estuarine waters), and industrial discharges pollute 2,609 square miles (10% of the surveyed estuarine waters). Urban sources contribute more to the degradation of estuarine waters than does agriculture because urban centers are located adjacent to most major estuaries.

Kings Park Elementary, 3rd Grade, Springfield, VA

Ocean Shoreline Waters Surveyed by States

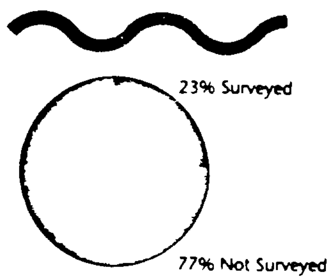
Including Alaska's Ocean Shoreline

1994 ■ 5,208 miles = 9%
■ Total ocean shoreline miles: 58,421[a]



Excluding Alaska's Ocean Shoreline

1994 ■ 5,208 miles = 23% surveyed
■ Total ocean shoreline miles: 22,421[a]



Of the surveyed ocean shoreline miles:

- 30% were monitored
- 36% were evaluated
- 34% were not specified

1992 ■ 3,398 miles = 17% surveyed
■ Total ocean shoreline miles: 20,121[b]

1990 ■ 4,230 miles = 22% surveyed
■ Total ocean shoreline miles: 19,200[c]

[a]Source: 1994 State Section 305(b) reports.
[b]Source: 1992 State Section 305(b) reports.
[c]Source: 1990 State Section 305(b) reports.

Ocean Shoreline Waters

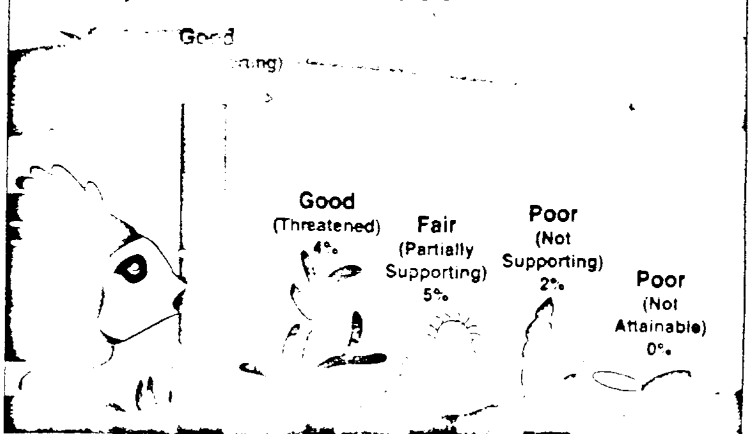
Thirteen of the 27 coastal States and Territories rated general water quality conditions in 5,208 miles of ocean shoreline. The surveyed waters represent 9% of the Nation's coastline (including Alaska's 36,000 miles of coastline), or 23% of the 22,421 miles of national coastline excluding Alaska (see Appendix C, Table C-6, for individual State information). Most of the surveyed waters (4,834 miles, or 93%) have good quality that supports a healthy aquatic community and public activities (Figure 4-7). Of these waters, 225 miles (4% of the surveyed shoreline) are threatened and may deteriorate in the future.

Some form of pollution or habitat degradation impairs the remaining 7% of the surveyed shoreline (374 miles). Five percent of the surveyed estuarine waters have fair water quality that partially supports designated uses. Most of the time, these waters provide adequate habitat for aquatic organisms and support human activities, but periodic pollution interferes with these activities and/or stresses aquatic life. Only 2% of the surveyed shoreline suffers from poor water quality that consistently stresses aquatic life and/or prevents people from using the shoreline for activities such as swimming and shellfishing.

Overall Surveyed Water Quality

Figure 4-7

Overall Use Support
in Surveyed Ocean Shoreline Waters



Based on data contained in Appendix C, Table C-6.

Individual Use Support

EPA requests that the States rate how well their ocean shoreline waters support five standard uses so that EPA can summarize the State data. The standard uses consist of aquatic life support, fish consumption, shellfish harvesting, primary contact recreation (such as swimming and diving), and secondary contact recreation (such as boating) (see Chapter 1 for a description of each individual use). Few States designate saline ocean waters for drinking water supply use and agricultural use because of high treatment costs.

The States provided limited information on individual use support in ocean shoreline waters (Appendix C, Table C-7, contains individual State information). Ten States rated aquatic life support and swimming use in their ocean shoreline waters, but fewer States rated their ocean waters for support of shellfishing, fish consumption, and secondary contact recreation. General conclusions cannot be drawn from information representing such a small fraction of the Nation's ocean shoreline waters (Figure 4-8).

Water Quality Problems Identified in Ocean Shoreline Waters

Only six of the 27 coastal States identified pollutants and sources of pollutants degrading ocean shoreline waters (Appendix C, Tables C-8 and C-9, contain individual State information). General conclusions cannot be drawn from the information supplied by these States because these States border less than 1% of the shoreline along the contiguous States. The six States identified impacts in their ocean shoreline waters from bacteria, metals, nutrients, turbidity, siltation, and pesticides (Figures 4-9 and 4-10). The six States reported that urban runoff and storm sewers, industrial discharges, land disposal of wastes, septic systems, agriculture, unspecified nonpoint sources, and combined sewer overflows (CSOs) pollute their coastal shoreline waters (Figures 4-9 and 4-10).

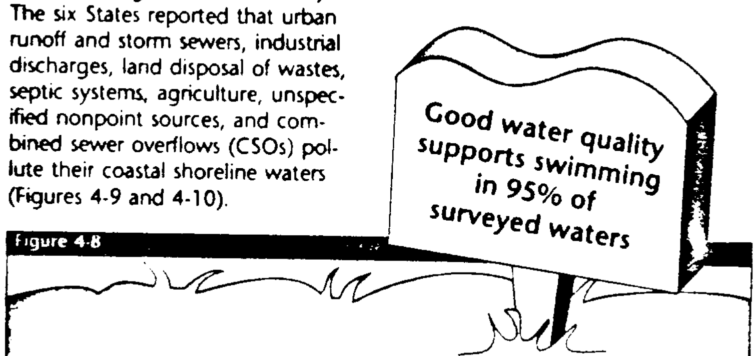


Figure 4-8

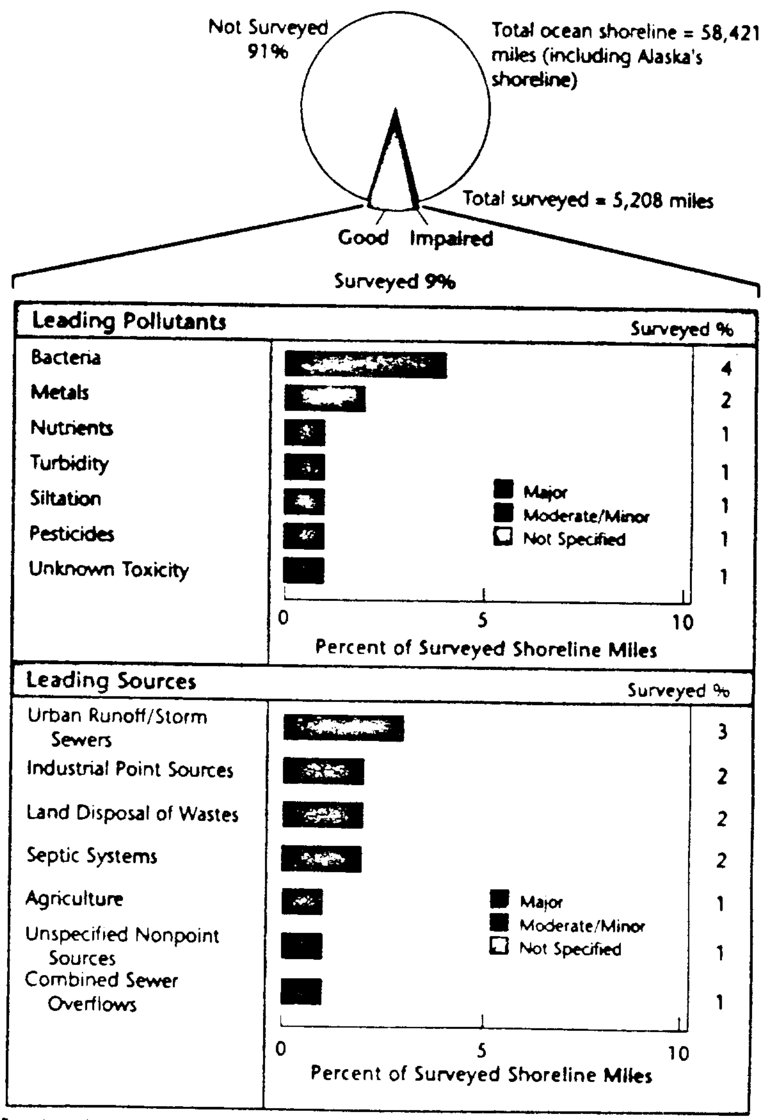
Individual Use Support in Ocean Shoreline Waters

Designated Use	Miles Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Aquatic Life Support	4,125	93	2	4	1	0
Fish Consumption	2,367		0	4	0	0
Shellfishing	2,636		<1	4	1	0
Primary Contact - Swimming	4,114	[illegible]	31	4	1	0
Secondary Contact	2,315		1	<1	1	0

Based on data contained in Appendix C, Table C-7

Figure 4-9

SURVEYED Ocean Shoreline: Pollutants and Sources

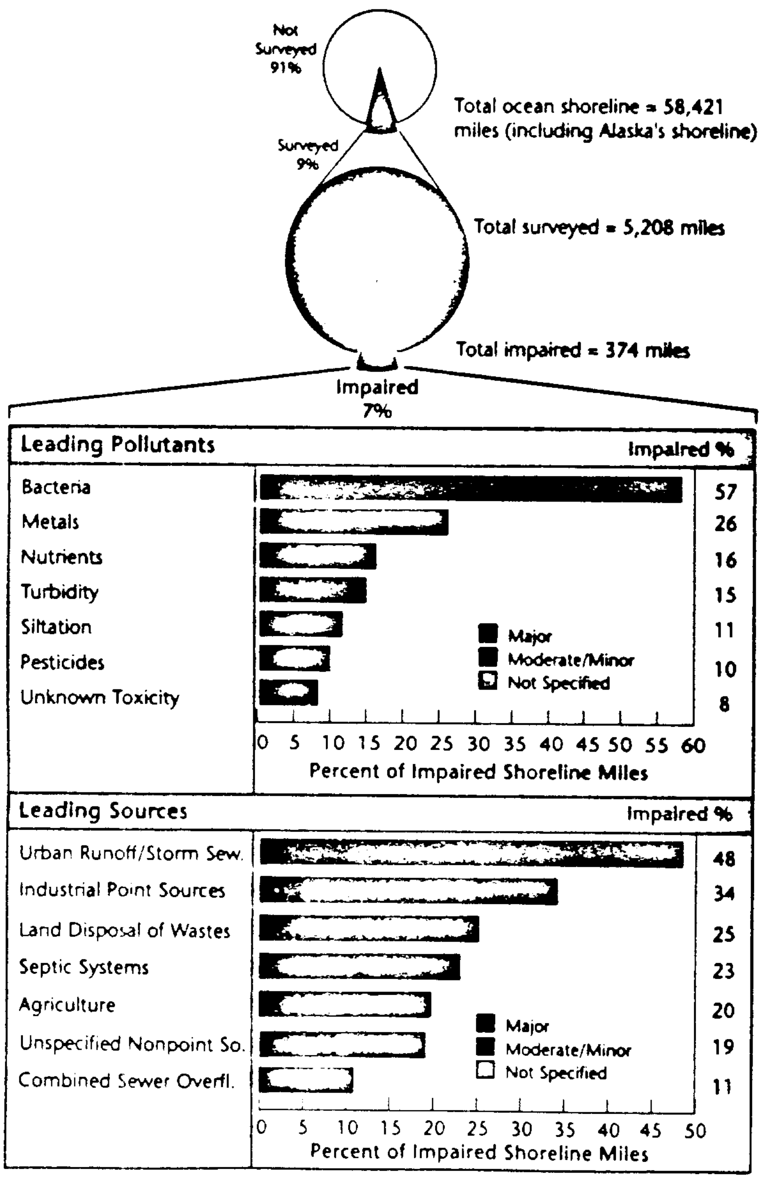


Based on data contained in Appendix C, Tables C-8 and C-9.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a segment of ocean shoreline.

Figure 4-10

IMPAIRED Ocean Shoreline: Pollutants and Sources



Based on data contained in Appendix C, Tables C-8 and C-9.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a segment of ocean shoreline.

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EMAP Estuaries Summary

The Environmental Monitoring and Assessment Program (EMAP) has been developed jointly by EPA, the National Oceanic and Atmospheric Administration (NOAA), and the National Biological Survey (NBS) to provide the public, scientists, and Congress with information to evaluate the general health of the Nation's ecological resources. EMAP works with local, State, regional, and national resource managers to facilitate information transfer and to ensure that key questions are being addressed. Consequently, there is a growing interest in EMAP methods, indicators, data, and results among decision makers at all levels. The concepts used for specific EMAP studies are being investigated at various levels as a potential basis for monitoring and assessment guidance for States.

EMAP conducts annual surveys to assess the presence of pollution and its effect on "ecological health" indicators such as aquatic plants, animals, and the habitats that sustain them. At present, the program is developing the necessary tools to characterize the condition of the Nation's water resources with the goal of implementing long-term monitoring that will provide information on the overall health of the environment and the effectiveness of strategies implemented for pollution prevention and control. EMAP sampling was designed to yield statistically representative estimates of environmental condition.

EMAP Estuaries, 1990-1993

The present focus of EMAP's estuarine component (EMAP-E) is the development of a national monitoring design, and the studies currently being completed will help to provide a framework for that design. In addition, the current studies can be used to estimate the regional health of estuarine waters or resources. Ecological health is being assessed through the investigation of distributions of fish and bottom-dwelling organisms. EMAP is determining what portion of estuaries are healthy enough to sustain or support these plants and animals. In addition, EMAP studies will evaluate why certain areas are not able to maintain populations of these organisms.

Between 1990 and 1993, EMAP-E investigated the ecological condition of two estuarine regions or provinces that combined represent 55% of the Nation's estuarine acreage:

- **Virginian Province:** estuaries of the Middle Atlantic States from Cape Cod, Massachusetts, to Cape Henry, Virginia (sampling began in 1990)

- **Louisianan Province:** estuaries of the Gulf of Mexico from Anclote Anchorage, Florida, to the Rio Grande, Texas (sampling began in 1991).

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Results will include estimates of the resources in these two provinces as well as national estimates based on this 55%.

Each summer since 1990, EMAP-E monitoring teams have collected bottom sediments to determine the number and types of organisms present and to see if these sediments contain harmful pollutants. Fish have been collected, identified, and examined for disease.

In addition, scientists have taken water quality measurements including dissolved oxygen, salinity, and temperature.

In General . . .

The EMAP-Estuary study design is based on a random site selection process so that monitored sites, as a whole, are statistically representative of the Nation's estuarine waters. Thus, information gained from the EMAP study, which assessed roughly 55% of our estuaries, can be used to estimate conditions of our estuarine resources on a national scale.

Based on the 1990-1993 pilot projects, about 74% of the Nation's estuaries are in good condition for supporting a diversity of plants, animals, and human uses. The remaining 23% to 29% have poor benthic (bottom-dwelling) and fish community conditions and unacceptable levels of pollution for human uses such as commercial shellfishing. Sediment contamination, affecting the diversity and abundance of pollution-sensitive benthic organisms, is a leading cause of poor conditions in both the Virginian and Louisianan Provinces.

Approximately 22% to 30% of the Nation's estuarine waters are categorized as degraded for some human use including swimming, boating, fishing, and walking along the shore. The factors contributing to this degradation are (1) water clarity, which affects recreational uses; (2) marine debris, which affects aesthetics and wildlife health; and (3) contaminants in the edible portions of fish and shellfish.

In the Virginian Province, marine debris is the most prevalent source of human-use degradation; water clarity and fish contamination are local rather than regional issues. In the Louisianan Province, marine debris and water clarity are the major contributors to human-use degradation.

Overall, contaminant concentrations in fish and shellfish are low, with the exception of some heavy metals. No fish or shellfish studied contain PCB residues greater than the health criteria set by the Food and Drug Administration (FDA). The overall incidence of fish contamination is low in both regions; however, elevated concentrations of contaminants might be expected in specific localities adjacent to contaminant sources. Periodic surveys will allow scientists to track potential changes in fish tissue residue levels

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and improvements or declines in the health of fish and shellfish.

Fish Diseases

Between 1990 and 1993, over 30,000 fish were examined for disease. Only 154 (<0.6%) had external abnormalities. The EMAP-E data provide the first evidence that the frequency of pathologies in estuarine fish is low. Bottom-dwelling fish (e.g., catfish) have the highest frequency of disease, 4 to 10 times more than other groups. The number of fish with external pathologies increases in areas with multiple contaminants in the sediments, regardless of the area of the country. Data indicate that pathologies are local in nature and appear to be associated with increased contaminant loadings.

Sediment Contamination and Toxicity

Most contaminants entering waterways (such as pesticides, PCBs, and heavy metals) end up in fish and bottom sediments; however, these substances are not always present at levels that are toxic to marine life. EMAP-E took more than 600 sediment samples during the pilot projects and examined them for 125 different contaminants. In general, the data show that about 34% of the Virginian Province and 6% of the Louisianan Province have a concentration of a contaminant above the ERM criterion. The ERM criterion is the level of a contaminant that will result in ecological effects approximately 50% of the time (based on scientific literature studies) and serves as a "red flag." For example, if a contaminant is found to be above the ERM criterion, then marine organisms will be affected about half the time.

There are distinct differences in the types of contaminants found in the two provinces. The Virginian Province is characterized by industrial contaminants and some urban pesticides; the Louisianan Province is characterized by agricultural contaminants. The presence of toxic sediments can have a direct effect on aquatic life. Sediments are actually considered toxic when there is greater than a 15% mortality rate in organisms exposed to the sediments. Through toxicity testing, approximately 19% of the Virginian Province sediments and 9% of the Louisianan Province sediments have been found to be toxic to estuarine organisms.

Water Quality

Dissolved oxygen (DO) is a fundamental requirement for all marine life. A threshold concentration of 4 to 5 ppm (parts per million) is defined by many States as a water quality standard. A concentration of 2 ppm is considered extremely stressful to most organisms. DO levels have natural daily and seasonal fluctuations and are usually higher during daylight hours due to photosynthesis, the production of oxygen by aquatic plants. Low levels occur mostly in bottom waters and have the greatest impact on organisms that live in the sediments such as oysters, crabs, and

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clams. Up to a quarter (9% to 25%) of the bottom water area in the Virginian Province has DO levels of below 5 ppm, whereas 4% to 8% has concentrations of less than 2 ppm. These depletions of oxygen occur primarily in the Chesapeake Bay. Less than 10% (2% to 8%) of the Louisianan Province's bottom waters have concentrations of less than 2 ppm. However, of these, about 50% are locations where daytime concentrations exceed 5 ppm. Approximately 15% to 21% of bottom waters in the Gulf of Mexico have DO levels below 5 ppm.

Marine debris has multiple negative effects, including entanglement and/or ingestion by animals and the economic cost of lost tourism and beach cleanups. EMAP-E estimates that 17% to 23% of the Virginian Province and 12% to 22% of the Louisianan Province have marine debris either floating on the water or lodged in the bottom sediments. This observed amount of debris would correspond to 3.8 million acres out of more than 23.6 million total acres nationally. About 80% of the debris observed is cans, glass, or paper; 15% appears to be plastics.

Clear water, another factor measured by EMAP-E, helps sustain healthy and productive ecosystems and is a trait that the public values. Water clarity was defined as the percentage of light reaching 1 meter depth. Less than 1% of the waters in the Virginian Province have clarity of less than 10% (primarily occurring in the upper portions of large tidal rivers), and 15% to 19% have clarity of less than 25%. In the Louisianan Province, 20% of waters have less than 10% clarity, while about half of the estuarine waters have clarity of less than 25%. The vast majority of waters with this low clarity are west of the Mississippi Delta.

A Program in Transition

In 1994, testing of ecological indicators and sampling design began in the Carolinian and Californian Provinces and was continued for a final year in the Louisianan Province. Also in 1994, EMAP-E began to expand its coverage to include additional coastal ecosystems, specifically coastal wetlands and offshore waters. A study to determine the best set of ecological indicators for coastal wetlands was completed, and monitoring programs were initiated for coastal waters in the Southern California Bight and the Gulf of Mexico through cooperative efforts with the State of California and NOAA.

The final year of province-wide monitoring and assessment was 1995 in the Carolinian Province (second year) and the West Indian Province (first year). For 1996, field sampling is continuing in the mid-Atlantic region (Delaware and Chesapeake Bays and coastal areas), and in regional EMAP programs begun in 1994. EMAP is continuing research on biological indicators of environmental condition and on the statistical elements of a national monitoring design.

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Recent Trends in Coastal Contamination*

Background

The National Oceanic and Atmospheric Administration (NOAA) created the National Status and Trends (NS&T) Program in 1984 to address national concerns over the quality of the coastal marine environment. One of its goals is to assess spatial distributions and temporal trends in chemical contamination. To meet that goal, the NS&T Mussel Watch Project was formed in 1986 to measure concentrations of a broad suite of trace metals and organic chemicals in surface sediments and whole soft-parts of mussels and oysters collected from about 300 coastal and estuarine sites. The mussels and oysters are collected every year, and the resulting time series indicates trends in chemical concentrations. The most important result to date is that contamination is decreasing for chemicals whose use has been banned, such as chlorinated hydrocarbons, or severely curtailed, such as cadmium. For other chemicals there is no evidence, on a national scale, for either an increasing or decreasing trend.

Chemicals and Species Monitored

The 14 elements and groups of organic compounds for which there are data on trends over the period 1986 to 1993 are: arsenic, cadmium, copper, mercury, nickel, lead, selenium, zinc, DDT (parent compound and metabolites), PCBs (18 congeners), PAHs (24 compounds), Chlordane (four compounds), Dieldrin (plus Aldrin), and butyltin (tri-,di-, and mono-butyltin).

Since no single species of mollusk is common to all coasts, it has been necessary to collect seven different ones: the blue mussel *Mytilus edulis* on the East Coast from Maine to Cape May, New Jersey; the American oyster *Crassostrea virginica* from Delaware Bay southward and throughout the Gulf of Mexico; the mussels *M. edulis* and *M. californianus* on the West Coast; the oyster Ostrea *sandvicensis* in Hawaii; the zebra mussel *Dreissena polymorpha* at sites in the Great Lakes; the mangrove oyster *Crassostrea rhizophorae* in Puerto Rico; and the smooth-edged jewel box *Chama sinuos* at the one site in the Florida Keys.

* The information contained in this highlight was extracted from *Recent Trends in Coastal Environmental Quality: Results from the Mussel Watch Project 1986 to 1993*, published by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland, June 1995.

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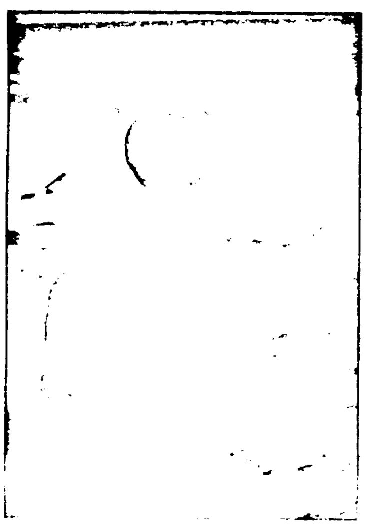
Temporal Trends

A trend is a correlation between concentration and time. There are 154 sites that have been sampled in at least 6 years. The data for those sites have been examined by a simple nonparametric statistical test to see if, with 95% confidence, concentrations are trending in a single direction, up or down.

The most common result is a lack of trends. Among the 2,156 combinations of 14 chemicals at 154 sites, there are only 41 increases and 217 decreases at the 95% level of confidence. On a per-chemical basis the trends are:

Chemical	Number of Increasing Trends	Number of Decreasing Trends
ΣChlordane	0	43
ΣDDT	0	24
ΣDieldrin	0	19
ΣPCB	0	26
ΣPAH	2	3
Σbutyltin	0	11
As	5	14
Cd	3	20
Cu	5	17
Hg	7	8
Ni	4	5
Pb	7	8
Se	2	12
Zn	6	7

Σ = sum



Julie Fountain, Youngsville, NC

Given a 5% probability of random data showing trends, there could be 54 increases and 54 decreases that are not real trends. Conceivably, none of the 41 increases are real. The important point, however, is that decreases greatly outnumber increases. Decreases exceed increases by a factor of three or more for all the chlorinated hydrocarbons, tributyltin, arsenic, cadmium, copper, and

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selenium. At a higher level of aggregation, as in Figure 1, there are decreasing trends in national geometric means for all of these chemicals except selenium.

Decreasing trends are not unexpected. All the monitored chlorinated hydrocarbons have been banned from use in the United States and tributyltin has been banned as a biocide on recreational boats. For cadmium and arsenic there have been decreases in their uses. There has been a 25% decrease in total annual cadmium consumption due to drops in uses for electroplating onto metal surfaces for rustproofing automobile parts, as a stabilizer in plastics, and for use in pigments. Annual consumption of arsenic in the United States has remained fairly steady since 1986, but there has been a decline in its agricultural uses. There has been no parallel decrease in use of copper within the United States. Possibly, its decreasing trend indicates increased success in control of copper emissions from many sources.

Although concentration data themselves do not indicate whether trace element levels in mollusks are affected by human activity, the existence of monotonic trends like those identified here are likely due to activities that are increasing or decreasing an element's concentration in the environment. All sorts of natural factors—either internal, such as mollusk growth or reproduction, or external, such as temperature or rainfall in the period preceding collection—can affect chemical concentrations. Such natural factors can make trends in chemical concentrations difficult to detect. However, it would be difficult to find a natural factor with year-to-year changes that would cause detection of a monotonic trend in chemical concentrations. The trace element trends, therefore, are most likely due to human actions.

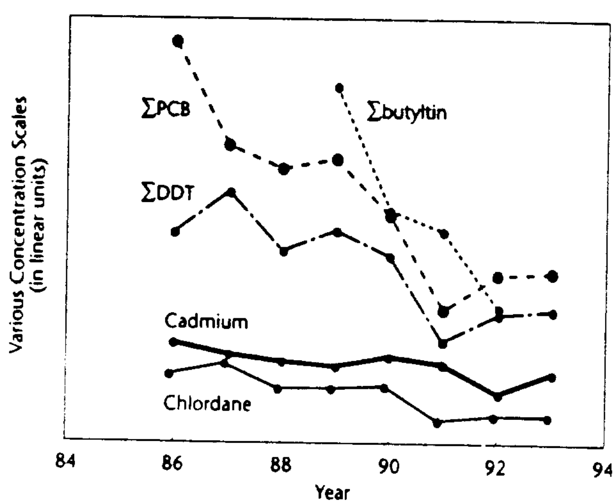

Figure 1. Decreasing National Geometric Mean Concentrations in Mollusks

Data Availability

A computer disk with all the raw data is available, and the raw data can also be obtained on the Internet using the Universal Resource Locator at http:\\www-orca.nos.noaa.gov/projects/nsandt/nsandt.html.

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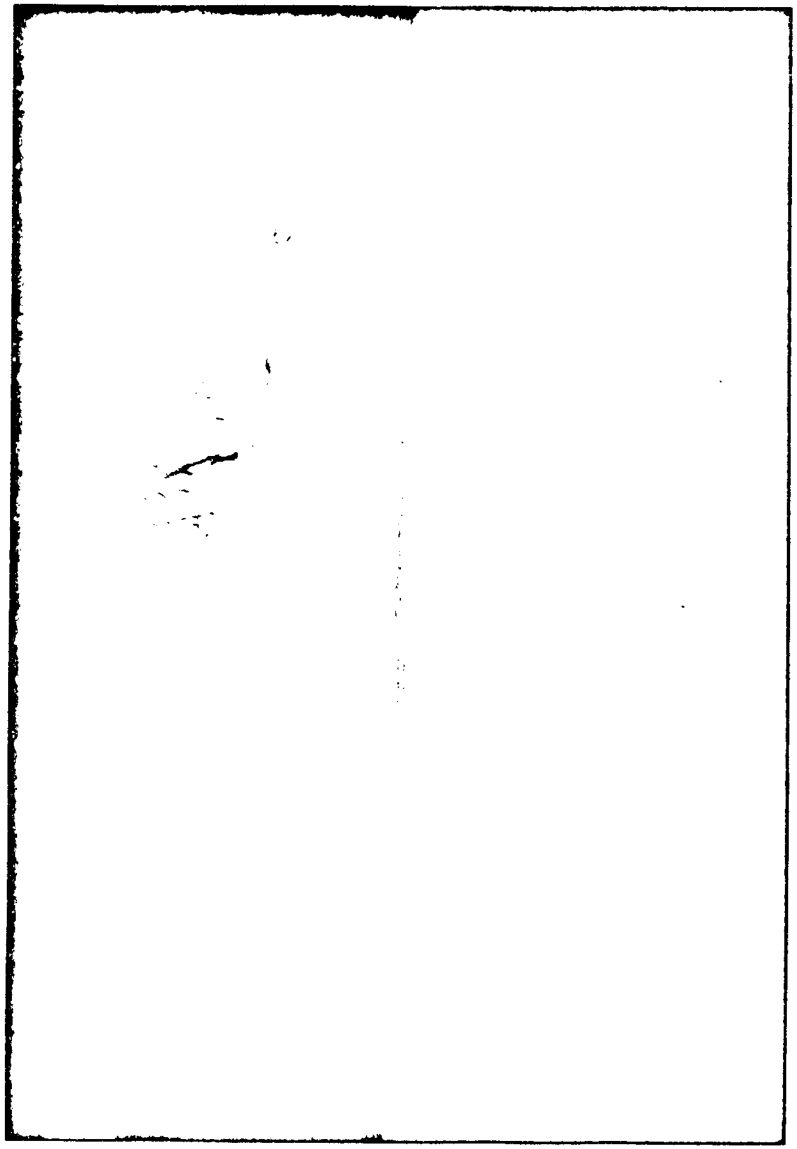
Audrey Moore, U.S. EPA Region 2



Wetlands

Introduction

Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support (and that under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions (Figure 5-1). Wetlands generally include swamps, marshes, bogs, and similar areas. This is the definition of wetlands as it appears in the regulations jointly issued by the Army Corps of Engineers (COE) and the U.S. EPA (33 CFR Part 328.3(b), 40 CFR Part 232.2 (r), and 40 CFR Part 230.3(t)).

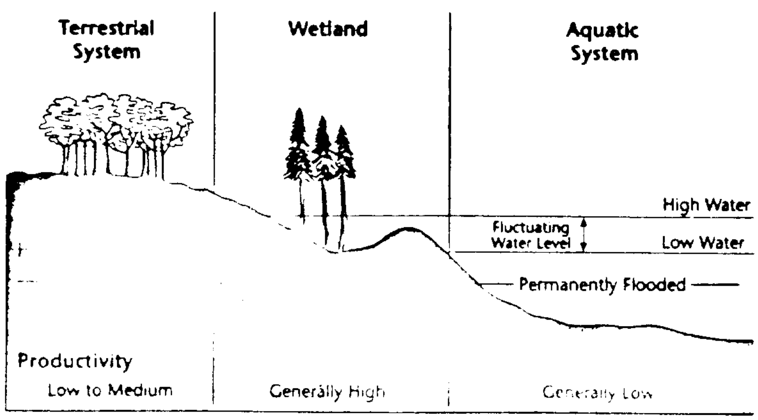
A wide variety of wetlands exist across the country as a result of regional and local differences in hydrology, vegetation, water chemistry, soils, topography, climate, and other factors. Wetlands type is determined primarily by local hydrology, the unique pattern of water flow through an area. In general, there are two broad categories of wetlands: coastal and inland wetlands.

With the exception of the Great Lakes coastal wetlands, coastal wetlands are closely linked to estuaries, where sea water mixes with fresh water to form an environment of varying salinity and fluctuating water levels due to tidal action. Coastal marshes dominated by grasses, sedges, and rushes and halophytic (salt-loving) plants are generally located along the Atlantic and Gulf coasts due to the gradual slope of the land. Mangrove swamps, which are dominated by halophytic shrubs and trees, are common in Hawaii, Puerto Rico, Louisiana, and southern Florida.

Inland wetlands are most common on floodplains along rivers and streams, in isolated depressions surrounded by dry land, and along the margins of lakes and ponds. Inland wetlands include marshes and wet meadows dominated by grasses, sedges, rushes, and herbs; shrub swamps; and wooded swamps dominated by trees, such as

Figure 5-1

Depiction of Wetlands Adjacent to Waterbody



Wetlands are often found at the interface between dry terrestrial ecosystems, such as upland forests and grasslands, and permanently wet aquatic ecosystems, such as lakes, rivers, bays, estuaries, and oceans.

Reprinted with modifications, by permission, from Mitsch/Gosselink: *Wetlands 1986*, fig. 1-4, p. 10. ©1986, Van Nostrand Reinhold.

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hardwood forests along floodplains. Some regional wetlands types include the pocosins of North Carolina, bogs and fens of the northeastern and north central States and Alaska, inland saline and alkaline marshes and riparian wetlands of the arid and semiarid West, vernal pools of California, playa lakes of the Southwest, cypress-gum swamps of the South, wet tundra of Alaska, the South Florida Everglades, and prairie potholes of Minnesota, Iowa, and the Dakotas.

Functions and Values of Wetlands

In their natural condition, wetlands provide many benefits, including food and habitat for fish and wildlife, water quality improvement, flood protection, shoreline erosion control, ground water exchange, as well as natural products for human use and opportunities for recreation, education, and research.

Wetlands are critical to the survival of a wide variety of animals and plants, including numerous rare and endangered species. Wetlands are also primary habitats for many species, such as the wood duck, muskrat, and swamp rose. For others, wetlands provide important seasonal habitats where food, water, and cover are plentiful.

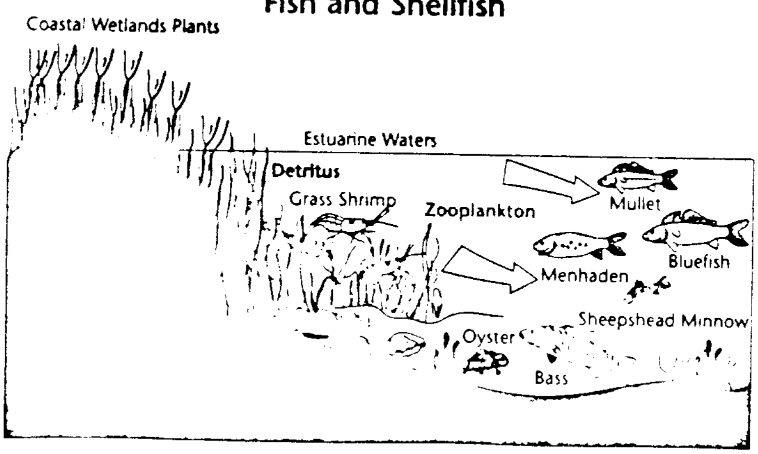
Wetlands are among the most productive natural ecosystems in the world. They produce great volumes of food, such as leaves and stems, that breaks down in the water to form detritus (Figure 5-2). This enriched material is the principal food for many aquatic invertebrates, various shellfish, and forage fish that are food for larger commercial and recreational fish species such as bluefish and striped bass.

Wetlands help maintain and improve water quality by intercepting surface water runoff before it reaches open water, removing or retaining nutrients, processing chemical and organic wastes, and reducing sediment loads to receiving waters (Figure 5-3). As water moves through a wetland, plants slow the water, allowing sediment and pollutants to settle out. Plant roots trap sediment and are then able to metabolize and detoxify pollutants and remove nutrients such as nitrogen and phosphorus.

Wetlands function like natural basins, storing either floodwater that overflows riverbanks or surface water that collects in isolated depressions. By doing so, wetlands help protect adjacent and

Figure 5-2

Coastal Wetlands Produce Detritus that Support Fish and Shellfish



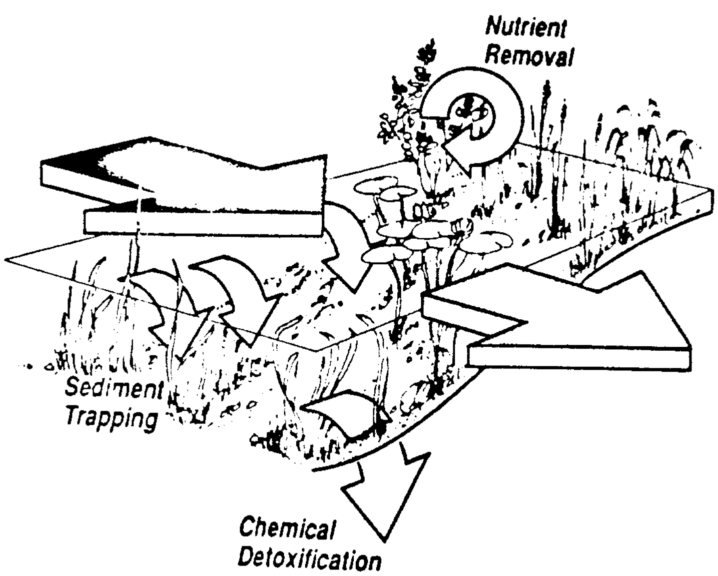
downstream property from flood damage. Trees and other wetlands vegetation help slow the speed of flood waters. This action, combined with water storage, can lower flood heights and reduce the water's erosive potential (Figure 5-4). In agricultural areas, wetlands can help reduce the likelihood of flood damage to crops. Wetlands within and upstream of urban areas are especially valuable for flood protection, since urban development increases the rate and volume of surface water runoff, thereby increasing the risk of flood damage.

Wetlands are often located between rivers and high ground (called uplands) and are therefore able to store flood waters and reduce channel erosion. Wetlands bind soil, dampen wave action, and reduce current velocity through friction. These properties are very valuable for stabilizing shorelines (Figure 5-5).

Wetlands water storage capacity also allows recharge of ground water, which may be used as sources of water for drinking or agricultural uses (Figure 5-6). Elevated ground water tables and water stored in wetlands are also important for maintaining stream base-flows. Water entering wetlands during wet periods is released slowly through ground water or as runoff, moderating stream flow volumes

Figure 5-3

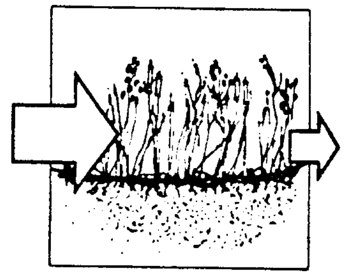
Water Quality Improvement Functions in Wetlands



Source: Washington State Department of Ecology.

Figure 5-4

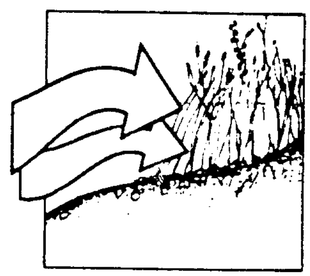
Flood Protection Functions in Wetlands



Source: Washington State Department of Ecology.

Figure 5-5

Shoreline Stabilization Functions in Wetlands



Source: Washington State Department of Ecology.

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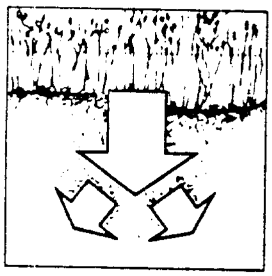
Figure 5-6

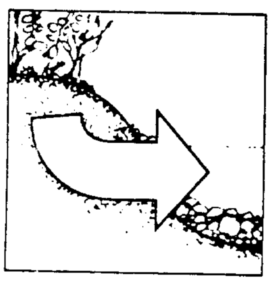
Ground Water Recharge Functions of Wetlands



Source: Washington State Department of Ecology.

Figure 5-7

Streamflow Maintenance Functions in Wetlands



Source: Washington State Department of Ecology.

necessary for the survival of fish, wildlife, and plants that rely on the stream (Figure 5-7).

Wetlands produce a wealth of natural products, including fish and shellfish, timber, wildlife, and wild rice. Much of the Nation's fishing and shellfishing industry harvests wetlands-dependent species. A national survey conducted by the Fish and Wildlife Service in 1991 illustrates the economic value of some of the wetlands-dependent products. Over 9 billion pounds of fish and shellfish landed in the United States in 1991 had a direct, dockside value of $3.3 billion. This served as the basis of a seafood processing and sales industry that generated total expenditures of $26.8 billion. In addition, 35.6 million anglers spent $24 billion on freshwater and saltwater fishing. It is estimated that 71% of commercially valuable fish and shellfish depend directly or indirectly on coastal wetlands.

Consequences of Wetlands Loss and Degradation

The loss or degradation of wetlands can lead to serious consequences, including increased flooding; species decline, deformity, or extinction; and declines in water quality. The following discussion describes several examples of the consequences of wetlands loss and degradation.

Floods continue to seriously damage the property and livelihoods of thousands of Americans despite expenditures of billions of local, State, and Federal dollars spent over the years to reduce flooding. Loss or degradation of wetlands intensifies flooding by eliminating the wetlands' capacity to absorb peak flows and gradually release flood waters.

- In Massachusetts, the U.S. Army Corps of Engineers estimated that over $17 million of annual flood damage would result from the destruction of 8,422 acres of wetlands in the Charles River Basin. For this reason, the COE decided to preserve wetlands rather than construct extensive flood control facilities along a stretch of the Charles River near Boston. Annual benefits of the preservation project average $2.1 million while annual costs average $617,000.

- The Minnesota Department of Natural Resources estimates that it costs the public $300 to replace the water storage capacity lost by development of 1 acre of wetlands that holds 12 inches of water. The cost of replacing 5,000 acres of wetlands would be $1.5 million, which exceeds the State's annual appropriation for flood control.

Another consequence of wetlands loss or degradation is decline, deformity from toxic contamination, or extinction of wildlife and plant species. Forty-five percent of the threatened and endangered species listed by the U.S. Fish and Wildlife Service (FWS) rely directly or indirectly on wetlands for their survival.

- The destruction of wetlands around Merritt Island and St. John's Island in Florida has been identified as a major contributor to the extinction of the Dusky Seaside

Sparrow. The sparrow's habitat was diked and flooded in an attempt to control mosquitos, then drained and burned to promote ranching. The last Dusky Seaside Sparrow died in captivity on June 16, 1987.

■ Over-logging of mature bottomland hardwood forests is believed to have caused the extinction of the Ivory Billed Woodpecker in the United States. The clearing of bottomland hardwood forests has also affected the Louisiana Black Bear, or swamp bear, by destroying the bear's habitat. With its population plummeting from the thousands to several hundred, the FWS recently listed the Louisiana Black Bear as "threatened" under the Endangered Species Act.

■ Populations of Mallard Ducks and Northern Pintail Ducks in North America declined continually between 1955 and the early 1990s. In 1990, the number of Mallard Ducks in the prairies of the United States declined 60% from the number counted in 1989 to the lowest population figures on record, although recent data indicate that waterfowl populations are rebounding. The well-being of waterfowl populations is directly tied to the status and abundance of wetlands. As waterfowl populations are squeezed into the remaining wetlands, confined conditions favor outbreaks of avian cholera and other contagious diseases in waterfowl.

Wetlands loss and degradation also reduce water quality purification functions performed by wetlands.

■ The Congaree Bottomland Hardwood Swamp in South Carolina provides valuable water quality services, such as removing and stabilizing sediment, nutrients, and toxic contaminants. The total cost of constructing, operating, and maintaining a tertiary treatment plant to perform the same functions would be $5 million.

■ Forested riparian wetlands play an important role in reducing nutrient loads entering the Chesapeake Bay. In one study, a riparian forest in a predominantly agricultural watershed removed about 80% of the phosphorus and 89% of the nitrogen from the runoff water before it entered a tributary to the Bay. Destruction of such areas adversely affects the water quality of the Bay by increasing undesirable weed growth and algae blooms.

■ A study of two similar sites on the Hackensack River in New Jersey demonstrated the increase in erosion that results from the destruction of marshlands. In the study, marsh vegetation was cut at one site and left undisturbed at the other site. The bank at the cut site eroded nearly 2 meters (more than 6 feet) in 1 year while the uncut site exhibited negligible bank erosion.

These examples illustrate the integral role of wetlands in our ecosystems and how wetlands destruction and degradation can have expensive and permanent consequences. By preserving wetlands and their functions, wetlands will continue to provide many benefits to people and the environment.

STATES REPORT that residential development and urban growth are the leading sources of recent wetlands loss.

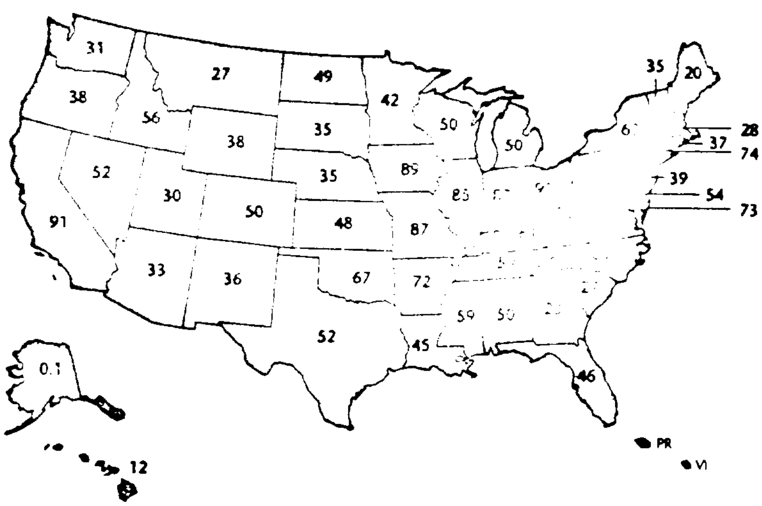
Extent of the Resource

Wetlands Loss in the United States

It is estimated that over 200 million acres of wetlands existed in the lower 48 States at the time of European settlement. Since then, extensive wetlands acreage has been lost, with many of the original wetlands drained and converted to farmland and urban development.

Figure 5-8

Percentage of Wetlands Acreage Lost, 1780s-1980s



Twenty-two States have lost at least 50% of their original wetlands. Seven of these 22 (California, Indiana, Illinois, Iowa, Missouri, Kentucky, and Ohio) have lost more than 80% of their original wetlands.

Source: Dahl, T.E., 1990, *Wetlands Losses in the United States 1780's to 1980's*, U.S. Department of the Interior, Fish and Wildlife Service.

Today, less than half of our original wetlands remain. The losses amount to an area equal to the size of California (see Figure 5-8). According to the U.S. Fish and Wildlife Service's *Wetlands Losses in the United States 1780's to 1980's*, the three States that have sustained the greatest percentage of wetlands loss are California (91%), Ohio (90%), and Iowa (89%).

According to FWS status and trends reports, the average annual loss of wetlands has decreased over the past 40 years. The average annual loss from the mid-1950s to the mid-1970s was 458,000 acres, and from the mid-1970s to mid-1980s it was 290,000 acres. Agriculture was responsible for 87% of the loss from the mid-1950s to the mid-1970s and 54% of the loss from the mid-1970s to the mid-1980s.

A more recent estimate of wetlands losses from the National Resources Inventory (NRI), conducted by the Natural Resources Conservation Service (NRCS), indicates that 792,000 acres of wetlands were lost on non-Federal lands between 1982 and 1992 for a yearly loss estimate of 70,000 to 90,000 acres. This net loss is the result of gross losses of 1,561,300 acres of wetlands and gross gains of 768,700 acres of wetlands over the 10-year period. The NRI estimates are consistent with the trend of declining wetlands losses reported by FWS. Although losses have decreased, we still have to make progress toward our interim goal of no overall net loss of the Nation's remaining wetlands and the long-term goal of increasing the quantity and quality of the Nation's wetlands resource base.

The decline in wetlands losses are a result of the combined effect of several trends: (1) the decline in profitability in converting wetlands for agricultural production; (2) passage of Swampbuster in the 1985 and 1990 Farm Bills; (3) presence of the CWA Section 404 permit programs as well as development of State management programs (see Chapter 17); (4) greater public interest and support for wetlands protection; and (5) implementation of wetlands restoration programs at the Federal, State, and local level.

Nineteen States listed sources of recent wetlands loss in their 1994 305(b) reports (Figure 5-9). Residential development and urban growth were cited as the leading sources of current losses (see Appendix D, Table D-1, for individual State information). Other losses were due to commercial development; construction of roads, highways, and bridges; agriculture; and industrial development.

Several States and the District of Columbia reported on efforts to inventory wetlands. Some of the programs are designed to augment the FWS's National Wetlands Inventory (NWI), while others are designed to produce independent status and trend information. Some of the programs have already been completed and others have been authorized but not funded.

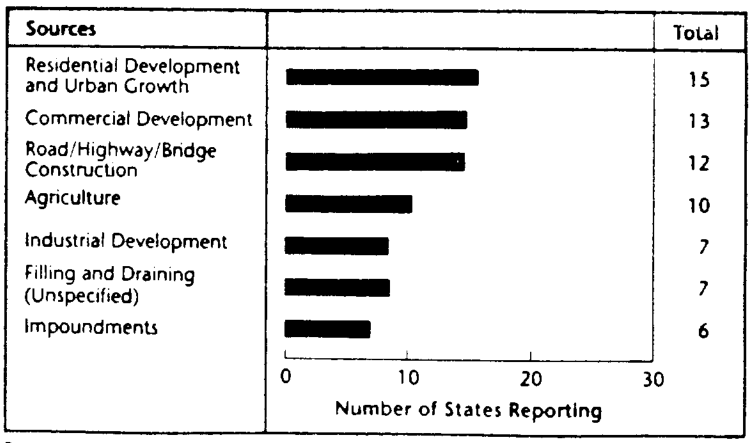
- In 1994, the District of Columbia adopted a new estimate of total wetlands acreage generated by applying the Planogrid method to aerial NWI maps. The finer detail and resolution of the new methodology almost doubled previous estimates of wetlands acreage.

- New Hampshire recently completed a wetlands mapping project that translated LANDSAT digital imagery into a geographic information system (GIS) format. The project included extensive field verification. The GIS mapping system revealed many small wetlands that were overlooked by previous surveys. As a result, New Hampshire's estimate of total wetlands acreage climbed from 200,000 acres to almost 400,000 acres.

- In 1993, the North Carolina Division of Environmental Management (DEM) used hydric soils as a baseline to inventory wetlands in the Coastal Plain, rather than NWI maps used in previous inventories. DEM randomly selected 27 sample sites of 9,900 acres each, mapped published soils data for each site, and calculated the total area of hydric soils in each site with a video software analysis package.

Figure 5-9

Sources of Recent Wetlands Losses
(19 States Reporting)



Based on data contained in Appendix D, Table D-4.

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■ The Ohio Department of Natural Resources (DNR) is conducting a statewide inventory of wetlands as part of its Remote Sensing Program with cooperation from numerous agencies. The program utilizes digital data from the LANDSAT Thematic Mapper, digitized soils data, low-level aerial photographs, and USGS topographic maps to identify and map different types of wetlands, including farmed wetlands. DNR plans to update the maps every 5 years.

Monitoring Wetlands Functions and Values

Wetlands monitoring data are critical to the achievement of important national goals, such as no overall net loss of wetlands functions and values. With States and Tribes developing water quality standards for their wetlands, State and Tribal monitoring programs are critical for determining if wetlands are meeting their designated and existing uses. Monitoring data are also needed to prioritize wetlands for restoration and protection and to define successful mitigation.

Monitoring programs can provide the data needed to identify degradation of functions and values in wetlands and sources of that degradation, but specific wetlands monitoring programs are still in their infancy. Currently, no State is operating a statewide wetlands monitoring program.

However, several States include a few wetlands in their ambient monitoring programs, and a growing number of States are implementing monitoring projects at selected reference wetlands that are relatively free from impacts. The States will use the data collected at these reference wetlands to define baseline conditions in healthy wetlands and standards to protect wetlands.

■ Every 3 years, Kansas collects water quality samples from seven wetlands (covering 25,069 acres) owned by the State or the Federal government. The State monitors one station per wetland for nutrients, minerals, heavy metals, clarity, suspended solids, pesticides, bacteria, algae, temperature, and dissolved oxygen.

■ Kentucky added several wetlands to its reference reach monitoring program to characterize chemical water quality, sediment quality, fish tissue concentrations of contaminants, habitat conditions, and general biotic conditions in each physiographic region of the State. The information will be used to develop designated uses and biological criteria for wetlands.

■ Minnesota initiated the Reference Wetlands Project to develop a basis for assessing the biological and chemical health of wetlands. The project is characterizing invertebrate communities, vegetation, amphibians, land cover, and water and sediment chemistry at 32 relatively undisturbed wetlands and three impacted wetlands. The information will provide the basis for determining use support status and evaluating wetlands health and will help the State determine if restored wetlands can achieve a condition comparable to natural wetlands.

■ New Hampshire plans to monitor a variety of parameters at five wetlands throughout the State during 1994-1995 to provide baseline data for developing specific wetlands water quality standards.

Designated Use Support in Wetlands

The States,Tribes, and other jurisdictions are making progress in developing specific designated uses and water quality standards for wetlands, but many States and Tribes still lack specific water quality criteria and monitoring programs for wetlands. Without criteria and monitoring data, most States and Tribes cannot evaluate use support. To date, only nine States and Tribes reported the designated use support status for some of their wetlands (see Appendix D, Table D-1). Only Kansas used quantitative data as a basis for the use support decisions.

■ California reported that 12% of the 121,900 acres of surveyed wetlands fully supports aquatic life use and 88% partially supports aquatic life use due to metals, nutrients, oxygen depletion, and salinity. Sources impacting wetlands include municipal wastewater treatment plants, urban runoff and storm sewers, and hydrologic and habitat modifications.

■ The Coyote Valley Band of Pomo Indians in northern California classified all 1.6 acres of their wetlands as partially supporting uses for wildlife and use as a riparian buffer. The use support analysis was based on reconnaissance surveys rather than monitoring in the wetland. The wetland is impaired by exotic species, filling and draining, and other habitat alterations.

■ The Hoopa Valley Tribe in northern California reported that all of its 3,200 acres of wetlands partially support aquatic life use, religious use, wildlife habitat use, and use as a riparian buffer. Filling and draining, flow alterations, other habitat alterations, and exotic species impair the wetlands. Agriculture, forestry, construction, hydrologic modifications, and unknown sources have degraded wetlands on the Hoopa Valley Reservation.

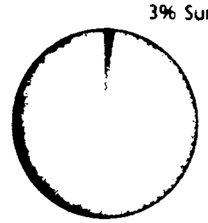
■ Iowa used best professional judgment to determine the designated use support status of 83 publicly owned wetlands covering 26,082 acres (about 69% of the State's total wetlands). Iowa reported that 3% of the surveyed wetlands acreage fully supports aquatic life use, 31% fully supports aquatic life use now but is threatened, 52% partially supports aquatic life use, and 14% does not support aquatic life use. Siltation, nutrients, habitat alteration, and pesticides have significant impacts on Iowa's wetlands. The leading sources of degradation are agricultural runoff and dewatering activities.

■ Kansas used monitoring data to determine use support in nine publicly owned wetlands (covering 25,069 acres) and qualitative information to assess one wetland (covering 70 acres). The State did not survey the remaining 25 publicly owned wetlands covering 10,388 acres. Kansas reported that 20% of

Wetlands Acres Surveyed by States and Tribes

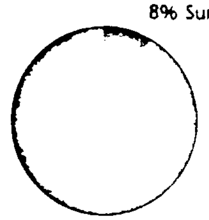
Including Alaska's wetlands

■ 8,822,472 acres = 3% surveyed
Total acres (including Alaska) = 277 million*



Excluding Alaska's wetlands

■ 8,822,472 acres = 8% surveyed
Total acres (excluding Alaska) = 107 million

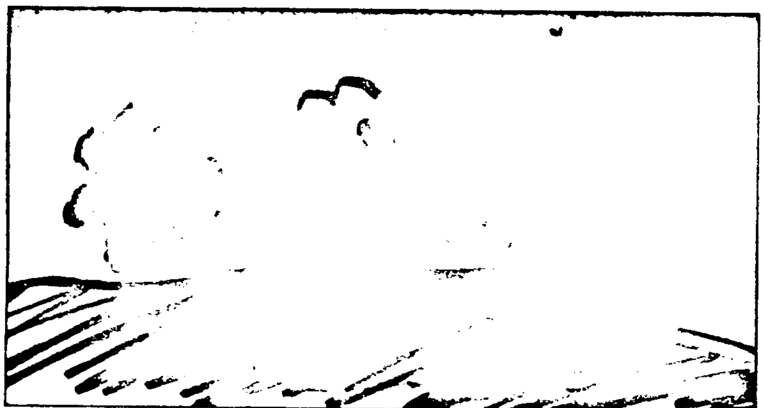


*From Dahl, T.E. 1990. *Wetlands Losses in the United States 1780's to 1980's.* U.S. Department of the Interior, Fish and Wildlife Service.

Source: 1994 Section 305(b) reports submitted by States, Tribes, Territories, and Commissions.

the surveyed wetlands acreage fully supports uses now but is threatened, 55% partially supports uses, and 25% does not support uses such as noncontact recreation and aquatic life support.

■ Louisiana assessed use support in almost 1 million acres of its 8.7 million total acres of wetlands. The State reported that 91% of the assessed wetland acres fully supports uses and 9% partially supports uses due to bacteria, siltation and suspended solids, and hydrologic modifications. Sources of impairment include channelization, dredging, flow regulation, drainage and filling, recreational activities, upstream sources, and natural sources.



Kings Park Elementary, 3rd Grade, Springfield, VA

■ Nevada surveyed use support in 36,169 acres (25%) of its 136,650 total acres of wetlands. Nevada reported that 28% of the surveyed wetlands partially supports uses, 67% does not support uses, and 6% cannot attain designated uses. The State reported that 100 acres are impaired by ammonia, pH, and organic enrichment and low dissolved oxygen concentrations.

■ North Carolina used aerial photographs and soil information to rate use support by current land use. North Carolina rated wetlands on hydric soils with natural tree cover as fully supporting uses. Partially supporting wetlands have modified cover and hydrology but still retain wetlands status and support most uses. For example, pine plantations still retain value for wildlife habitat, flood control, ground water recharge, nutrient removal, and aquatic habitat, although the modified wetlands support these uses less effectively than undisturbed wetlands. Wetlands converted to agriculture or urban land use are classified as not supporting original wetlands uses.

North Carolina used this methodology to survey use support in over 7 million acres of wetlands. The State reported that 66% of the surveyed wetlands fully supports uses, 13% partially supports uses, and 22% does not support uses.

- Oklahoma assessed one wetland covering 120 acres. The State classified all 120 acres of the wetland as threatened.

EPA cannot draw national conclusions about water quality conditions in all wetlands because the States used different methodologies to survey only 3% of the total wetlands in the Nation.

Summarizing State wetlands data would also produce misleading results because two States (North Carolina and Louisiana) contain 91% of the surveyed wetlands acreage.

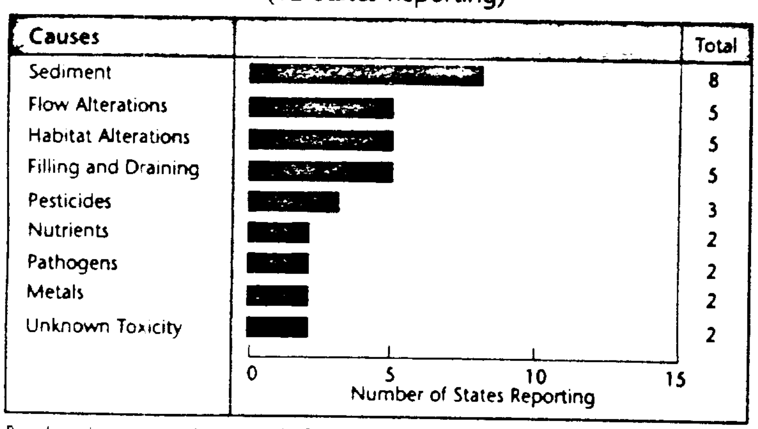
More States and Tribes will assess use support in wetlands as they develop standards for wetlands. Many States are still in the process of developing wetlands water quality standards, which provide the baseline for determining beneficial use support (see Chapter 13). Improved standards will also provide a firmer foundation for assessing impairments in wetlands in those States already reporting use support in wetlands.

More information on wetlands can be obtained from EPA's Wetlands Hotline at 1-800-832-7828, between 9 a.m. and 5 p.m. Eastern Standard Time.

Figure 5-10

Causes Degrading Wetlands Integrity

(12 States Reporting)



Based on data contained in Appendix D, Table D-2.

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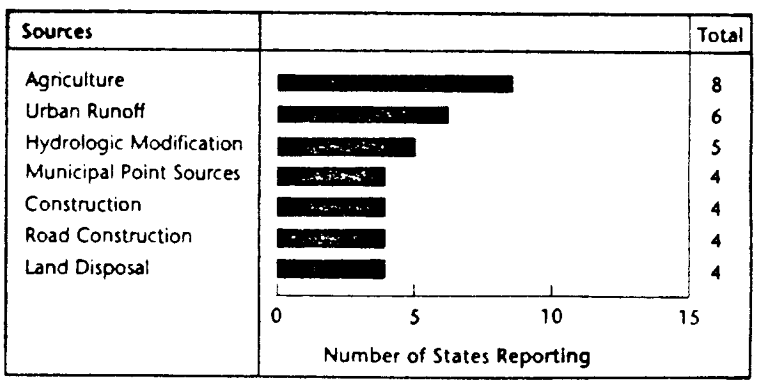
The States have even fewer data to quantify the extent of pollutants degrading wetlands and the sources of these pollutants. Although most States cannot quantify wetlands area impacted by individual causes and sources of degradation, 12 States identified causes and 13 States identified sources known to degrade wetlands integrity to some extent (Figures 5-10 and 5-11). These States listed sediment as the most widespread cause of degradation impacting wetlands, followed by flow alterations, habitat modifications, and draining. Agriculture topped the list of sources degrading wetlands, followed by urban runoff, hydrologic modification, and natural sources (see Appendix D, Tables D-3 and D-4, for individual State information).

Summary

Currently, most States are not equipped to report on the integrity of their wetlands. Only nine States and Tribes reported attainment of designated uses for wetlands in 1994. National trends cannot be drawn from this limited information. This is expected to change, however, as States adopt wetlands water quality standards and enhance their existing monitoring programs to more accurately assess designated use support in their wetlands.

Figure 5-11

Sources Degrading Wetlands Integrity
(13 States Reporting)



Based on data contained in Appendix D, Table D-3.

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Jeff Reynolds, Raleigh, NC

Ground Water Quality

Ground water is a vital national resource that is used for a myriad of purposes. It is used for public and domestic water supply systems, for irrigation and livestock watering, and for industrial, commercial, mining, and thermoelectric power production purposes. In many parts of the Nation, ground water serves as the only reliable source of drinking and irrigation water. Unfortunately, this vital resource is vulnerable to contamination, and ground water contaminant problems are being reported throughout the country. In their 1994 305(b) reports, States, Tribes, and Territories identified contaminant sources and the associated contaminants that threaten the integrity of their ground water resources. Controlling these sources of contamination and preventing further contamination of the resource have become the focus of numerous local, State, and Federal programs.

This chapter contains information provided by 48 States, 2 Territories, and 5 Tribes in their 1994 305(b) reports. The 1994 305(b) reports are based on guidelines, developed by EPA, requesting that each reporting agency characterize the quality of its ground water resources. Because few States and Tribes possess the capability to characterize ground water quality using ambient monitoring data, EPA asked them to provide available information on specific contaminant sources and associated contaminants degrading ground water quality. And, for the first time, EPA asked States and Tribes to provide information on selected parameters that will be used in the future to provide an indication of spatial and temporal trends in ground water quality.

This chapter presents an overview of ground water use in the United States as well as a discussion detailing State-identified sources of contamination and contaminants that are adversely impacting our Nation's ground water quality. State progress in the development of ambient ground water monitoring networks is highlighted. The progress made in developing ground water indicators is also described.

GROUND WATER is a source of drinking water for 51% of the population.

Ground Water Use in the United States

In 1990, ground water supplied 51% of the Nation's population with drinking water—the highest-priority use of water. Overall, ground water supplied approximately 20% (80.6 billion gallons per day [bgd] out of a total 408.4 bgd) of all water uses in the United States. These water uses include public and domestic water supply, irrigation, livestock watering, mining, and commercial, industrial, and thermoelectric cooling applications. Figure 6-1 illustrates the distribution of ground water use among these categories. As shown, irrigation

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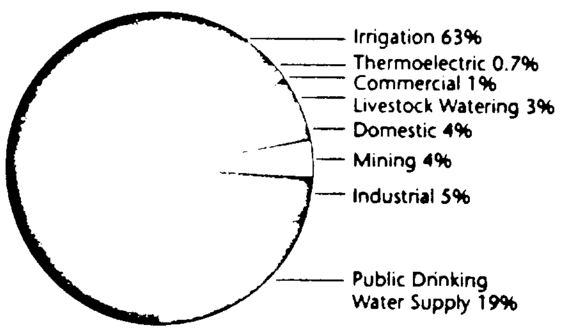
Figure 6-1

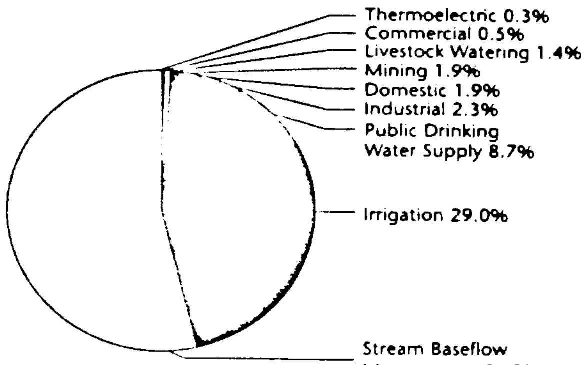
National Ground Water Use as a Percentage of Total Withdrawals



Source: Open-File Report 92-63, U.S. Geological Survey.

Figure 6-2

Withdrawal and Discharge of Ground Water as a Percentage of Contribution



Source: Open-File Report 92-63, U.S. Geological Survey, and *National Water Summary 1986, Hydrologic Events and Ground-Water Quality*, U.S. Geological Survey, Water-Supply Paper 2325.

(63%) and public water supply (19%) are the largest uses of ground water withdrawals.

One of the largest and most important contributions of ground water is not presented in Figure 6-1. The volume of ground water that is naturally discharged to streams and other surface waterbodies, thereby maintaining streamflow during periods of low flow or drought conditions, was previously unrecognized and unquantified. This volume, 492 bgd, is measured using special instruments or estimated using stream gaging and hydraulic gradient data. The importance of ground water flow into streams and other surface waters cannot be underestimated. Ground water can transport contaminants to streams and affect surface water quality and quantity, which may impact drinking water supplies drawn from surface waters, fish and wildlife habitats, swimming, boating, fishing, and commercial navigation. Modifications to the quantity or quality of ground water discharged into surface water ecosystems can also have major economic repercussions as a result of adverse impacts on recreation, public health, fisheries, tourism, and general ecosystem integrity.

The importance of ground water to stream baseflow maintenance is illustrated in Figure 6-2, which shows all of the major uses of ground water in relation to stream baseflow maintenance. Stream baseflow maintenance accounts for 54% of ground water discharges. The next highest use of ground water is irrigation, which accounts for 29% of national ground water use. Figure 6-3 shows that ground water use for drinking water supply, agricultural supply, industrial/

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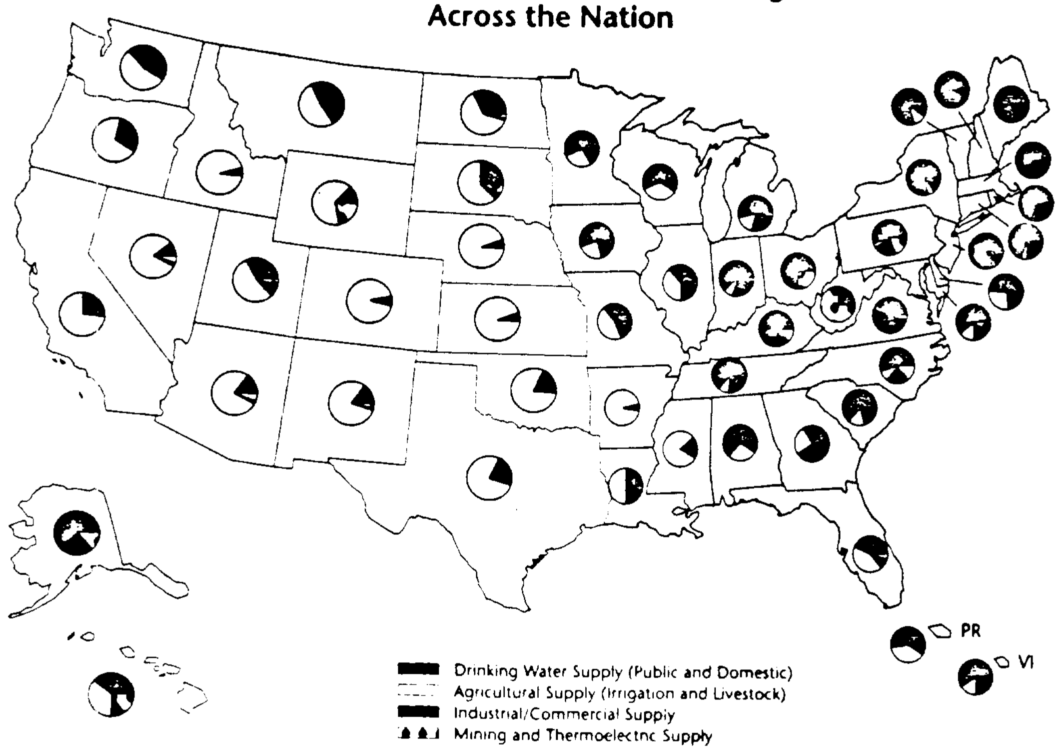
commercial supply, and mining and thermoelectric supplies varies in different regions of the country. For example, ground water is more heavily used for drinking water and industrial/commercial supplies in eastern States and for drinking water and agricultural supplies in western States.

Despite the variation in usage across the Nation, ground water used for drinking water supply is one of the most critical uses. Data reported by the U.S. Geological Survey were used to estimate ground water statistics related to public water supply (PWS) and private wells on a State-by-State basis. Specifically, the data were used to determine whether there was an increase or a decrease in the volume of ground water used for PWS from 1970 to 1990; the percent change in volume during the same period; the ratio of the change in ground water use from 1980 to 1990 to the change in surface water use during the same period for PWS; the percent of population dependent upon ground water for drinking water the

Figure 6-3

Distribution of Ground Water Usage Across the Nation



Source: Open-File Report 92-63, U.S. Geological Survey.

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Vulnerability

Virtually all aquifers have some inherent susceptibility to contamination. To determine the susceptibility of aquifers to contamination from shallow (Class V) injection wells, EPA performed a nationwide assessment.* The purpose of the assessment was to determine ground water vulnerability and aquifer sensitivity for each of the 48 conterminous States.

Ground water vulnerability is dependent upon the geology of the physical system. However, population density and distribution are also important as the greatest number of shallow injection wells occur in areas of high population density. Aquifer sensitivity is related to the potential for contamination to occur. Aquifers that have a high degree of vulnerability and occur in areas of high population density are considered to be the most sensitive. The assessment determined that 44% of the shallow unconfined aquifers in the continental United States are highly susceptible to contamination, and that 60% have some degree of susceptibility.

Estimates of inherent susceptibility can be obtained through a variety of assessment methods that consider different characteristics of the aquifer and/or overlying materials. The assessment method selected depends on the goal of the assessment. Because the goal of, and method for, each assessment may be different, multiple assessments may yield different results. Such a seeming discrepancy in results does not detract from the benefits of susceptibility assessments for ground water management purposes, because results are goal-specific.

Several States have performed their own statewide aquifer susceptibility assessments to address a high-priority management concern. For example, Georgia performed a "DRASTIC" assessment of susceptibility and determined that approximately 65% of the State was either moderately or highly susceptible to surface-applied sources of contamination. These results are similar to those obtained by Pettyjohn et al. (1991)* in which it was estimated

* Pettyjohn, W.A., M. Savoca, and Dale Self, 1991, *Regional Assessment of Aquifer Vulnerability and Sensitivity in the Conterminous United States*, Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma, 319 pages.

HIGHLIGHTS

that 62% of Georgia is susceptible to shallow subsurface sources of contamination.

Although high-priority concerns differ among States, the results of the nationwide assessment show that a significant part of the Nation is highly susceptible to at least some type of contamination. That such a significant portion of the Nation's ground water is susceptible attests to the need for contaminant prevention.

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Examples of Surface Water Contaminated by Contaminated Ground Water

EPA's Chesapeake Bay Office estimates that 30% to 40% of the nitrates entering the Bay, the major pollutant in the Bay, comes from ground water discharge. Agriculture is the primary source of these nitrates because farming is common in the huge watershed draining into the Bay. Along with nitrates, pesticides also enter the Bay. Pesticides are used to control pests on land and may be destroying beneficial organisms in ground water as well. Thus, the benefit that these organisms provide in cleaning ground water before it enters the Bay is lost. To further exacerbate the problem, the forests that surround the shoreline continue to be cleared as development spreads. Research shows that trees are effective in removing nitrates and other pollutants from ground water before it discharges to surface water, and thus another water cleaning mechanism is lost. In addition, the development that removes the trees adds yet more pollutant load to the watershed. This general model, with minor variations, is common throughout the country.

EPA recently published *A Review of Methods for Assessing Nonpoint Source Contaminated Ground Water Discharge to Surface Water,** which identified seven methods commonly used to estimate the quantity of ground water discharging to surface water. Although these methods are well established, published research that describes loadings from ground water for specific locations is not abundant. Nevertheless, a review of the scientific literature identified more than 100 studies nationwide in which contaminated ground water was discharged into and contaminated surface water. For example,

- In the Missouri Valley watershed, ground water accounts for 84% to 95% of the nitrate loading to surface water.

- On the St. John's River, Florida, about 20% of chloride loading comes from ground water seeping into canals that drain into the river.

- At the Mahantango Creek watershed in Pennsylvania, a link was observed between the intensity of corn production and concentrations of atrazine in ground water. As corn production and the use of atrazine increased, higher concentrations of atrazine were observed in more wells. Specifically, atrazine was

*U.S. EPA, 1991, Office of Water, EPA 570/9-91-010.

detected at concentrations less than EPA standards in 74% of all sampled wells.

- In Rehoboth Bay, Indian River Bay, and Little Assawoman Bay, Delaware, over 75% of nitrogen loading comes from ground water discharge.
- In Key Largo Marine Sanctuary, Florida, ground water discharge showed numerous pesticide peaks and heavy metal concentrations 100 to 10,000 times above sea water levels.
- In Cedar River, Iowa, the pesticides atrazine and deethylatrazine were found in the river and 75% was contributed from ground water.
- In the Indian River estuary in Florida, dissolved reactive phosphate was found and 99% came from ground water discharge.

Microbial Paths of Contamination

Various pathogenic microorganisms are also introduced into ground water and surface water as a result of various human activities. These activities include malfunctioning septic systems, back-siphonage of water systems, and maintenance deficiencies. The most relevant diseases spread by these pathogens are those related to consumption of contaminated drinking water, including gastroenteritis, campylobacteriosis, and hepatitis A. The protozoan *Cryptosporidium* has recently been recognized as a significant human pathogen. Floods and other natural disasters can also cause pathogens to enter ground water and surface water used for drinking water supplies.

In the summer of 1994, State agencies in Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin and the Centers for Disease Control and Prevention coordinated a survey of the contamination of well water. Samples were taken from 5,530 private wells evenly spaced across these States. Preliminary results of the survey indicated that coliform bacteria were present in 41% of these wells. The presence of coliform bacteria may indicate contamination by harmful bacteria and viruses. In the sampled wells, Federal drinking water standards established for nitrates and atrazine in public water systems were exceeded in 14% and 0.4% of these wells, respectively. The results are being analyzed for associations between well contamination and well construction practices and health effects.

supplies in 1990; and the percent of ground water used for private drinking water supplies. Ground water statistics are provided in Appendix I-1. Figure 6-4 illustrates the percentage of population dependent upon ground water for drinking water in 1990. As shown, New Mexico, Mississippi, and Florida rely on ground water for 90% or more of their drinking water supply. Following is a brief summary of significant trends.

For the period 1970 to 1990,

- Twenty-one States and one Territory increased ground water use for public water systems at a rate greater than overall public water use.
- Alaska, Arizona, California, Florida, Kentucky, Missouri, and Puerto Rico more than doubled their use of ground water for public supply.
- Hawaii, Idaho, Louisiana, Maryland, Minnesota, Montana, Massachusetts, New Mexico, North Carolina, Pennsylvania, Texas, and Wyoming nearly doubled their use of ground water for public supply.

For the period 1980 to 1990,

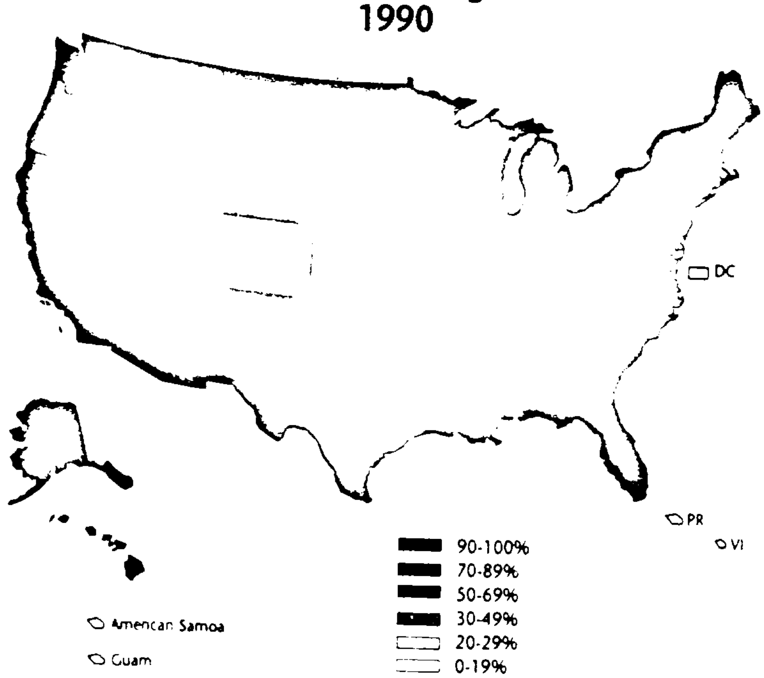
- For incremental drinking water use, ground water supplied two of every three additional gallons of water supplied by public water systems nationally.

In 1990,

- More than half of the national population was dependent upon ground water for drinking water.
- More than half of the population (51% to 93%) in 30 States relied on ground water for drinking water.
- Approximately 32% of the national population dependent upon ground water obtained their drinking water from private wells.
- Ninety-five percent of the population in rural areas relied on ground water for their water supply.
- In Kentucky, Maine, North Carolina, South Carolina, and West Virginia, 65% to 77% of the population relied on ground water from private wells.

Figure 6-4

Percent of Population Dependent on Ground Water for Drinking Water 1990



Source Open File Report 92-63, U.S. Geological Survey.

■ At least 40% of the population in 23 States and 1 Territory relied on ground water from private wells.

Ground Water Quality

Ground water moves slowly, on the order of less than an inch to tens of feet per day. Consequently, contaminants introduced into the subsurface are less likely to be diluted than those introduced into more rapidly moving surface water. The slow movement of ground water often results in a delay in the detection of ground water contamination. In some cases, contaminants introduced into the subsurface more than 10 years ago are only now being detected and affecting ground water uses.

While the larger ground water resource is of good quality, localized areas of high demand and chemical use can be affected by contamination. This situation exists because locations of more productive ground water yields are often places that allow more infiltration and recharge of aquifers, carrying contaminants more easily to ground water. This vast resource remains exceedingly vulnerable to contamination by toxic compounds, bacteria, viruses, and inorganic contaminants. In one study of five midwestern States, the Ground Water Protection Council* estimated that between 15% and 48% of the land area is underlain by highly vulnerable aquifers.

Contamination of ground water typically occurs in localized areas. These incidents are frequently serious and often pose threats to human health or result in increased costs to consumers. Many locations within every State have shown water quality degradation that constrains the use of ground water resources. As ground water quality is degraded, Americans are becoming increasingly aware that contaminated ground water is both difficult and expensive to clean up.

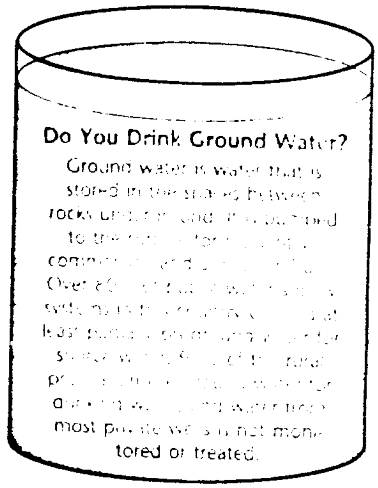
The following statistics help to illustrate the prevalence of localized ground water contamination incidents:

■ More than 85% of abandoned hazardous waste disposal sites (Superfund sites) have some degree of ground water contamination. Most of these sites impact aquifers that are currently used or could potentially be used for drinking water.

■ Of the contaminated aquifers at Superfund sites, 62% discharge into surface waters. Of these aquifers, 38% are used to supply drinking water. Nineteen percent of these contaminated aquifers discharge to sensitive ecological environments.

■ At 49% of the Superfund sites where cleanup costs are expected to exceed $20 million, dealing with large volumes of contaminated ground water is a key factor contributing to that cost.

■ Currently, 418 land disposal facilities are subject to ground water monitoring requirements under the Resource Conservation and Recovery Act (RCRA). Of these, an estimated 37% are undertaking measures to clean up existing ground water contamination. The EPA estimates



* Wayne A. Pettyjohn, *Aquifer Vulnerability, Sensitivity, and Ground Water Quality in Selected States*, Ground Water Protection Council, 1994, 94 pages.

that another 10% of the land disposal facilities will detect ground water contaminants in the next 2 years.

- EPA estimates that 1.2 million federally regulated underground storage tanks (USTs) are buried at over 500,000 sites nationwide. An estimated 139,000 USTs have leaked and impacted ground water quality.

- EPA estimates that the total number of leaking USTs could reach 400,000 in the next several years.

The EPA requested that States provide information on the degradation of ground water resources used for public drinking water supply. As a result, 21 States reported on the quality of ground water supplied by a total of 20,294 public water systems that serve approximately 52 million people. Among these States:

- Nineteen reported incidents of public water systems that use ground water exceeding the Maximum Contaminant Level (MCL) for at least one contaminant. These exceedances occurred in 3% of the ground-water-supplied public water systems and affected drinking water quality for 1.4 million Americans.

- Eleven reported incidents in which ground water supplied by public water systems exceeded the MCL for nitrate. Barium, arsenic, and fluoride were cited most frequently among the other 12 inorganic contaminants reported to have exceeded MCLs.

- Fifteen volatile organic compounds (VOCs) and eight pesticides were noted to have exceeded MCLs in ground-water-supplied public water systems. Among the most frequently cited of these compounds were trichloroethylene, tetrachloroethylene, and benzene.* Atrazine, alachlor, and lindane were the most frequently cited pesticides.

Sixteen States also reported on the occurrence of ground water contaminants at levels that are approaching the MCL. The concentrations of these contaminants in ground water do not yet present human health hazards. Nonetheless, they provide a clear indication that future uses of ground water may be impaired. Of the 16 States reporting:

- Fourteen States detected nitrate at a level between 50% and 100% of the MCL in ground water supplied by public water systems. Among the 12 other inorganic contaminants reported to be approaching the MCL, the most frequently cited were cadmium, nickel, selenium, and thallium.

- Fourteen VOCs and 13 pesticides were reported at levels that approached MCLs. The most frequently cited of these compounds were benzene, carbon tetrachloride, and vinyl chloride.* Lindane, simazine, and aldicarb were the most frequently cited pesticides.

* Trichloroethylene is a carcinogen (i.e., cancer-causing substance) used in textiles, adhesives, and metal degreasers. Tetrachloroethylene is a carcinogen used in dry cleaning and other solvents. Benzene is a widely used carcinogenic component of gasoline, pesticides, paints, and plastics.

* Carbon tetrachloride is a carcinogenic component of solvents and their degradation products. Vinyl chloride is a carcinogen that may leach from polyvinyl chloride pipe or be formed by the breakdown of other solvents.

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Ground Water Contaminant Sources

Ground water quality may be adversely impacted by a variety of potential contaminant sources. EPA presented a list of potential contaminant sources in the 1994 305(b) guidelines and requested each State to identify and rank the specific sources that threaten their ground water resources. Ranking was based on the best professional judgment of the State ground water officials and took into account the number of each type of source in the State, the location of the various sources relative to ground water used for drinking water purposes, the size of the population at risk from contaminated drinking water, the risk posed to human health and/or the environment from releases, hydrogeologic sensitivity (the ease with which contaminants enter and travel through soil and reach aquifers), and the findings of the State's ground water protection strategy and/or related studies.

Figure 6-5 lists potential ground water contaminant sources ranked according to the number of States that identified each source as a high, medium, low, or unspecified priority. As shown, the greatest number of States reported that leaking underground storage tanks (USTs) are a source of ground water contamination with 41 States rating USTs as a high-priority source of ground water contamination in their 1994 305(b) reports. Montana indicated that there have been 963 confirmed releases from USTs and that half of these releases impacted ground water resources. Leaking USTs have also caused serious ground water pollution problems in Rhode Island with more than 511 leaking USTs identified in the State since 1985. Many of these sites have required active remediation of contaminated ground water. In several cases, restoration of contaminated ground water was deemed infeasible, and alternative measures had to be taken to supply affected areas with drinking water.

The primary causes of leakage in USTs are faulty installation and corrosion of tanks and pipelines. It is estimated that, on a national basis, 139,000 tanks have leaked and impacted ground water quality, and reports of leaking USTs continue to increase. Rhode Island indicated that new reports of leaking UST sites requiring investigation for potential ground water contamination numbered 50 to 70 per year during 1992-1993. Montana indicates that new reports of leaking USTs come in at a rate of 20 to 30 per month. This rise in the number of reports of leaking USTs most likely reflects increased awareness, stricter requirements on site assessments upon closure of tanks, and monetary aid to assist responsible parties to clean up the contaminated sites. In addition, increased reporting of UST leaks may reflect an increase in leaks as older tanks corrode.

In general, most USTs are found in the more heavily developed urban and suburban areas of a State. They are primarily used to hold petroleum products such as gasoline. Ninety-five percent of the USTs in Texas contain petroleum products. Rhode Island reports that, of 255 active sites, approximately 75% involve motor fuels (gasoline

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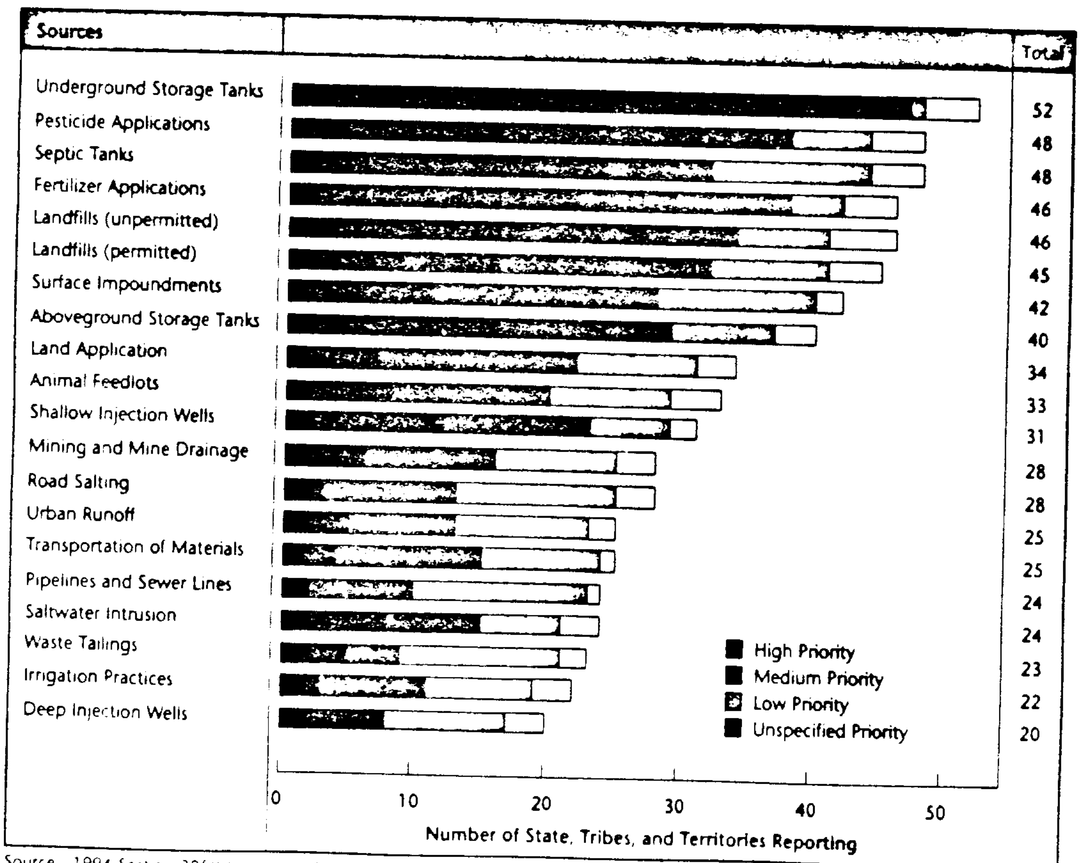
and diesel fuel). The majority of these leaks at the active sites in Rhode Island occurred at gasoline service stations. North Carolina reported that leaking USTs accounted for 87% of the ground water contamination incidents occurring from October 1991 through September 1993. Of these incidents, 86% were related to the release of gasoline. Maine reports that petroleum leakage has contaminated over 200 private wells between 1990 and 1992.

Septic tanks and shallow injection wells were listed as the third and eleventh most common sources of ground water contamination, respectively. Shallow injection wells (classified as Class V wells in the Underground Injection Control Program) inject fluids into or above

Figure 6-5

Contaminant Sources Prioritized by States



Source: 1994 Section 305(b) reports submitted by States, Tribes, and Territories.

underground sources of drinking water. They include dry wells, septic systems, geothermal reinjection wells, industrial and utility disposal wells, and aquifer recharge wells. New Jersey reports that in a four-county study, including Passaic, Somerset, Camden, and Ocean Counties, subsurface discharges of wastewater from industrial septic systems, dry wells, and service station drains are a major source of drinking water contamination. One-hundred and twenty-four private wells and five municipal wells were contaminated—half by subsurface discharges.

Contamination of drinking water from shallow injection wells may take years to be detected in nearby wells. A chemical company in the Bethpage/Hicksville area of New York disposed of industrial wastewater containing a carcinogenic compound—vinyl chloride—into sumps. Two million gallons of wastes were discharged each year for 19 years. This led to extreme contamination of the Magothy aquifer. Fourteen wells, including five municipal supply wells, were contaminated with industrial organic wastes. An estimated 100,000 people were affected by the contaminated wells.

One obstacle in remediating ground water contaminated by shallow injection wells is determining the responsible parties. Three wells were closed in Burlington, Maine, due to trichloroethylene (TCE) and tetrachloroethylene (PCE) contamination. The closure of the wells affected 50% of the town's primary well field and approximately 20,000 people. Two nearby manufacturing plants are unconfirmed but suspected sources of contamination. Both facilities have dry wells and septic systems that contain TCE and PCE. The town continues to supply water to residents using a wellfield that previously served as a backup water supply.

In severe cases, even when responsible parties are required to remediate the contaminated area, costs are high—often too high for the responsible party or parties to afford. From the 1950s through 1981, a thermostat manufacturer in South Cairo, New York, poured wastes containing TCE and PCE sludges down drains connected to an abandoned septic system. As a result, high levels of TCE and PCE were detected in five privately owned wells in the vicinity. A 1983 Consent Order required the manufacturer to clean up the site, supply bottled water, and install, monitor, and maintain carbon filter systems for the five affected homes. In 1985, the manufacturer filed for bankruptcy, and EPA has assumed responsibility for maintaining the carbon filter systems and monitoring. EPA has also installed two new carbon filtration units and an air stripping system and drilled a new well in an effort to provide clean water. Future remedial action will include the provision of an alternate water supply through a pipeline at estimated capital costs of $2,270,000 and annual operation and management costs of $100,000.

A March 22, 1991, report prepared for EPA entitled *Drinking Water Contamination by Shallow Injection Wells* estimated that shallow injection wells contaminated the drinking water of approximately

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1.3 million people at a cost ranging from $30,000 to $3.8 million.

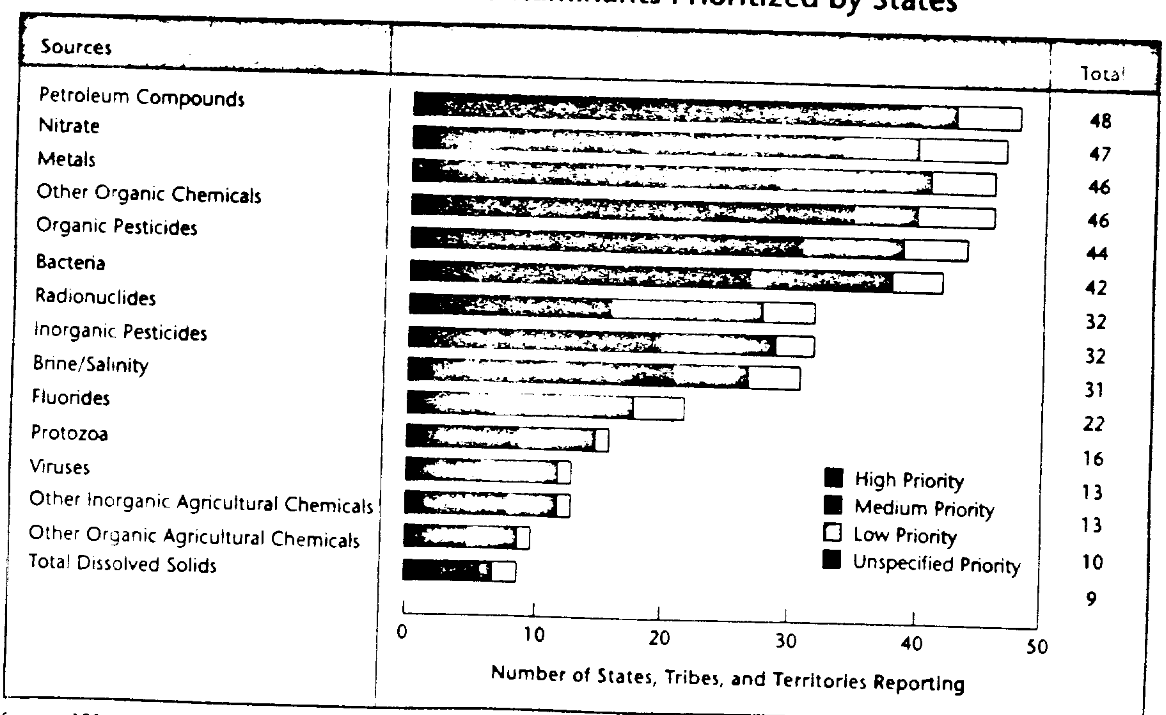
Ground Water Contaminants

EPA also requested that States identify and rank the contaminants impacting their ground water resources. This information was also based upon the best professional judgment of the State ground water experts. Factors that were considered include the areal extent of contamination, the location of contamination relative to ground water supplies used for drinking water purposes, the size of the population at risk from drinking water threatened by the contaminant, the risk posed to human health and/or the environment from this contaminant, hydrogeologic sensitivity, and findings of the State's ground water protection strategy or other reports.

As shown in Figure 6-6, the greatest number of States cited petroleum compounds as a high-priority contaminant in their ground water. Petroleum compounds are

Figure 6-6

Ground Water Contaminants Prioritized by States



Source 1994 Section 305(b) reports submitted by States, Tribes, and Territories.

generally associated with underground and aboveground storage tanks, and their frequent detection in ground water is consistent with the high priority assigned by the States to storage tanks as a contaminant source.

Petroleum is a complex mixture of more than 200 different compounds. Studies have found that four compounds (benzene, toluene, ethyl benzene, and xylenes) make up 95% of the compounds detected in ground water impacted by petroleum releases. It is generally these compounds that are most frequently detected in contaminated ground water. Using this information, Montana was able to relate five incidents of benzene contamination in public water supplies to leaking USTs.

Nitrate was the second most common ground water contaminant cited in State 305(b) reports. Twenty-four States indicated that nitrate was a major concern. Ten of these States indicated that nitrate was the prime contaminant of concern. High concentrations of nitrate in drinking water can cause serious human health problems, especially in babies. Exposure to high concentrations of nitrate (>10 mg/L) in drinking water causes methemoglobinemia, or blue baby syndrome, an inability to fix oxygen in the blood.

Nitrate is soluble in water, and, as a consequence, it is easily transported from the soil surface to ground water. Nitrate is applied extensively on agricultural fields, residential lawns, and golf courses to promote crop and lawn growth. Sources of nitrate include fertilizer, domestic wastewater and sludge, and septic tanks. Natural concentrations of nitrate in ground water vary, but a concentration of 3 mg/L is often considered to be typical outside of areas of naturally high nitrate levels. Concentrations measured above this level are typically considered to be the result of human activity. Elevated concentrations of nitrate in ground water are frequently considered to be an important indication of the degradation of ground water resources. The EPA drinking water standard for nitrate is 10 mg/L.

Following are highlights of several State programs focusing on nitrates.

Maine

The Maine Soil and Water Conservation Districts collected soil from the plow layer of 249 corn fields as part of a Manure Management Project. Soil nitrate was found to be twice the level needed to produce a normal corn crop, suggesting a threat that the excess nitrate could leach to ground water. In response, the Maine Cooperative Extension Service developed guidelines for manure utilization that include (1) the analysis of nitrate levels in soils and plants prior to fertilization, and (2) fertilization according to realistic crop uptake rates.

South Dakota

The Oakwood Lakes-Poinsett Rural Clean Water Program examined the impacts of agricultural chemical practices on ground water quality. A total of 114 monitoring wells were installed at seven study sites that represented both farmed and unfarmed areas. The study results showed that nitrate concentrations in ground water ranged from less than 0.1 mg/L to more

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Frequently Detected Pesticide Residues in Ground Water

Ground water monitoring for agricultural chemicals during the past decade has shown that this vital resource is susceptible to contamination. The tabulated information on the following pages shows the results of recent monitoring for pesticides in the ground water of some States. These studies indicate that among the most frequently detected pesticides are those with active ingredients from the triazine (atrazine, cyanazine, simazine, and prometon) and amide (alachlor, metolachlor, and propachlor) herbicide families. While a number of pesticides have been detected in ground water, however, very few are found at levels that exceed health-based standards for drinking water.

Atrazine is the common name of an herbicide that is frequently used to control weeds in corn, sorghum, and other agricultural crops. Atrazine has a high potential to be transported to ground water, and is the seventh most frequently detected active ingredient tracked in the U.S. Environmental Protection Agency's Pesticides in Ground Water Database.* Atrazine residues were found in 1,512 (5.6%) of the 26,909 well samples that were collected for studies conducted across the United States from 1971 to 1991. Only 172 of the wells (0.6%) yielded samples in which atrazine levels exceeded the MCL.

Alachlor is the common name of an herbicide that is commonly applied to weeds in corn, cotton, soybeans, and peanuts. Alachlor has a moderate potential to be transported to ground water and is the ninth most frequently detected pesticide residue listed in the Pesticides in Ground Water Database. Of the 26,856 wells tested for alachlor residues in the past two decades, 543 (2%) contained detectable levels of this herbicide. Alachlor residues that exceeded the MCL for this compound were found in 101 wells (0.4%).

Simazine is the common name of an herbicide used primarily to control weeds in corn, vineyards, citrus orchards, and other agricultural crops. Simazine has a moderate potential to be transported to ground water. The Pesticides in Ground Water Database lists simazine as the tenth most frequently detected pesticide residual found in ground water over the past two decades. Simazine residues were found in 486 (2.2%) of the 22,374 well samples that were reported from 1971 to 1991. Only 89 of the wells (0.4%) yielded samples in which simazine levels exceeded the MCL.

*U.S. Environmental Protection Agency, 1992. *EPA Pesticides in Ground Water Database: A Compilation of Monitoring Studies from 1971-1991*. EPA 734-12-92-001, 182 pages.

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Factors Affecting Pesticide Occurrence in Ground Water

In a study of the corn and soybean producing region of the midcontinental United States, researchers sought to understand the occurrence and distribution of selected agricultural chemicals and their degradation products in shallow aquifers.* The study region included parts of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. Nearly 60% of the pesticides and nitrogen fertilizers used in the United States is applied to crops in these 12 States. A total of 303 wells were sampled during both the preplanting and postplanting seasons. Herbicides and metabolites were detected in 24% of the samples. None of the pesticides were detected at levels that exceeded the MCL.

Many of the studies summarized in the attached table sought to discern relationships between the occurrence of pesticides in shallow ground water and specific aquifer or land use conditions that rendered the cropland particularly susceptible to ground water contamination. In a recent study of agricultural chemicals in the ground water of Nebraska,* the authors concluded that the following factors may be related to pesticide occurrence in ground water:

- Nearly 70% of the atrazine detections occurred in highly vulnerable areas where nonpoint nitrate contamination has also been documented.

- The dispersed pattern of alachlor detections may suggest contamination that originated from misuse, overuse, back siphoning, or spills at mixing/loading areas, rather than through normal agricultural application.

- Some detections of propachlor in ground water may be related to use of the pesticide to control weeds around the wellhead of unsealed irrigation wells.

*Burkart, M.R., and D.W. Kolpin, 1993. Hydrologic and land-use factors associated with herbicides and nitrate in near-surface aquifers, *Journal of Environmental Quality*, Vol. 22, No. 4, pp. 646-656.

*Exner, M.E. and R.F. Spalding, 1990. *Occurrence of Pesticides and Nitrate in Nebraska's Ground Water*, Water Center, Institute of Agriculture and Natural Resources, University of Nebraska, Report WC', 34 pp.

Recent Monitoring Results for Pesticides in Ground Water

State	Study Purpose[1]	No. Wells in Study	Pesticides (Percent of wells with pesticides detected below the MCL)												
			2,4-D	Alachlor	Atrazine	Bentazone	Chlordane	Chlorpyrifos	Cyanazine	DBCP	Dicamba	Dieldrin	Diuron	Endrin	
California	Evaluate ground water quality for 15 major ground water basins in Southern California[2]	3,500 municipal water supply wells	•		•	•	•			•				•	
	Summary of sampling for pesticides in California ground water from July 1, 1992, to June 30, 1993[3]	Varies by analyte (from 393 to 1,271 wells)			3	2							3		
	Summary of sampling for pesticides in California ground water from July 1, 1993, to June 30, 1994[4]	Varies by analyte (from 261 to 1,328 wells)			1	1							4		
Colorado	Monitor South Platte Alluvial Aquifer for presence of commercial fertilizers and pesticides in ground water[5]	96		2	26										
Maryland	Document statewide water quality conditions and establish basis for long-term water quality monitoring[6]	Varies by analyte (from 7 to 38 wells)	3	5	24				5		14	4			
Nebraska	Characterize the areal distribution of agrichemicals in ground water and correlate occurrence with parameters that enhance leaching[7]	Varies by analyte (from 35 to 2,260 wells)	3	1	13				1			6			
South Dakota	Assess presence of pesticides and nitrogen-based fertilizers in ground water in 1993[8]	44	6	14	6				1		8				
	Evaluate effectiveness of BMPs on reducing pesticides and nitrate in the Big Sioux aquifer, Oakwood Lakes-Poinsett project area (10-year study)[9]	73	30	33	3				4		27				

• = Detected at levels below the MCL. Number of wells unspecified

[1] The reader is referred to the footnoted studies for additional information concerning sampling strategies, detection limits, and more detailed data.

[2] Anderson, Lisa, 1994, *Groundwater Quality, A Regional Survey of Groundwater Quality in the Metropolitan Water District Service Area*, Metropolitan Water District of Southern California, Report Number 991.

[3] California Environmental Protection Agency, 1993, *Sampling for Pesticide Residues in California Well Water, 1993 Update, Well Inventory Data Base*, Department of Pesticide Regulation.

[4] California Environmental Protection Agency, 1994, *Sampling for Pesticide Residues in California Well Water, 1994 Update, Well Inventory Data Base*, Department of Pesticide Regulation

[5] Colorado Department of Health, *Report to the Commissioner of Agriculture, Colorado Department of Agriculture, Ground Water Monitoring Activities, South Platte Alluvial Aquifer, 1992-1993*

[6] Bolton, David W., *A State-Wide Ground-Water Quality Network for Maryland. Network Design. Description of Sampling Sites, and Initial Ground-Water-Quality Data*, Department of Natural Resources, Maryland Geological Survey, Prepared in cooperation with the United States Department of Interior Geological Survey, the United States Environmental Protection Agency, and the Maryland Department of the Environment.

[7] Exner, Mary E., and Roy F. Spalding, 1990, *Occurrence of Pesticides and Nitrate in Nebraska's Ground Water*. Water Center, Institute of Agriculture and Natural Resources, University of Nebraska

[8] Department of Environment and Natural Resources, 1994, *1993 Pesticide and Nitrogen Sampling Program*, prepared for the 1994 South Dakota Legislature, prepared by the Division of Environmental Regulation, Ground-Water Quality Program

[9] Rural Clean Water Program, 1991, *South Dakota Oakwood Lakes-Poinsett Project 20, Ten Year Report*, in cooperation with the U.S. Department of Agriculture, the South Dakota Department of Environment and Natural Resources, and the Brookings, Kingsbury, and Hamlin Counties.

NOTE: Blank boxes indicate that data were not ava[illegible]

	Pesticides (Percent of wells with pesticides detected below the MCL)															Pesticides (Percent of wells with pesticides detected above the MCL)							
	Fonofos	Heptachlor	Heptachlor epoxide	Lindane	Methoxychlor	Metolachlor	Metribuzin	Picloram	Prometon	Propachlor	Silvex	Simazine	Terbufos	Toxaphene	Trifluralin	2,4-D	Alachlor	Atrazine	Bentazone	Chlordane	DBCP	Heptachlor	Heptachlor epoxide
		•	•	•	•						•	•		•					<1	<1	1	<1	<1
									<1			3											
									<1			2											
																	1						
				4		5			3			5				0	0	3					
	<1					1			1	12		8	<1		<1								
						13		2		1													
	10			3		16	8	4							10								

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A National Look at Nitrates*

In addition to work being conducted by States, the U.S. Geological Survey evaluated nitrate concentrations on a national basis. The U.S. Geological Survey conducted an analysis of approximately 12,000 water samples collected from wells and springs in 18 of the 20 Study Units of the National Water Quality Assessment and five supplemental study areas.

The analysis indicated that about 50% of the wells were characterized by elevated levels of nitrate (levels that exceeded 3 mg/L, which is typically held as the threshold indicating human impacts). Nitrate concentrations exceeded the EPA maximum contaminant level (MCL) of 10 mg/L in approximately 21% of the samples. Samples collected from agricultural areas had significantly higher nitrate concentrations than other land use settings (for example, forest), with 16% of the samples exceeding the MCL. The nitrate concentrations were generally highest in the Northeastern, Northern Plains, and Pacific States. This reflects the fact that much of the agricultural land in these regions of the country is underlain by permeable, more well-drained materials, such as unconsolidated sand and gravel, or fractured carbonate bedrock. It was shown that nitrate concentrations were highest in areas of sandy soil.

The analysis indicated that nitrate concentrations exceeding the MCL were most frequently detected in irrigation and stock wells (16%) as opposed to private wells (9%) and public water supply wells (1%). However, EPA still urges well owners who know or suspect that their wells are affected by nitrates to have the water tested. Because of the many factors that may influence the contamination of drinking water wells, EPA recommends an approach that focuses on pollution prevention. Among the steps that should be considered to protect the Nation's ground water resources are appropriate applications of pesticides and fertilizers, site-specific assessments to accurately target and protect vulnerable ground water supplies, identification and protection of ground water recharge areas and wellhead areas, more careful use of flood irrigation, and continued efforts to identify problem areas.

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* From *Nutrients in Groundwater and Surface Water of the United States – An Analysis of Data Through 1992*, Water-Resources Investigations Report 95-4031, by D.K. Mueller, P.A. Hamilton, D.R. Helsel, K.J. Hitt, and B.C Ruddy, U.S. Geological Survey, Denver, Colorado, 1995

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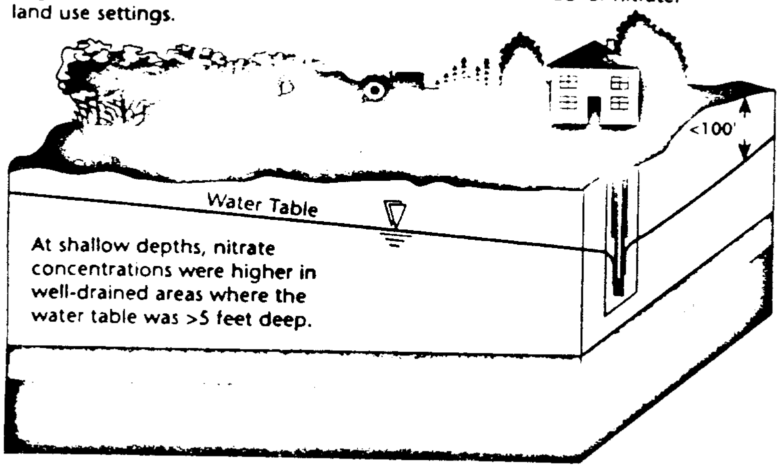
Occurrence of Nitrate Concentrations Associated with Hydrogeologic and Land Use Factors



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than 70 mg/L. Fifteen percent of the 3,092 samples exceeded the EPA MCL of 10 mg/L. The highest nitrate concentrations were found in the top 20 feet of the aquifer, and nitrate concentrations were significantly higher at the farmed sites.

Arizona

Nitrate is one of the most common pollutants in Arizona's ground water. Large portions of aquifers within the Salt River Valley, including areas within Glendale, Mesa, Chandler, and Phoenix, contain ground water with nitrate concentrations high enough to render the water unfit for consumption. In addition, high nitrate levels occur in Marana, St. David, Quartzsite, Bullhead City, and other areas. Septic tank discharges are particularly prevalent sources of nitrate in rural areas and have often contaminated drinking water wells.

As a consequence, the following investigations are under way:

- Studies will be conducted in the Bullhead City/Riviera, Fort Valley, and Casa Grande areas to investigate the impacts of septic tanks and other nitrate contributions.
- Maps that reflect nitrate concentrations in Arizona's ground water are being produced to target prevention activities.

Georgia

The Georgia Environmental Protection Division (EPD) sampled over 5,000 shallow domestic drinking water wells for nitrate/nitrite. Results indicate that only 1% of the 5,000 wells is characterized by nitrate concentrations that exceed the MCL of 10 mg/L for nitrate in drinking water. Water from 97% of the wells is characterized by nitrate concentrations of less than 5 mg/L. Although it does not appear that nitrate is a widespread problem in Georgia, the EPD observed a very slight increase in average nitrate concentrations in the recharge areas of some Coastal Plain aquifers. These increases may indicate a future increase in nitrate in the down-dip confined portions of the aquifers. EPD will continue to monitor changes in the aquifers.

Iowa

Agriculture, Iowa's largest industry, is currently the primary source of ground water contamination in the State. One of the most significant impacts is related to the application of commercial fertilizers. An estimated 30% to 50% of the nitrogen applied as fertilizer to Iowa farm acres is volatilized and lost to the atmosphere or is lost through infiltration through the soil. Currently, approximately 18% of the State's rural population is served by water with nitrate concentrations in excess of the MCL (10 mg/L as nitrogen). However, only 10 out of 1,130 ground-water-based community public water supplies (PWSs) have levels of nitrate exceeding the MCL. High levels of nitrate affect a relatively low percentage of the population of Iowans served (0.3%).

Ground Water Monitoring

Section 106(e) of the Clean Water Act requests that each State monitor the quality of its ground water resources and report the status to Congress biennially. The most comprehensive approach to determining overall ground water quality is to use an ambient ground water monitoring network. However, the expense associated with installation and maintenance of such a network is often high and, depending upon State priorities, it may be prohibitive. Despite this, many States are taking the initiative to develop programs designed to evaluate the quality and vulnerability of their ground water resources, to identify potential threats to ground water quality, and to determine ways to protect their ground water resources from degradation. Thirty-three States indicated that they have implemented statewide ground water monitoring programs that focus on one or more contaminants. This is an increase of four States from what was reported in 1992. Additionally, six States indicated that they are in the process of developing similar programs. Following is a brief description of several State monitoring programs.

Pennsylvania – Fixed Station and Ambient Monitoring Programs

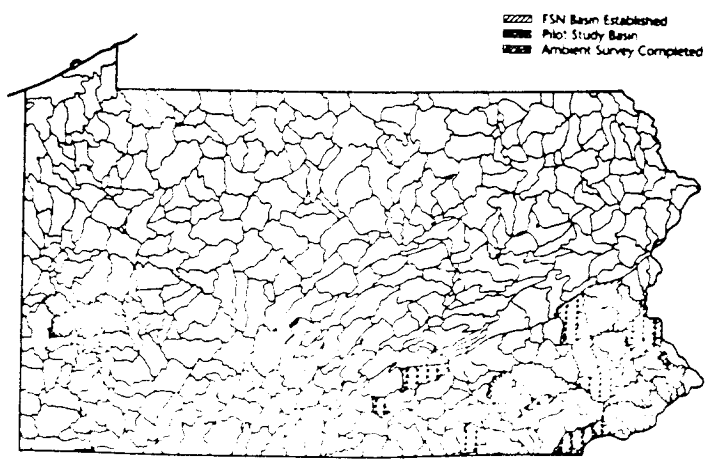
To improve the effectiveness of its ground water resource protection efforts, the Pennsylvania Bureau of Water Quality Management developed two ground water quality monitoring programs—the Fixed Station Monitoring Network and the Ambient Ground Water Quality Survey Programs. These joint programs enable Pennsylvania to (1) detect emerging ground water problems, (2) evaluate the impacts of unmonitored sources of pollution, and (3) assess the overall effectiveness of their regulatory program.

Pennsylvania's Fixed Station Monitoring Program was developed following division of the State into 478 ground water basins (Figure 6-7). These basins were then prioritized based on ground water use, land use (potential unmonitored sources of pollution), and environmental sensitivity. The 50 highest ranking basins were selected for inclusion in the Fixed Station Monitoring Network Program.

To date, 537 ground water monitoring stations have been established in 20 basins covering 2,318 square miles. The average ground water basin is 125 square miles in size and includes 25 monitoring locations, which are selected to represent the ambient ground water quality of a 4-square-mile area. Each ground water sample is analyzed for 27 parameters.

Figure 6-7

Ground Water Basin Map of Pennsylvania



Source: 1994 Water Quality Assessment, 305(b) Report, Commonwealth of Pennsylvania

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Pennsylvania's Ambient Ground Water Quality Survey Program was initiated in 1988 to obtain ground water quality data in those basins not covered by the Fixed Station Program. Because these basins are considered to be less vulnerable, ground water samples are scheduled to be collected only two times.

Florida – Comprehensive Monitoring Networks

Florida's Water Quality Assurance Act required the establishment of a ground water monitoring network designed to (1) establish the baseline water quality of the major aquifer systems in the State, (2) detect and predict changes in ground water quality resulting from the effects of various land use activities and potential sources of contamination, and (3) disseminate to local governments and the public water quality data generated by the network. The Florida Network has three components: the Background Network, the Private Well Survey, and the Very Intense Study Area Network.

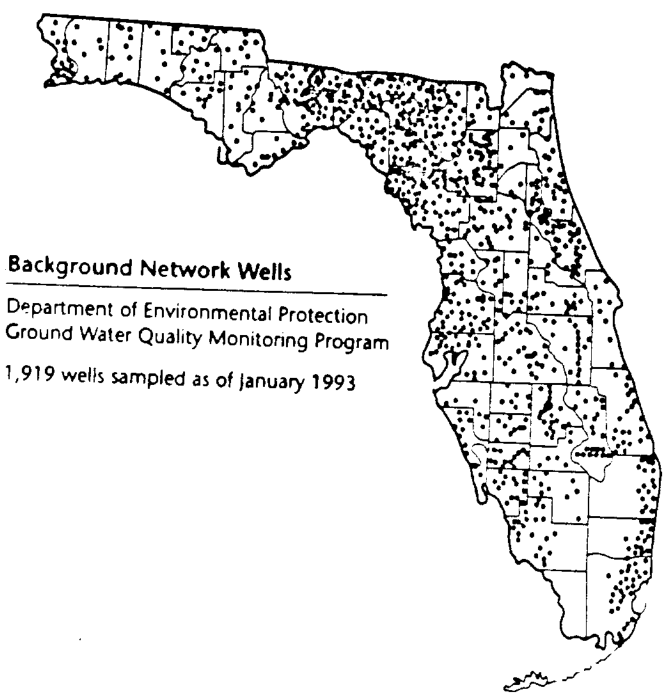
The Background Network was designed to help define background water quality using a statewide grid of wells that collectively tap all major aquifers, including the surficial, intermediate, Floridan, and Claiborne aquifers (Figure 6-8). One-third of the wells are sampled annually with a complete rotation of wells every 3 years. Approved data are available to the public on the Florida Ground Water Quality Monitoring Network Electronic Bulletin Board and in three State publications.

The Private Well Survey provides an evaluation of water quality in private drinking water wells serving families in 67 Florida counties. The survey calls for 50 private water wells to be sampled in each individual county. To date, sampling in 23 counties has been completed.

Twenty-three areas believed to be highly susceptible to ground water contamination based on predominant land use and hydrogeology are being studied as part of the Very Intense Study Area Network. A total of 461 wells make up this network, which is designed to monitor the effects of multiple

Figure 6-8

Location of Ground Water Quality Monitoring Program Background Network Wells in Florida



Source 1994 Florida Water Quality Assessment, 305(b) Report, Florida Department of Environmental Protection.

sources of contamination on water quality within a segment of an aquifer. The land uses represented are urban, suburban, industrial, agricultural, and mixed. Cumulative monitoring data will be compared to similar parameters in the Background Network representing the same aquifer segment to determine the effects of land use and site hydrogeology upon ground water quality.

Kansas – Assessing Temporal and Spatial Trends

Kansas established a Ground Water Quality Monitoring Network in 1976 to procure long-term, statewide ground water quality data for use in the identification of temporal and spatial trends related to (1) alterations in land use, (2) application of land treatment methods and other nonpoint source best management practices, (3) changes in ground water availability or withdrawal rates, and (4) variations in climatological conditions within the State. In addition, the network is intended to assist in the identification of ground water contamination problems.

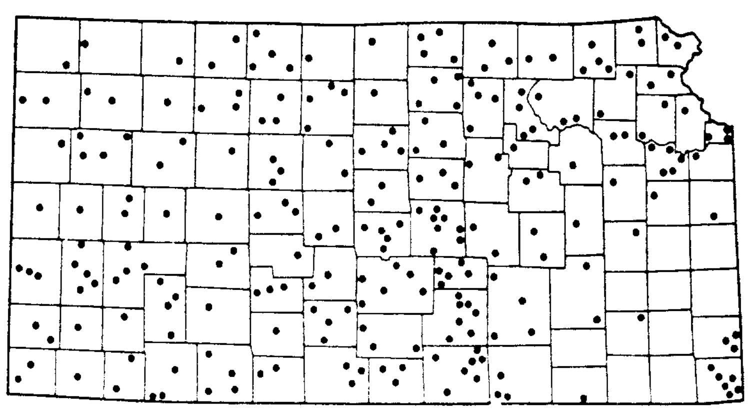
The network currently consists of 242 wells (Figure 6-9), including public water supply wells (71%), irrigation wells (14%), private domestic wells (10%), multiple use wells (3%), livestock watering wells (1%), and industrial supply wells (1%). During the period 1990-1993, 599 samples were analyzed for common inorganic chemicals and heavy metals; 285 samples were analyzed for pesticides; 110 samples were analyzed for volatile organic chemicals; and 105 samples were analyzed for radionuclides. In evaluating the data, 103 instances were found in which the chemical quality of the raw ground water samples exceeded State drinking water standards. Of these, 71 were related to the presence of nitrate.

Wisconsin – Pesticide Monitoring Program

Wisconsin developed a pesticide monitoring program in response to the detection of aldicarb in 1980 in ground water near Stevens Point. Initially the monitoring program focused on aldicarb; however, it was expanded in 1983 to include additional pesticides (e.g., atrazine), and several studies were initiated to determine the potential impact of pesticide use on ground water quality. Following are the results of four studies:

Figure 6-9

Kansas Ground Water Quality Monitoring Network



Source 1994 Kansas Water Quality Assessment, 305(b) Report, Kansas Department of Health and Environment.

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- In 1985, the Wisconsin Department of Agriculture, Trade, and Consumer Protection installed monitoring wells at a number of farm fields in susceptible geologic environments. To date, atrazine was detected at 25 of the 35 study sites and alachlor was detected at 7 of the 23 study sites.

- During the period between August 1988 and February 1989, well water from 534 Grade A dairy farms was randomly collected by the Wisconsin Department of Agriculture, Trade, and Consumer Protection and analyzed for 44 pesticides. One or more pesticides were detected in 71 wells.

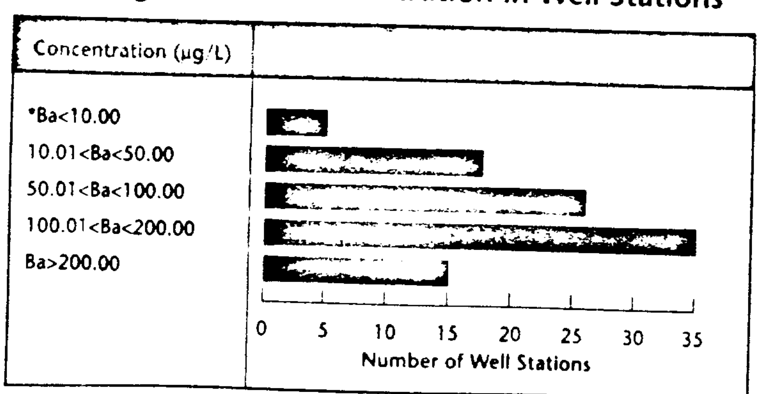
- Sixty-nine of the 71 Grade A dairy farm wells were resampled by the Wisconsin Department of Natural Resources along with 212 wells located in the areas of concern to determine the possible extent of the pesticide occurrences. One or more pesticides were detected in 57 of the 69 resampled wells and 63 of the other 212 wells.

- To better understand pesticides and nitrates in ground water, the Wisconsin Department of Agriculture, Trade, and Consumer Protection sampled nearly 2,200 rural wells for atrazine and triazine herbicides. Sixteen percent, or 351 of 2,187 wells, contained detectable concentrations of triazine-class compounds.

In response to concerns about pesticides in ground water, Wisconsin adopted an administrative rule to regulate atrazine use starting with the 1991 growing season. This rule has been revised in each subsequent year to account for additional atrazine data. Application rates are limited statewide based on soil texture and former use. The use of atrazine is prohibited in certain areas of the State. Throughout the rest of the State, a rate of application is required that is more stringent than Federal recommended limits.

Figure 6-10

Ambient Ground Water Data from Ohio: Average Barium Concentration in Well Stations



*Detection Limit = 10 µg/L.

Source: 1994 Ohio Water Resource Inventory, State of Ohio Environmental Protection Agency.

Arkansas – Ambient Ground Water Monitoring

The Arkansas Department of Pollution Control and Ecology has established an ambient monitoring program at various locations statewide that enables the State to gather background ground water quality data from various aquifers in the State. Arkansas monitors water quality in 100 wells and 10 springs once every 3 years. The wells and springs are monitored for specific constituents likely to be found in the respective areas. Monitoring wells located at industrial or landfill sites regulated by the Resource Conservation and Recovery Act (RCRA) or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are monitored at least annually, but only for indicator parameters required by the regulations

Ohio – Tracking Ground Water Quality Using GIS

The Ohio Environmental Protection Agency Division of Drinking and Ground Waters is responsible for characterizing Ohio's ground water quality. The Division has collected an extensive amount of ground water quality data through three monitoring programs: the Ambient Network, the Pollution Source Network, and the Nonpoint Source Network. The Ambient Network currently includes approximately 200 well stations at nearly 150 sites. Of the total sites, roughly 110 (70%) are public water systems and roughly 40 (30%) are industrial/commercial water suppliers. Raw water samples are collected semiannually and are analyzed for a series of inorganic constituents. Organic constituents are analyzed at least annually.

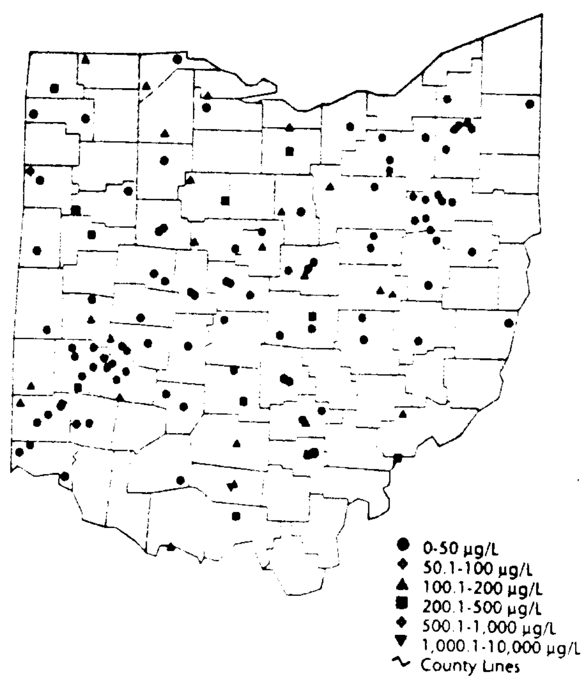
Until recently, the ambient ground water data were kept solely in hard-copy files. However, during the past 2 years, the data were entered into a comprehensive database system, and locational information pertaining to each well station was entered into a GIS. In using the GIS program, the Ohio EPA has gained the ability to provide both graphical and numerical summaries of their monitoring data. Several preliminary plots are presented in Figures 6-10 and 6-11.

Indicators of Ground Water Quality

Developing the ability to characterize trends in ground water quality over space and time was one of the key recommendations of EPA's 1986 Ground-Water Strategy. However, data collection and organization varies among the States, and a single data source for

Figure 6-11

Ambient Ground Water Data from Ohio: Geographic Barium Plot – Preliminary Averages



Source: 1994 Ohio Water Resource Inventory, State of Ohio Environmental Protection Agency.

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Ground Water Quality Indicators

EPA's 1986 Ground-Water Strategy recommended that States develop the ability to characterize trends in ground water quality over time. To support this goal, EPA's Ground Water Protection Division has been involved in the Intergovernmental Task Force for Monitoring Water Quality (ITFM), which has developed a set of environmental indicators that EPA and the States may use to target monitoring efforts and set priorities in ground water protection activities.

Selection of ground water indicators by the ITFM was based on their relevance to important water quality issues, such as human health protection, monitoring objectives, and the existence of appropriate analytical methodologies. The following criteria were considered in the selection of indicator parameters for ground water monitoring:

- Is the indicator parameter potentially toxic to human health and the environment, livestock, and/or beneficial plants?

- Does the presence of the parameter (e.g., hardness, iron, taste, odor, color) impair the suitability of the water for general use?

- Is the parameter of concern in surface water and is it easily transported from ground water to surface water?

- Is the parameter an important "support variable" for interpreting the results of physical and chemical measurements (e.g., temperature, specific conductance, major ion balance, depth to the water table)?

- Is analysis of the parameter affordable using well-established analytical methods at appropriate minimum detection and reporting levels necessary to achieve the objectives of the study?

Due to regional differences in the relative importance of water quality issues and the potential for significant differences in the objectives of monitoring programs, no one set of indicators is suitable or appropriate for all monitoring programs. However, the following table provides examples of ground water monitoring parameters that could be considered for monitoring in areas of differing land use and contaminant sources. The table focuses on classes of contaminants, including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), petroleum hydrocarbon compounds, pesticides, and pathogens. The table does not include physical indicators such as color, odor, pH, specific conductance, temperature, or total dissolved solids because these six indicator compounds are suggested for each of the categories in the table.

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The abbreviated table below provides a starting point for evaluating the relationship between land use patterns and likely contaminant loading to ground water. Monitoring agencies may tailor this list by reviewing existing data to determine what parameters are likely to be present in a given area. If documented occurrences of a particular parameter exist, that parameter should be included in the monitoring program.

If not, the likelihood that that parameter will be present in the ground water system must be determined. For example, whether potential sources of the contaminant exist in the area, whether the physical and chemical properties of the indicator parameter are likely to enhance mobility in the environment, and whether the aquifer system is susceptible to contamination must be considered.

Potential Indicator Parameters Based on Land Use

Land Use	Municipal		Domestic	Commercial	Agricultural
Parameters	Landfill	Sewer/ Pipeline	Storage Tanks	Property	Animal Feedlots
VOCs	●		●		
PCE	●				
TCE	●				
1,1-DCE	●				
Vinyl Chloride	●				
SVOCs	●		●		
PCP	●				
PAHs	●				
Dioxins	●				
PCBs	●				
Petroleum Hydrocarbons	●		●	●	
BTEX	●	●	●	●	
Pesticides				●	●
Pathogens		●			●
Nitrate		●			●

characterizing ground water quality does not exist for purposes of this report. To amend this problem, the Office of Ground Water and Drinking Water developed a set of indicators to track progress and set priorities in ground water protection efforts. The initial (1992) set of ground water indicators included

- MCL violations in public drinking water systems supplied by ground water, and the population at risk from these violations
- Extent of ground water contamination resulting from hazardous waste sites, and the population at risk from exposure to this contamination
- Detections and levels of VOCs in ground water
- Detections and levels of nitrates in ground water
- Extent of leachable agricultural pesticide use.

In its guidelines for preparation of the 1992 State 305(b) reports, EPA encouraged States to use one or more of the above indicators to characterize ground water quality. As development of ground water indicators progressed, more explicit guidance was provided to the States for preparation of their 1994 State 305(b) reports.

The 1994 guidelines focused on four indicators specifically selected to provide a relative indication of the condition of ground water resources. The selected indicators were based on existing data and/or data that could readily be collected by the States over time. Where data were available, the States were encouraged to report the following:

- Number of MCL exceedances for ground-water-based or partially ground-water-supplied community water systems
- Number of ground-water-based or partially ground-water-supplied community water systems with reported MCL exceedances
- Number of ground-water-based or partially ground-water-supplied community water systems with detections between 50% and 100% of the MCLs
- Number of ground-water-based or partially ground-water-supplied community water systems that have local Wellhead Protection Programs in place.

Although this was the first time EPA had requested information specific to ground-water-based or partially ground-water-supplied public water systems, 21 States were able to provide quantitative data characterizing at least one of the above indicator parameters. States most frequently reported the total number of samples analyzed for metals, VOCs, pesticides, and nitrates, along with the number of exceedances in each category.

The above set of indicator parameters is being refined so that, over time, it can be used to detect and predict changes in ground water quality resulting from human effects and to assess the overall effectiveness of State ground water monitoring programs.

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Ground Water: What We Still Need to Know

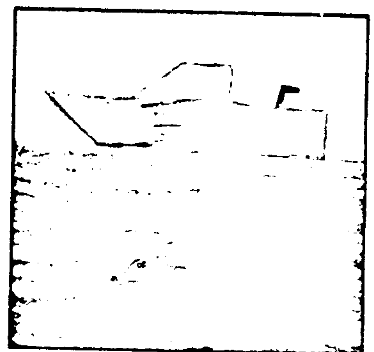
We are continuing to learn a great deal about the nature and quality of our Nation's ground water. Still, there is much we do not yet know about how to most effectively protect and preserve this vast and often vulnerable resource.

While the importance of ground water as a source of water in private wells is recognized, the quality of the water drawn from those wells is largely unknown. There are indications that private wells are vulnerable to contamination from microorganisms, nitrates, and pesticides. The occurrence of viruses in ground water and their impacts on private drinking water wells are poorly understood. Furthermore, the risks associated with redirecting surface water runoff into surface impoundments and infiltration ponds are frequently overlooked.

Whereas ground water protection measures are accepted as a "good idea," the performance of these measures in improving the quality of vulnerable ground water has not been tested. What are the differential impacts of nonpoint source best management practices on ground water and surface water? How effective are wellhead protection approaches in areas with fractured bedrock, sinkholes, or areas near surface water features? What are the indicators that should be used to track ground water quality and assess change over time?

We are only beginning to understand the capacity of the land to assimilate contaminants without adversely affecting the use of the ground water. Scientists have only begun to explore the effectiveness of natural ecosystems in processing and degrading contaminants. Many people are able to drink untreated ground water because natural processes improve water quality. Natural ground water systems may remove contaminants that conventional treatment does not address, such as pesticides, heavy metals, and a variety of toxic chemicals present at low concentrations. Ground water organisms are continually found and identified, yet their function in contaminant degradation and their impacts on ground water quality are only beginning to be understood. The interactions between ground water and surface water are known to be significant at the local level, but we do not often recognize the larger-scale implications on the quality of both resources.

Our continued quest for high quality and representative information about the status of our ground water resources will help to answer these questions. Through a greater understanding of how human activities have influenced the quality of our waters, we can better ensure the long-term availability of high-quality water for future generations.


Alisha Batten, age 8, Bruner Elementary, North Las Vegas, NV

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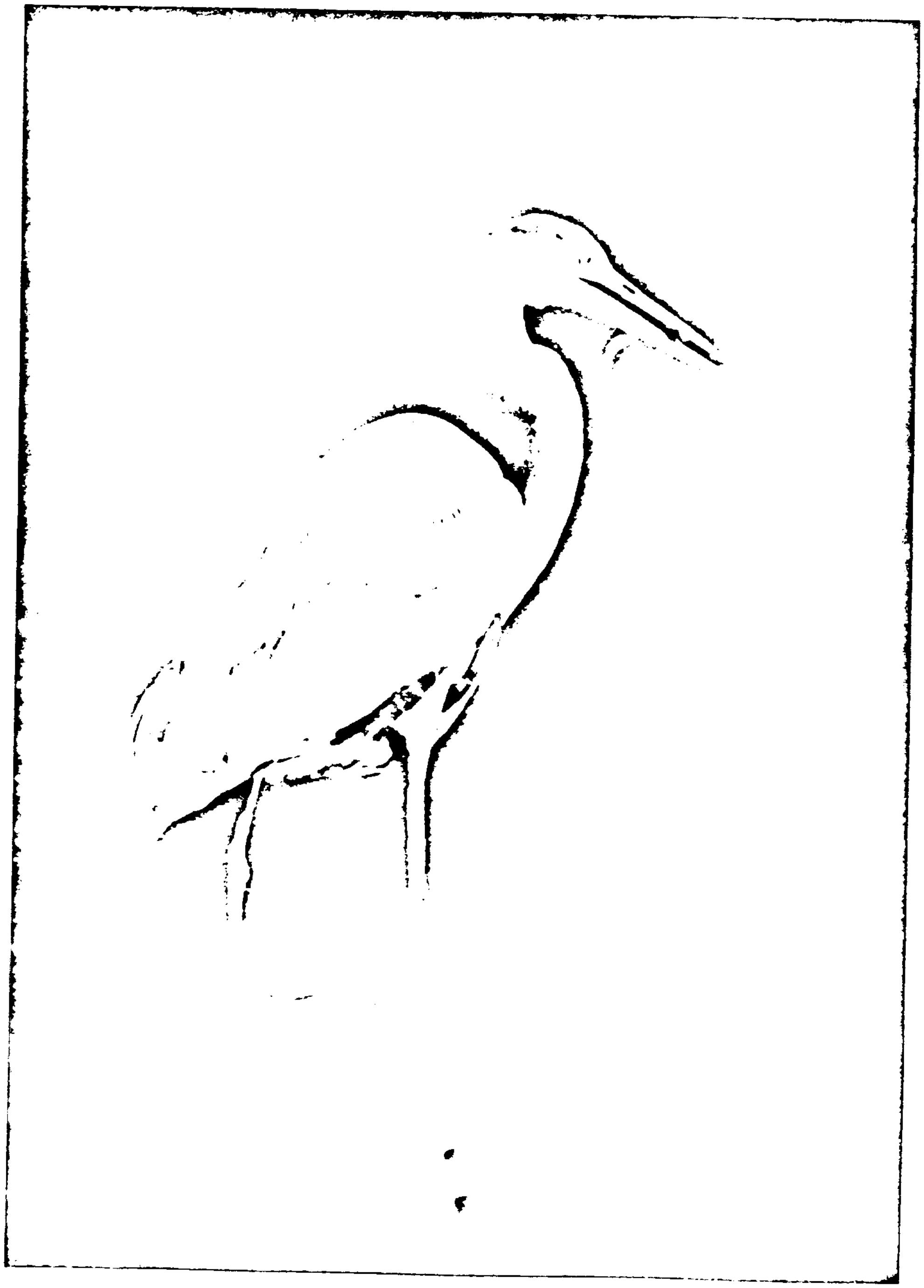

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Public Health and Aquatic Life Concerns

Water pollution threatens public health by contaminating seafood, drinking water supplies, and recreational waters with toxic substances as well as pathogenic viruses and bacteria, which cause disease. Aquatic organisms tolerate most bacteria and viruses pathogenic to humans, but many aquatic organisms are more sensitive to toxic substances than humans are. Aquatic organisms also suffer if chemical and physical conditions exceed an acceptable range. Important chemical and physical conditions include acidity (pH), dissolved oxygen concentration, and temperature.

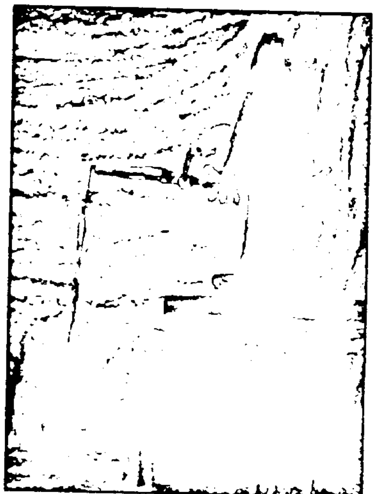
Public Health Concerns

Toxic Pollutants

Health officials link waterborne toxic pollutants, such as mercury, PCBs, and some pesticides with human birth defects, cancer, neurological disorders, and kidney ailments. Once discharged to surface waters, these toxicants persist in the sediments and contaminate the food chain and the overlying water. Waterborne toxicants can enter human systems via ingestion of contaminated fish, shellfish, or drinking water supplies. Swimmers may also swallow toxic substances or absorb toxic pollutants through skin exposure in contaminated recreational waters. Fish and shellfish contamination usually poses a greater human health risk than does contaminated drinking water or recreational waters because fish and shellfish concentrate many toxic substances in their tissues (see sidebar, page 128). As a result, the concentration of toxicants within fish and shellfish tissues may be from ten to one million times the concentration of toxicants in the surrounding waters.

Fish Consumption Advisories

States issue fish consumption advisories to protect the public from ingesting harmful quantities of toxic pollutants in contaminated fish and shellfish. In general, advisories recommend that the public limit the quantity and frequency of consumption of fish caught in specific waterbodies. The States tailor individual advisories to minimize health risks based on contaminant data collected in their fish tissue sampling programs. Advisories may completely ban fish consumption in severely polluted waters or limit fish consumption to several meals per month or year in cases of less severe contamination. Advisories may target a subpopulation at risk (such as



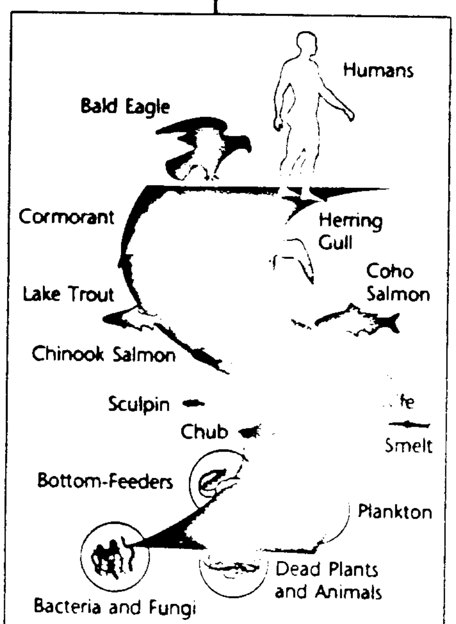
Michael Lira, age 8, Bruner Elementary, North Las Vegas, NV

Many toxic chemicals concentrate in fish and shellfish.

Bioaccumulation of Pollutants in the Food Chain

Certain organic pollutants (such as PCBs and DDT) have two properties that lead to high bioaccumulation rates. These pollutants are hydrophobic (i.e., do not have an affinity to water) and thus attach to the surface of particulates such as clay particles and small aquatic plants called phytoplankton. These organic pollutants are also lipophilic (i.e., have an affinity to lipids or fatty tissues) and readily dissolve in fatty tissues of plants and animals. As a result, these pollutants biologically accumulate (bioaccumulate) in phytoplankton at concentrations that greatly exceed the pollutant concentrations in surrounding waters, which may be so low that they cannot be measured even by very sensitive methods.

Small fish and zooplankton (microscopic grazers) consume vast quantities of phytoplankton. In doing so, any toxic chemicals accumulated by the phytoplankton are further concentrated in the fish, especially in their fatty tissues. These concentrations are increased at each level in the food chain. This process of increasing pollutant concentration through the food chain is called biomagnification.



The top predators in a food chain, such as lake trout, coho and chinook salmon, and fish-eating gulls, herons, and bald eagles, may accumulate concentrations of a toxic chemical high enough to cause serious deformities or death or to impair their ability to reproduce. The concentration of some chemicals in the fatty tissues of top predators can be millions of times higher than the concentration in the surrounding water.

Eggs of fish-eating birds often contain some of the highest concentrations of toxic chemicals. Thus, the first apparent effects of a toxic chemical in a waterbody may be unhatched eggs or dead or malformed chicks. Scientists monitor colonies of gulls and other aquatic birds because these effects can serve as early warning signs of a growing toxic chemical problem.

Biomagnification of pollutants in the food chain is also a significant concern for human health. To protect their residents from these risks, States issue fish consumption advisories or warnings about eating certain types of fish.

Source: Adapted from *The EPA Great Waters Program: An Introduction to the Issues and the Ecosystems*, 1994, EPA-453/B-94/030, Office of Air Quality Standards, Durham, North Carolina.

children, pregnant women, or nursing mothers), specific fish species that concentrate toxic pollutants in their flesh, or larger fish within a species that may have accumulated higher concentrations of a pollutant over a longer lifetime than a smaller (i.e., younger) fish.

EPA evaluates the national extent of toxic contamination in fish and shellfish by counting the total number of waterbodies with consumption advisories in effect. EPA used its database, the National Listing of Fish Consumption Advisories, to tabulate the number of State advisories. EPA built the database to centralize fish consumption advisory information separately maintained in various State agencies and the U.S. Fish and Wildlife Service. EPA contacted each State in the fall of 1994 to update the database.

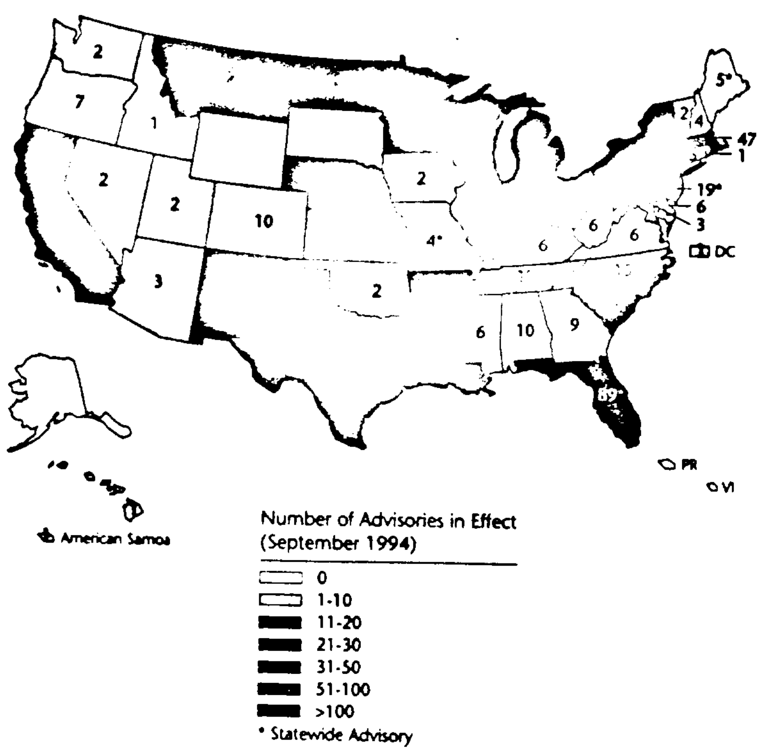
The 1994 EPA National Listing of Fish Consumption Advisories listed 1,531 advisories in effect in 47 States, the District of Columbia, and American Samoa (Figure 7-1). The database counts one advisory per waterbody, regardless of the number of species affected and the number of toxic pollutants detected at dangerous concentrations in fish sampled within a waterbody (see Appendix E, Table E-1, for individual State data).

EPA cannot identify States with a high proportion of toxic contamination based solely on the number of fish consumption advisories issued by each State. National statistics on advisories are difficult to interpret because the intensity and coverage of State monitoring programs vary widely from State to State and each State can set its own criteria for issuing advisories. Simply comparing the total number of fish advisories in each State unfairly penalizes States with superior toxicants monitoring programs and strict criteria for issuing consumption warnings.

The EPA has advocated consistent criteria and methods for issuing

Figure 7-1

Fish Consumption Advisories in the United States



Note: States that perform routine fish tissue analysis (such as the Great Lakes States) will detect more cases of fish contamination and issue more advisories than States with less rigorous fish sampling programs. In many cases, the States with the most fish advisories support the best monitoring programs for measuring toxic contamination in fish, and their water quality is no worse than the water quality in other States.

Based on data contained in the EPA National Listing of Fish Consumption Advisories acquired from the States in September 1994 (see Appendix E, Table E-1, for individual State data)

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fish consumption advisories in several recent publications and workshops (see sidebar, page 131). However, it will be several years before the States implement consistent methods and criteria and establish a baseline inventory of advisories. EPA expects the States to issue more advisories as they sample more sites and detect contamination that previously went undetected.

Mercury, PCBs, chlordane, dioxins, and DDT (with its byproducts) caused almost all of the fish consumption advisories in effect in 1994 (Figure 7-2). EPA and the States have banned or restricted the use of PCBs, chlordane, and DDT for over a decade, yet these chlorinated hydrocarbon compounds persist in sediments and fish tissues and still threaten public health.

During the 1990s, the States began reporting widespread mercury contamination in fish. As States expanded their fish tissue monitoring programs, they found elevated concentrations of mercury in fish inhabiting remote lakes that were previously considered unpolluted. States from Wisconsin to Florida reported widespread mercury contamination in fish collected primarily from lakes. The source of the mercury contamination is difficult to identify because mercury naturally occurs in soils and rock formations. Natural processes, such as weathering of mercury deposits, release some mercury into surface waters. However, resource managers believe that human activities have accelerated the rate at which mercury accumulates in our waters and enters the food web.

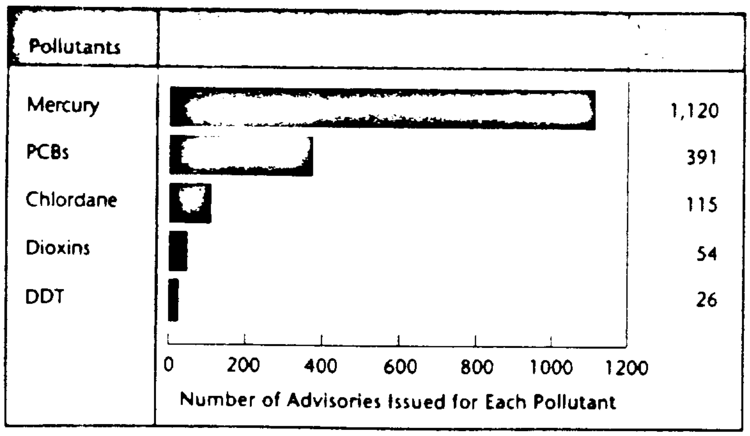
Air pollution may be the most significant source of mercury contamination in surface waters and fish. According to EPA's Toxics Release Inventory, almost all of the mercury released by permitted polluters enters the air; industries and waste treatment plants discharge very little mercury directly into surface waters. Emissions from waste incinerators, coal-fired plants, smelters, and mining operations may carry mercury many miles to remote watersheds (see sidebar, page 132). Other potential sources of mercury contamination include slag heaps from metal mines and land-disturbing activities that may mobilize natural mercury deposits, such as channelization, reservoir construction, and drainage projects.

Air emissions may further aggravate mercury contamination by generating acid precipitation that increases acidity in lakes. The accumulation of mercury in fish appears to correlate with acidity in a waterbody. Slightly acidic conditions promote the chemical conversion of mercury to a methylated form that

MERCURY
is the most common contaminant found in fish.

Figure 7-2

Pollutants Causing Fish Consumption Advisories



Based on data contained in Appendix E, Table E-2.

is more readily available for uptake and accumulation in fish. States, such as Louisiana, are using this correlation to target waterbodies with acidic pH and low buffering capacity for mercury sampling in fish.

EPA sponsored a symposium to gather and exchange the available information on mercury contamination in fish. The National Forum on Mercury in Fish met in September of 1994 to examine fate and transport of mercury in the environment and methods to assess the health effects of mercury.

The EPA Fish Consumption Advisory Database does not identify sources of contamination in fish. Sources of contamination are difficult to isolate because migratory fish may be exposed to toxic pollutants in the sediments and water column or may ingest toxic contaminants concentrated in prey miles from the sampling areas where they are collected. Furthermore, migratory or resident fish may be exposed to toxic pollutants that have been transported great distances from where they originated.

Bacterial and Viral Contamination

Waterborne viral and bacterial pollutants may also cause serious human illness and death. People can contract infectious hepatitis, gastroenteritis, dysentery, and cholera from waters receiving inadequately treated sewage. Bacteria and viruses may enter human systems through contact with contaminated swimming and bathing waters or through ingestion of contaminated drinking water or shellfish.

Shellfish Contamination

Contaminated shellfish pose a public health risk particularly to those who consume raw shellfish. Shellfish, such as oysters, clams, and mussels, extract their food (plankton) by filtering water over their gills. In contaminated waters, shellfish accumulate bacteria and viruses on their gills and mantle and within their digestive systems. If shellfish grown in contaminated waters are not cooked properly, consumers may ingest live bacteria and viruses.

To protect public health, the U.S. Food and Drug Administration administers the National Shellfish Sanitation Program (NSSP). The NSSP establishes minimum monitoring requirements and criteria for State shellfish programs that want to participate in interstate commerce of shellfish. States cannot sell shellfish outside of their State boundaries unless their shellfish sanitation program follows NSSP protocols. Coastal States routinely monitor shellfish harvesting areas for bacterial contamination and restrict shellfish harvests in contaminated waters. Most often, States measure concentrations of fecal coliform bacteria such as *Escherichia coli*, which are nonpathogenic bacteria that populate human digestive systems and occur in fecal wastes. Their presence in water samples is an indicator of sewage contamination that may pose a human health risk from pathogenic viruses and bacteria. Fecal bacteria, however, may exceed criteria even when no human sewage is present because birds and nonhuman mammals also excrete them.

The NSSP recognizes three types of shellfish harvesting restrictions:

In 1990, EPA began developing technical guidance to help the States adopt consistent criteria and methods for issuing fish consumption advisories. The guidance consists of four volumes:

- *Volume I: Fish Sampling and Analysis* recommends standard methods for sampling and analyzing contaminants in fish tissue.
- *Volume II: Risk Assessment and Fish Consumption Limits* suggests protocols for selecting criteria for unsafe concentrations of contaminants in fish.
- *Volume III: Risk Management* suggests protocols for determining if the health risk justifies issuing an advisory.
- *Volume IV: Risk Communication* recommends methods for informing the public about fish consumption advisories.

EPA published the first edition of Volume I in 1993 and released a second edition in the Fall of 1995. Volume II was issued in 1994. Volume III is due to be released in 1996, and Volume IV was released in the Spring of 1995. EPA presented the first two volumes to State, Tribal, and Regional managers at two workshops in 1994.

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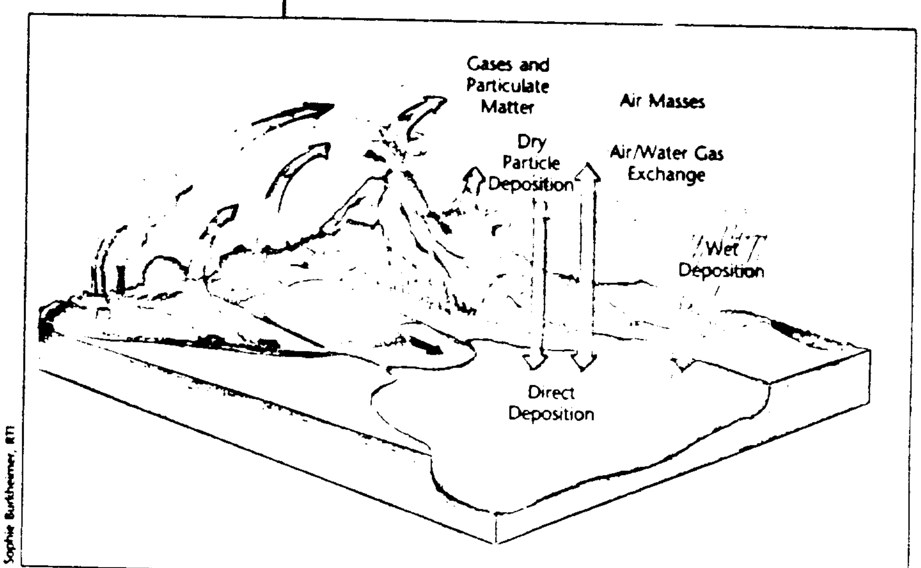
Air Pollution Impacts on Water Quality

- Pollutants are released into the air from man-made or natural sources. Man-made sources include industrial stacks, municipal incinerators, pesticide applications, and vehicle exhaust. Natural sources can be volcanic eruptions, windblown gases and particles from forest fires, windblown dust and soil particles, and sea spray.

- Pollutants released to the air are carried by continental wind patterns away from their areas of origin. Depending on weather conditions and the chemical and physical properties of the pollutants, they can be carried varying distances from their sources and can undergo physical and chemical changes as they travel.

- Air pollutants are deposited to the earth or directly to waterbodies by either wet or dry deposition. Wet deposition occurs when pollutants are removed from the air by falling rain or snow. Dry deposition occurs when particles settle out of the air by gravity or when gases are transferred directly from the air into water. Air pollutants that deposit on land can be carried into a waterbody by stormwater runoff.



Source: Adapted from *The EPA Great Waters Program: An Introduction to the Issues and the Ecosystems*, 1994, EPA-453/B-94/030, Office of Air Quality Planning and Standards, Durham, North Carolina

- **Prohibited Waters** violate criteria consistently; therefore, shellfish cannot be harvested at any time.

- **Restricted Waters** may be harvested if the shellfish are transferred to clean waters to reduce concentrations of bacteria.

- **Conditionally Approved Waters** temporarily exceed bacteriological criteria following predictable events (such as a storm). Shellfish from these waters may be harvested when criteria are met.

The size of waters with shellfish harvesting restrictions does not equate with the size of polluted estuarine waters because States sometimes restrict harvesting in clean waters. The NSSP requires that a State prohibit shellfishing in clean waters if the State cannot monitor a waterbody on a routine schedule that ensures rapid detection of unsafe conditions. As a result, funding for monitoring activities can raise or lower the size of waters classified as "prohibited" even if water quality does not change. Georgia, for example, reported that funding for a new laboratory position during 1992 and 1993 restored shellfishing to clean waters previously classified as "prohibited" due to a lack of monitoring.

As a preventive measure, the States also automatically prohibit the harvest of shellfish near marinas and pipes that discharge wastewater. These closures protect the public from accidental releases of contaminated wastewater due to treatment plant malfunctions or overflows during severe weather. The preventive closures apply to marinas because fecal bacteria concentrations may increase during high use periods, such as weekends. The States prohibit shellfishing in these waters even though these waters may not contain harmful concentrations of fecal bacteria most of the time.

Despite these drawbacks, the size of waters with shellfishing restrictions is our most direct measure of impacts on the shellfishing resource. However, only 16 of the 27 coastal States and Territories reported the size of their estuarine waters affected by shellfish harvesting restrictions (Table 7-1). With so

Table 7-1. Shellfish Harvesting Restrictions Reported by the States

State	Number of Waterbodies with Restrictions	Area Affected (sq. miles)
Alabama	3	533.0
Alaska	—	—
California	—	—
Connecticut	—	—
Delaware	—	—
Delaware River Basin	1	33.2
District of Columbia[a]	—	—
Florida	51	2,186.1
Georgia	—	506.2
Hawaii	0	0
Louisiana	26	—
Maine	238	170.0
Maryland	—	176.3
Massachusetts	—	561.2
Mississippi	—	—
New Hampshire	11	18.7
New Jersey	—	164.2
New York	67	306.5
North Carolina	—	—
Oregon	—	56.5
Puerto Rico	—	—
Rhode Island	20	53.6
South Carolina	99	323.6
Texas	25	802.8
Virginia	192	160.5
Virgin Islands	—	—
Washington	—	—
Totals	733	6,052.4

[a] The District of Columbia prohibits commercial harvest of shellfish in all of its waters.

Source: 1994 State Section 305(b) reports.

— Not reported in a numerical format.

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few States reporting numerical data, EPA cannot summarize the national scope of shellfish harvesting conditions at this time. The National Oceanic and Atmospheric Administration is developing a database to track State restrictions that should provide a more complete profile of shellfishing conditions in the future.

The reporting States prohibit, restrict, or conditionally approve shellfish harvesting in 6,052 square miles of estuarine waters. About one-third of these waters are conditionally approved, so the public can harvest shellfish from these waters when the State lifts temporary closures. For comparison, 12 States reported that almost 8,000 square miles of estuarine waters are fully approved for harvesting shellfish at all times (Appendix E, Table E-3, contains individual State data).

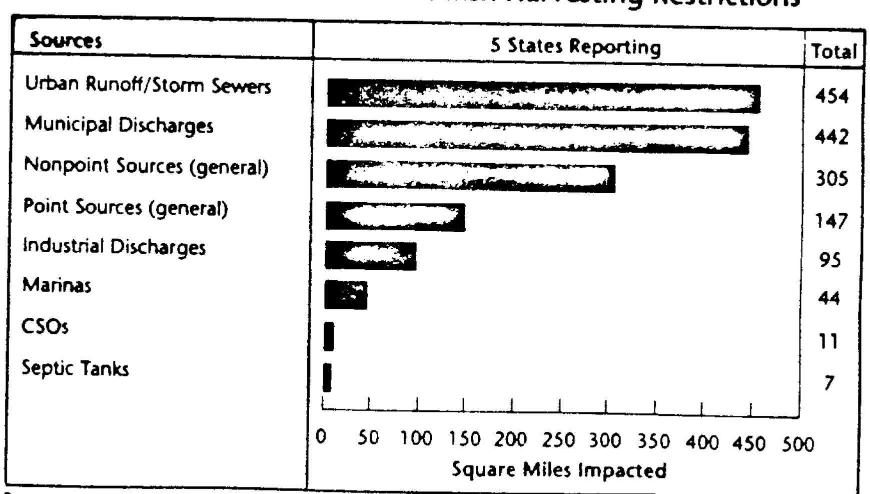
Only five States reported the size of shellfish restrictions caused by specific sources of pathogen indicators (Figure 7-3). Other States provided narrative information about sources degrading shellfish waters.

- Georgia reported that the State prohibits shellfish harvesting in 362 square miles of its waters. Harvesting is prohibited in 280 square miles of potential shellfish waters due to a lack of data. Most of Georgia's other restricted areas are closed because of their proximity to industrial discharge pipes and marinas.

- Louisiana reported that sewage treatment plant upgrades expanded areas open for shellfish harvesting, but the size of healthy oyster growth zones still decreased because of nonpoint source pollution, sewage from camps, saltwater intrusion, and marsh erosion.

Figure 7-3

Sources Associated with Shellfish Harvesting Restrictions



Based on data contained in Appendix E, Table E-4.

■ Maryland reported that nonpoint source runoff is the most pervasive source of bacterial contamination in the State's shellfish waters. Other sources include boating activity, agricultural runoff, seafood processing, and combined sewer overflows.

■ New Hampshire reported that the State has upgraded and constructed five treatment plants in recent years and eliminated several combined sewage outfalls discharging into coastal waters. The State plans to upgrade the four remaining sewage plants discharging into coastal waters and begin addressing nonpoint sources, such as septic tanks, by 1997.

Drinking Water Concerns

After decades of concerted effort, Americans can generally turn on their taps without worry about the quality of the drinking water that flows out. Yet many important questions about drinking water safety remain unsettled. The EPA reviewed available information concerning the safety of public water supplies and discovered that there are pockets of serious trouble, gaps in information, and emerging threats to drinking water safety.

Rising consumer awareness of pollution and other environmental problems has raised concerns about drinking water safety:

■ A 1993 survey commissioned by the National Geographic Society found that nearly one-third of Americans believe that their drinking water is either contaminated or may become contaminated in the future.

■ The rising sales of bottled water, now exceeding 2.2 billion gallons annually with a wholesale value estimated at over $2.4 billion, bear testimony to consumer concerns over tap water quality.

■ Consumer and environmental groups have lobbied for improved public information and education on drinking water safety issues, including monitoring, source water protection, and drinking water treatment.

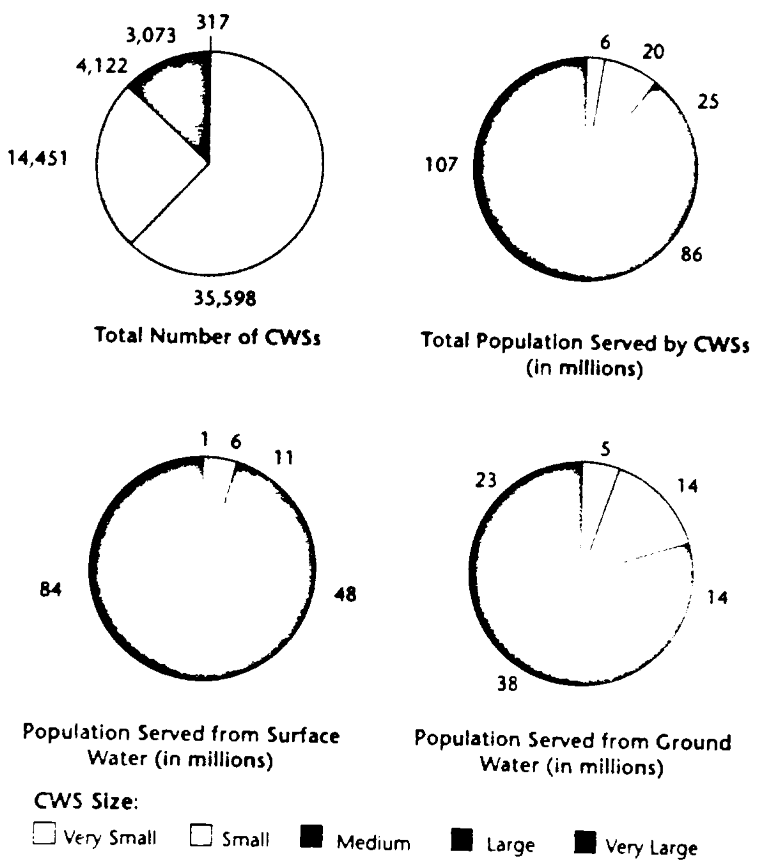
There are approximately 57,600 Community Water Systems that provide year-round drinking water to the homes of approximately 244 million Americans (roughly 90% of all U.S. households) (Figure 7-4). The EPA also regulates over 140,000 additional systems that provide year-round drinking water to people at schools, roadside rest stops, and other facilities. These community and noncommunity systems draw water from surface water or ground water and are subject to the drinking water regulations set forth under the Safe Drinking Water Act. Under this Act, water suppliers are required to conduct tests to determine whether drinking water quality meets safety standards (Figure 7-5). The suppliers must then report the results to the State agency responsible for drinking water protection.

Community Water Systems

The EPA estimates that almost 10% of Community Water Systems have experienced one or more violations of Federal safety standards in the past few years. Most of the violations relate to actual contamination by microorganisms or lead or the failure to adequately test drinking water quality. In fact, one system out of every three conducts only part of the monitoring required to verify drinking water safety.

Figure 7-4

Number of Community Water Systems (CWSs) and Population Served by Size of System



National Primary Drinking Water Regulations

The EPA has promulgated National Primary Drinking Water Regulations (NPDWRs) covering 84 contaminants. These contaminants include 21 volatile organic compounds, 35 synthetic organic compounds, 18 inorganic compounds, three radionuclides, five microorganisms, a water quality indicator, and a disinfection byproduct. Most of these regulations relate to contaminants that may be introduced into source water due to land use practices near the water supply. The NPDWRs provide enforceable standards that protect the quality of the Nation's drinking water.

Drinking Water Quality and Microbiological Contaminants

Thanks to basic drinking water disinfection, drinking water in the United States is virtually free of certain diseases. Cholera and typhoid fever, which afflict many people in other nations, have been effectively removed from our drinking water supplies. However, Americans are not free of drinking water problems posed by microbiological contaminants. Many of the following problems were due to microbiological contamination of source waters.

- In 1993, an estimated 403,000 residents of Milwaukee became ill from an outbreak of the common waterborne protozoan, *Cryptosporidium.*

- Residents of Sheboygan, Wisconsin, parts of New York City, and a large portion of the Washington,

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DC, metropolitan area were advised to boil their tap water due to risks of microbiological contamination.

- States report that more than 850 Community Water Systems, collectively serving more than 1 million people, were ordered to issue "boil water" advisories.

- Drinking water contamination was not uncommon in 1993 following the summer floods in the midwestern and southern States.

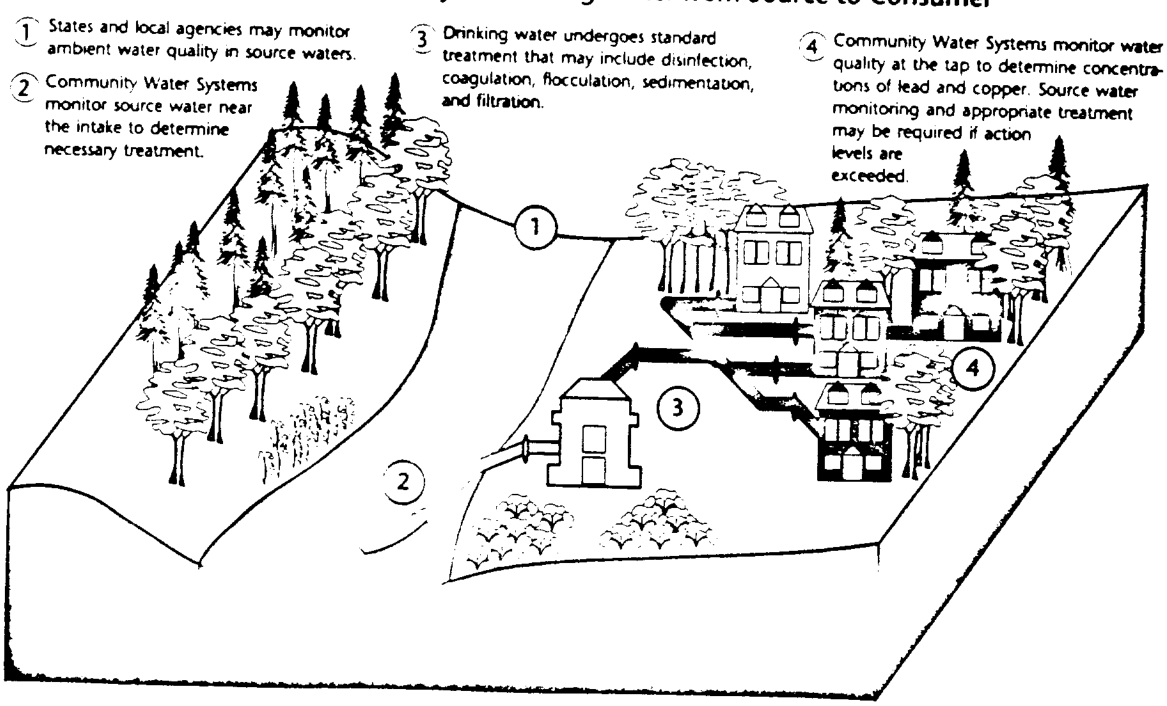
- In 1993, 67% of the Community Water Systems that violated NPDWRs did so by failing to meet microbiological requirements.

Drinking Water Quality and Chemical/Radiological Contaminants

A total of 16,294 Community Water Systems (nearly 29%) experienced violations of NPDWRs in 1992. Approximately 32% of Community Water Systems experienced violations of NPDWRs in 1993. Violations occurred in virtually every State and influenced the water quality of approximately 63 million people. Most of the violations affected very small systems serving between 25 and 500 people. The following violations of health-based standards occurred in 1993.

Figure 7-5

Monitoring the Quality of Drinking Water from Source to Consumer



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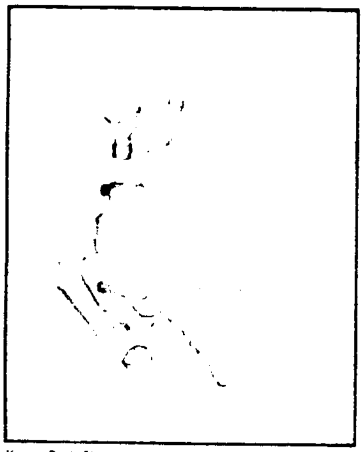


Kings Park Elementary, 3rd Grade, Springfield, VA

- The drinking water supplied to nearly 11% of the population served by Community Water Systems (26.5 million people) violated health-based standards.

- 1,516 Community Water Systems experienced violations for inorganic contaminants. These violations affected 7.2 million people.

- 852 Community Water Systems experienced violations for organic contaminants. These violations affected 8.7 million people.

- 576 Community Water Systems experienced violations for radiological contaminants. These violations affected 1.3 million people.

- 574 Community Water Systems experienced serious, frequent, or persistent noncompliance with chemical or radiological requirements (11% violated health-based standards for nitrate, 3% for fluoride, and 3% for radium).

- 12 Community Water Systems and 22 Noncommunity Water Systems experienced health-based violations related to trichloroethylene, a carcinogen used in textiles, adhesives, and metal degreasers.

- Other organic chemicals that caused health-based violations in drinking water supplies include atrazine, ethylene dibromide, and benzene.

Except for naturally occurring contaminants such as fluoride and radium, all of the violations mentioned above resulted from land-use practices near the affected water supplies.

The Benefits and Costs of Keeping Our Drinking Water Safe

As with many other environmental concerns, it is difficult to quantify the benefits of maintaining safe drinking water. As more water supply systems meet the standards set forth in the Act, EPA estimates that the following national health benefits may be realized.

- Reduced lead exposure for approximately 50 million Americans, and protection of approximately 200,000 children from dangerous levels of lead in their blood

- Prevention of more than 100,000 cases of gastrointestinal illnesses

- Reduced exposure to dozens of toxic contaminants that may affect the drinking water of millions of Americans

- Avoidance of more than 100 excess cancer cases each year from reduced exposure to carcinogenic contaminants in drinking water.

The costs of compliance with the Safe Drinking Water Act have also been estimated. These estimates are based on appraisals of the number of water supply systems that will need to invest in treatment to meet drinking water standards and anticipated treatment costs.

- The national costs attributable to compliance with existing drinking water safety regulations are estimated to be $1.4 billion annually.

- The projected effect on household water bills ranges from an increase of 25 cents per month for systems serving 1 million or more households to $12 per month for systems serving 100 or fewer households.

- Greater than two-thirds of the estimated costs relate to control of microbiological contaminants and lead in drinking water.

- The projected effect of monitoring requirements on household water bills ranges from an average of 1 cent to 35 cents per month for 90% of American households.

- For small Community Water Systems, however, the projected effect of monitoring requirements could exceed $10 per month.

Protecting Drinking Water Sources

Land use in both urban and rural settings may pose chemical and microbiological threats to current and future drinking water supplies. Urban uses of land have more than tripled since the 1950s, rising from 18.3 million acres to 56.6 million acres. Population growth and the expansion of urban land use are likely to pose new risks of contamination in areas that may not have been at risk before. In rural areas, the use of agricultural chemicals has doubled since the 1960s. Many States list agriculture as the leading source of water quality impairment in our Nation's rivers.

In a 1988 survey of surface water utilities and State drinking water agencies, the American Water Works Association investigated the relationship between land use and water treatment. Their results suggest that more advanced water treatment practices are necessary for source waters derived from watersheds where urban or agricultural land use practices predominate.

Virtually all groups interested in drinking water safety promote stronger efforts to prevent pollution from entering drinking water sources rather than relying solely on water treatment to reduce health threats. The EPA encourages source water protection activities geared at protecting surface water and ground water that is used for drinking water supply.

Recreational Restrictions

State reporting on recreational restrictions, such as beach closures, is often incomplete because most State agencies rely on local health departments to voluntarily monitor and report beach closures. Most State agencies that prepare the 305(b) reports do not have access to an inventory of beach closures. The information obtained varies in quality because health departments that monitor infrequently will detect fewer bacteria violations than health departments with rigorous beach monitoring schedules.

Twelve States reported that there were no contact recreation restrictions reported to them during the 1994 reporting cycle, but one State mentioned that unreported closures could exist. Twenty-two States identified 374 sites where recreation was restricted at least once during the reporting cycle (Appendix E, Table E-6, contains individual State data). Local health departments closed many of these

beach closures.

sites more than once. Pathogen indicator bacteria caused most of the restrictions, but Louisiana reported that advisories remain in effect at three sites where sediments are contaminated with toxic chemicals from an industry, an abandoned creosote factory, and an abandoned hazardous waste facility.

The States identified sewage treatment plant bypasses, malfunctions, and pipeline breaks as the most common sources of elevated bacteria concentrations in bathing areas. The States also reported that runoff, failing septic systems, a livestock operation, and combined sewer overflows restricted recreational activities.

Aquatic Ecosystem Concerns

Many native aquatic organisms are more sensitive than humans to toxic pollutants. In severe cases of contamination, toxic pollutants kill all aquatic life; in less severe cases, toxic pollutants eliminate some species from the aquatic community. The aquatic system deteriorates as toxic contaminants poison aquatic organisms (including fish, shellfish, benthic organisms, and plants), increase their susceptibility to disease, interfere with their reproduction, or reduce the viability of their young. Toxic pollutants also disrupt the chemical and physical balance in an aquatic ecosystem and indirectly cause mortality. Chapter 1 provides additional information about toxic pollutants.

Low oxygen concentrations, excessive temperatures, or high or low acidity can have more devastating impacts on aquatic communities than toxic pollutants. Organic pollutants (such as sewage, manure, food processing wastes, and lawn clippings) impose a biochemical oxygen demand (BOD) on receiving waters because bacteria consume oxygen as they decompose organic wastes. Nutrients also may indirectly deplete oxygen concentrations by feeding algal blooms (see Chapter 1 for a full discussion of dissolved oxygen depletion).

Acidity (the concentration of hydrogen ions measured as pH) drives many chemical reactions in living organisms. Many biological processes (such as reproduction) cannot function in either acidic (low pH) or alkaline (high pH) waters. Acidic conditions also aggravate toxic contamination problems because sediments release toxicants in acidic waters. Common sources of sulfuric acid, and, to a lesser extent, nitric acid, include mine drainage, runoff from mine tailings, and atmospheric deposition.

Alkaline conditions (high pH) may result indirectly from inputs of nutrients that induce excessive algal activity. In order to fuel photosynthesis, rapidly expanding algae populations may break down carbonate compounds after they consume all of the carbon dioxide available in the water column. As the algae convert carbonates to carbon dioxide, hydroxyl groups (OH^- ions) are released into the water column, raising the pH. Alkaline conditions (high pH) harm gill membranes on fish and other aquatic organisms. The pH may swing back down during the night as the algae halt photosynthesis and stop scavenging carbon dioxide from carbonates. At night, the algae also continue to respire, which returns carbon dioxide into the water column that can bind up the hydroxyl groups and lower pH. Such fluctuations in pH severely stress aquatic organisms.

Human activities on shore can aggravate physical and chemical conditions in waterbodies. The States report growing concern over instream impacts from removal of shoreline vegetation. Shoreline vegetation shades streams from excessive heat and binds shoreline soils together, which prevents sediment from entering the water column.

Fish Kills Caused by Pollution

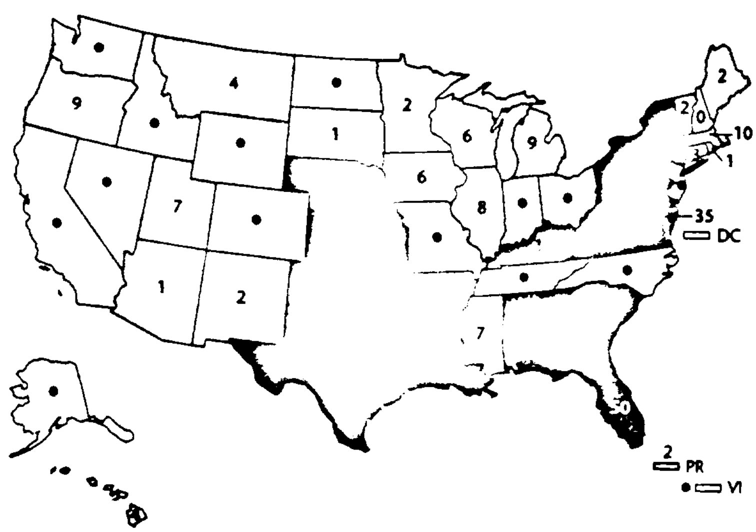
The number of fish kills provides a limited indication of pollutant impacts on aquatic life because fish kills do not always result from pollution. Both natural conditions (such as drought, low flow, and warm water temperatures) and pollution can deplete dissolved oxygen in a waterbody and suffocate fish. Pollutants may also weaken fish and make them more susceptible to natural stressors, such as disease. In many cases, investigators cannot determine if pollution, natural causes, or both caused a fish kill because there is little evidence at the site of the fish kill. The exact location of the fish kill may be a mystery because currents can carry fish downstream from the source, further complicating the investigation.

Forty States, Tribes, Commissions, and Territories submitted numerical data about fish kills in their 1994 Section 305(b) reports (Appendix E, Table E-7a, contains individual State data). Two Tribes, the District of Columbia, the Delaware River Basin Commission, and New Hampshire stated that there were no fish kill incidents reported in their waters during 1992 and 1993. Thirty-five States and one Territory reported that pollution caused 737 fish kills in their waters (Figure 7-6). **This figure underestimates the real number of fish kills in the Nation because 15 States did not provide fish kill data and fish kills in remote areas may not be detected or reported to State fish and wildlife officials.**

EPA summarized the number of kills due to pollution, natural conditions, hydrologic modification,

Figure 7-6

Number of Reported Fish Kills Caused by Pollution



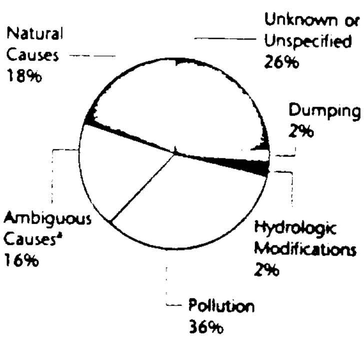
- Campo Indian Reservation
- Coyote Valley Reservation
- Gila River Indian Community
- Hoopa Valley Reservation
- Hopi Tribe
- Soboba Band of Mission Indians

- • Not Reported
- 0
- 1-10
- 11-30
- 31-70
- >70

Based on data contained in Appendix E, Table E-7a.

Figure 7-7

Causes of Fish Kills
(29 States reporting 1,454 fish kills)



Based on data contained in Appendix E, Table E-7b.

*Ambiguous causes include low dissolved oxygen without a specified source, algae blooms, red tide, disease, and thermal shock, which may be due to either pollution or natural conditions.

ambiguous causes, and unknown causes. EPA used the following criteria to classify the cause of fish kills:

- Pollution – the State clearly identified a specific pollutant responsible for the kill or clearly stated that oxygen was depleted by pollutants.

- Natural Conditions – the State used the term "natural" to describe the kill.

- Ambiguous Causes – the State attributed the kill to low oxygen concentrations, disease, red tides, algal blooms, or thermal shock and did not specify whether pollution contributed to these problems or not.

- Hydrologic Modifications – the State identified dam construction, dewatering, channelization, or drawdown as the cause of the kill.

- Dumping – throwing unwanted fish into waterbodies.

- Unknown – the State did not identify a cause of the kill.

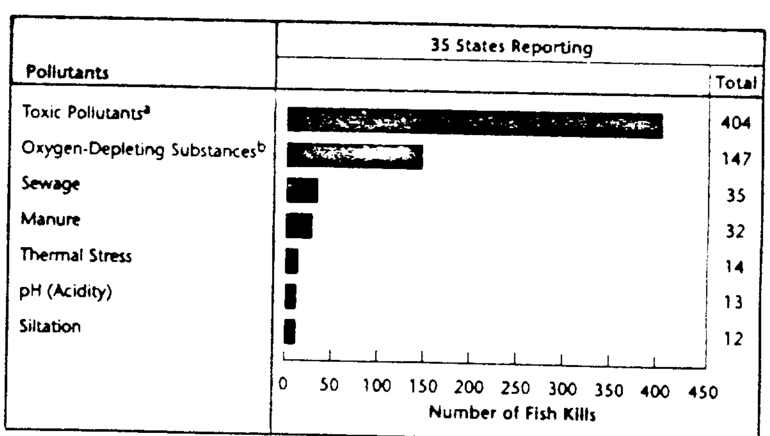
EPA classified 1,454 total fish kills in 29 States that reported both the total number of fish kills and the number due to pollution (Figure 7-7). Pollution clearly caused about one-third of the fish kills. Natural conditions caused about one-fifth of the fish kills. Almost half of the fish kills were due to unknown or ambiguous causes.

The States reported that toxic pollutants caused more than half (55%) of the fish kills attributed to human activities (Figure 7-8). Toxic pollutants include pesticides,

The States reported that toxic pollutants caused more than half (55%) of the fish kills attributed to human activities.

Figure 7-8

Pollutants Causing Fish Kills



Based on data contained in Appendix E, Tables E-8a, E-8b, and E-8c.

^a Toxic pollutants include pesticides, oil and gas, ammonia, chlorine, and unspecified toxic chemicals.

^b Oxygen-depleting substances include BOD, food processing wastes, and some industrial wastes. Does not include kills attributed to low dissolved oxygen from natural sources.

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herbicides (weed killers and defoliants), oil and gasoline products, chlorine, ammonia, metals, and unspecified hazardous substances. Pesticides were the most frequently identified toxic pollutant causing fish kills (Figure 7-9). Many pesticide kills occurred on small private lakes and ponds and impacted few fish, but several pesticide releases killed over 10,000 fish per incident. The States reported that agricultural application and runoff caused most fish kills from pesticides, but the States also reported that golf course maintenance and mosquito abatement projects released pesticides and killed fish. Historically, the most devastating pesticide kills have resulted from train derailments releasing highly concentrated pesticides and herbicides into waterbodies.

Following pesticides, oil and gasoline products (including jet fuel) and chlorine caused many fish kills. The States reported that oil and gasoline products entered waterbodies from traffic accidents, airport runoff, and leaking storage facilities. The States reported that chlorine from drinking water treatment plants, sewage plants, and swimming pools entered waterbodies in lethal concentrations. The States also reported that less common toxic pollutants caused fish kills, including road tar, deicing chemicals used at airports, and fire suppression foam used at the scene of traffic accidents.

The States reported that oxygen-depleting substances caused 20% of the fish kills attributed to human activities. In waterbodies, bacteria consume oxygen when they decompose substances containing organic plant, fish, or animal matter. Oxygen-depleting substances include food products and byproducts (such as molasses, bad milk, and seafood processing waste), agricultural feed, sewage, manure, rendering wastes, and other industrial wastes that contain plant or wood fibers. Sewage and manure can also contain high concentrations of ammonia, which is toxic to fish and other aquatic organisms. The States reported that sewage contributed to 5% of the fish kills due to pollution, and manure from animal and poultry operations contributed to 4% of the kills due to pollution.

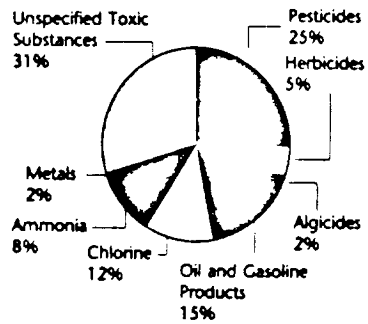
Thirty-five States listed sources of pollution causing fish kills (Figure 7-10). These States identified agriculture as the leading source of fish kills. Agricultural runoff may contain manure and fertilizer, in addition to pesticides and herbicides. Sewage treatment plants followed agriculture as the leading source of fish kills. Sewage treatment plants also release ammonia, nutrients, and oxygen-depleting substances into receiving waters. Sewage treatment plants also cause fish kills by discharging overchlorinated effluent. The other leading sources of fish kills included industry; spills and leaks from storage tanks, trucks, barges, trains, and pipelines; nonagricultural applications of pesticides; general runoff; and drinking water systems. Less common sources of fish kills included swimming pools, petroleum activities, land disposal of wastes, bridge demolition, fountain maintenance, and dam releases.

The summary data on fish kills obscure important variations in the number of fish killed and the value of the species affected during

Figure 7-9

Toxic Pollutants Causing Fish Kills

(33 States reporting 404 fish kills due to toxic pollutants)



Based on data contained in Appendix E, Table E-8b.

individual fish kill incidents. The summary data cannot distinguish a fish kill that affected 10 fish from a fish kill that affected several hundred thousand fish. Numbers of fish killed cannot measure the value of a fish kill because consumers and anglers value some fish species more highly than others, and we do not understand the value of different species in the ecosystem. The States reported that many desirable fish species were killed by pollution, including trout, salmon, perch, mullet, shad, bass, aholehole, crappie, bluegills, menhaden, herring, and catfish.

Sediment Contamination

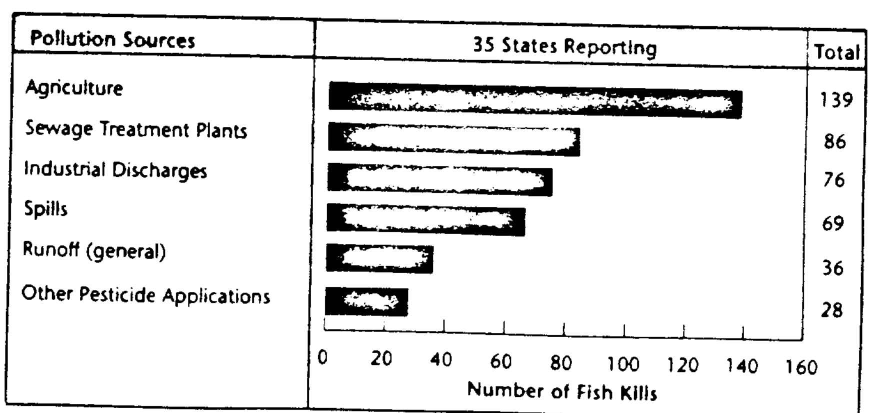
Many waterborne toxic pollutants settle to the bottom and partition between the sediment material and the solution in the interstitial water between the sediment particles. Bacteria degrade some toxicants in sediments, but many toxic contaminants (such as metals and PCBs) persist in sediments for many years after the original toxic source has been eliminated. Disruption of contaminated sediments or natural interactions may reintroduce toxicants into the water column for decades.

Dredging contaminated sediments may also reintroduce toxicants into the water column and food web. Due to these impacts, sediment contamination can obstruct maintenance dredging of harbors and navigation channels. Dredge spoil disposal methods (such as open water dumping, spreading on "reclaimed" lands, and diked containment areas) may also create new aquatic life threats.

Currently, no national criteria are in effect that define harmful concentrations of pollutants in sediment. However, EPA released draft sediment criteria for five pollutants (endrin, dieldrin, phenanthrene, fluoranthene, and acenaphthene) in January of 1994 for public comment and plans to publish final criteria for

Figure 7-10

Sources Associated with Fish Kills



Based on data contained in Appendix E, Table E-9.

the five toxicants in 1996 after responding to final comments. An approach for assessing metals contamination in sediments was presented to the EPA Science Advisory Board in January of 1995. The approach for determining metals toxicity in sediments received a very favorable review.

In 1994, 23 States reported incidents of sediment contamination in their 305(b) reports (see Appendix E, Table E-10, for individual State data). Several States preferred not to list contaminated sites until EPA publishes national criteria for screening sediment data. Other States lack the analytical tools and resources to conduct extensive sediment sampling and analysis. Therefore, the following discussion probably understates the extent of sediment contamination in the Nation's surface waters.

Twenty-two States listed 641 separate sites with contaminated sediments and identified pollutants detected in sediments. These States most frequently listed metals (e.g., mercury, cadmium, and zinc), PCBs, DDT (and its byproducts), chlordane, polyaromatic hydrocarbons (PAHs), and other priority organic toxic chemicals. These States also identified industrial and municipal discharges (past and present), landfills, resource extraction, abandoned hazardous waste disposal sites, and combined sewer overflows as the primary sources of sediment contamination.

EPA develops guidance and information sources to provide States with better tools for assessing and managing sediment contamination, including

- A compendium of sediment assessment methods (Fall 1992)
- Draft Sediment Quality Criteria for Non-ionic Organics (October 1993)
- National Sediment Inventory (Report to Congress, Spring 1996)
  - Evaluation of Contaminated Sediment Sites (Fall 1995)
  - Point Sources Inventory (Fall 1995)
  - Nonpoint Sources Inventory (Fall 1996)
- Sediment Remediation Methods (Spring 1993)
- EPA's Sediment Management Strategy will focus the Agency's resources on preventing, remediating, and managing disposal of dredged contaminated sediments (Summer 1994)
- A testing manual for evaluating sediment disposal in inland waters under Section 404 of the Clean Water Act (Spring 1994)
- Guidance documents describing methods for conducting acute toxicity tests, chronic toxicity tests, and bioaccumulation tests for sediments (Fall 1993)
- Methods for deriving sediment quality criteria for heavy metals (late 1997).

Waters Surveyed for Toxic Contamination

- River miles surveyed: 160,335
- Total river miles: 3.5 million

- Lake acres surveyed: 7.5 million
- Total lake acres: 40.8 million

- Great Lakes miles surveyed: 5,161
- Total Great Lakes shore miles: 5,559

- Estuarine waters surveyed: 7,865 square miles
- Total estuarine waters: 34,388 square miles (excluding Alaska)

- Ocean shore miles surveyed: 205
- Total ocean shore miles: 22,421 (excluding Alaska)

Total Waters Affected by Toxic Pollutants

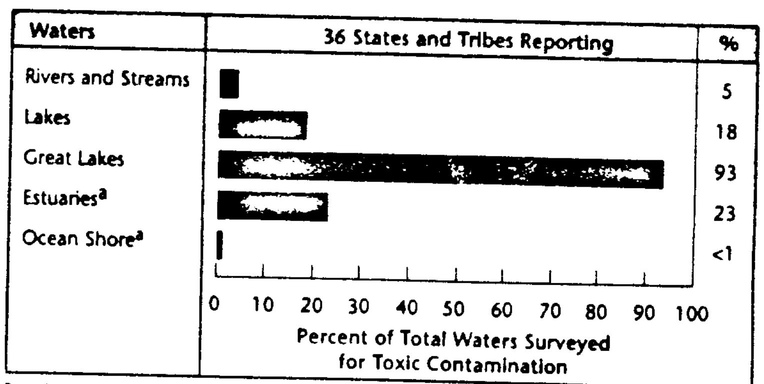
Responding to public concern about toxic pollutants, EPA requested that States track the overall extent of toxic contamination in their surface waters. Forty-two States and Tribes reported the size of waters surveyed for toxicants (either in the water column, sediments, or aquatic organisms) and the total waters found to contain elevated concentrations of toxic pollutants (see Figure 7-11 and Appendix E, Table E-11, for individual State data).

Thirty-six States and Tribes reported that they surveyed toxicants (primarily in the water column) in 160,335 miles of rivers and streams. These States and Tribes surveyed only 5% of the Nation's 3.5 million river miles for toxic contamination. The States and Tribes detected elevated concentrations of toxicants in 25% of the surveyed rivers and streams (Figure 7-12).

Thirty-four States and Tribes reported that they sampled

Figure 7-11

Waters Surveyed for Toxic Contamination



Based on data contained in Appendix E, Table E-11.
[a]Excluding the Alaska shoreline.

toxicants in more than 7.5 million acres of lakes, reservoirs, and ponds. The surveyed acres represent 18% of the Nation's 40.8 million lake acres. The States and Tribes found elevated concentrations of toxicants in 29% of the sampled lake acres.

Seventeen coastal States sampled toxicants in 23% of the Nation's estuarine waters. These States detected elevated toxic concentrations in 26% of the 7,865 square miles of estuarine waters that they sampled.

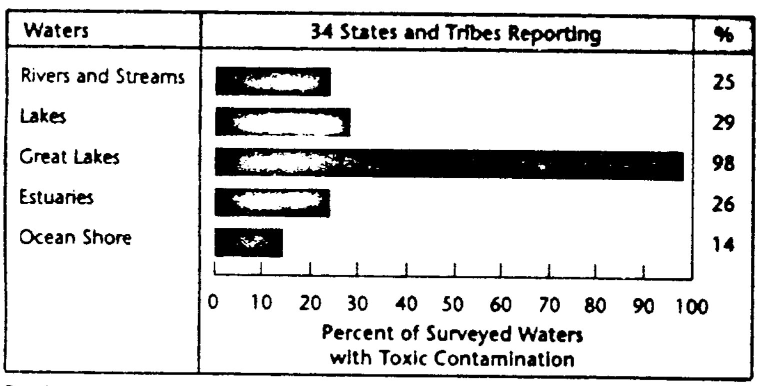
Only three States and the Virgin Islands reportedly surveyed toxicants in ocean shoreline waters. These States found elevated concentrations of toxicants in 14% of the sampled coastline, but this information cannot be applied nationally because the States surveyed less than 1% of the Nation's coastal waters (excluding the Alaska shoreline).

Five States reported that they surveyed most of their Great Lakes' shoreline for toxicants (primarily in fish tissue samples) and detected elevated toxicants in 98% of the shoreline.

The results do not describe the extent of toxic contamination in all waters across the Nation because most toxic pollutants are found in the sediment and the food chain, not in the water column.

Figure 7-12

Percentage of Surveyed Waters with Toxic Contamination



Based on data contained in Appendix E, Table E-11.

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Protecting Our Drinking Water: EPA's Source Water Protection Initiative

Americans have long enjoyed the luxury of safe, affordable drinking water. A rising awareness of water pollution incidents, however, has caused people to be concerned about drinking water quality. Many communities have recognized that preventing the pollution of lakes, rivers, streams, and ground water is the key to ensuring the long-term safety of drinking water. This common sense approach is known as **source water protection**.

The Safe Drinking Water Act emphasizes monitoring and treatment to protect drinking water safety. However, protection based on monitoring and treatment alone is not sufficient. Nearly all groups interested in drinking water safety see a need for stronger efforts to prevent pollution from entering drinking water sources rather than relying solely on water treatment to reduce health threats.

The EPA encourages this prevention-oriented approach and is actively promoting the development of grass roots source water protection activities. As part of the Source Water Protection Initiative, EPA hopes to:

- Restore the public's rights and responsibilities to protect their drinking water
- Raise public confidence in the safety and quality of their drinking water supply
- Reduce the costs of providing safe drinking water.

Wellhead Protection Programs

Many States and communities are currently promoting source water protection in Wellhead Protection (WHP) programs. The 1986 Amendments to the Safe Drinking Water Act established the Wellhead Protection Program to aid communities in protecting their drinking water quality. Through wellhead protection, communities identify the land areas that contribute ground water to public water supply wells. They then develop plans to manage the potential sources of contamination in those vulnerable areas, thereby reducing the likelihood of polluting the drinking water source.

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By the end of December 1994, a total of 37 States and Territories had EPA-approved WHP Programs in place. In addition, thousands of local WHP initiatives have been undertaken in communities across the Nation. As of 1993, approximately 3,800 communities that are dependent on ground water for drinking water had complete WHP programs.

Expanded Source Water Protection Goals

The idea of wellhead protection can apply to surface water supplies as well. The EPA is encouraging stronger watershed protection programs, through approaches available under the Federal Clean Water Act, to protect surface waters used for drinking water supplies. Source water protection, for both ground water and surface water, may offer significant advantages to both drinking water purveyors and consumers.

The EPA is planning a National Source Water Protection Workshop in 1996. This workshop will provide communities with the tools and information needed to establish source water protection programs. The workshop will be televised and will target communities that have delineated their source water protection areas and carried out source identification. The workshop will also assist communities in moving toward source management.

The EPA has also set the following interim and long-term source water protection goals:

- By 1997, establish a core network of 10,000 communities with active and comprehensive local WHP programs in place.
- By 1997, incorporate source water protection and source management as priority objectives in projects requiring financial assistance from other Federal programs.
- By 1997, begin to expand source water protection approaches to communities reliant on surface water for drinking water.
- By 2005, have 50% of all community water supplies covered by active and comprehensive local source water protection programs.

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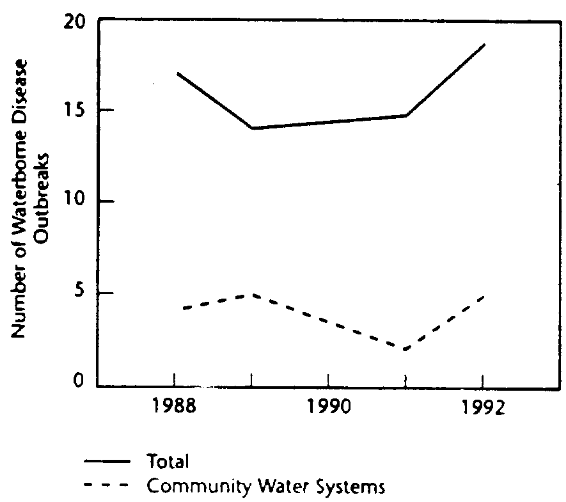
Healthy People 2000 Environmenta Health Water Objectives

Background

In the late 1980s the Public Health Service (PHS), working with over 300 government and non-government organizations, began developing *Healthy People 2000*, a set of public health goals and objectives for the year 2000. This initiative was a logical extension of their previous efforts, the *1990 Health Objectives for the Nation*. Both initiatives included sets of health objectives with targets to be achieved at the end of the respective decades. Both also included chapters that specifically focused on improvements in environmental health and objectives related to water quality and its relationship to human health.

Monitoring the 1990 environmental objectives had been severely limited by lack of data and the ongoing development of Federal regulations relating to specific media, including water. Therefore, one focus of *Healthy People 2000* was to identify objectives that were measurable. *Healthy People 2000* includes 16 environmental health objectives, three of which relate water to health; data to monitor these objectives have been available on either an annual or biennial basis since the year 1990 and will be available at least through the year 2000. At the end of 1994, 10 of the 16 objectives showed some progress toward their year 2000 targets.



Source: Waterborne Surveillance System, CDC/NCEH.

Figure 1. Waterborne Disease Outbreaks, 1988-92.

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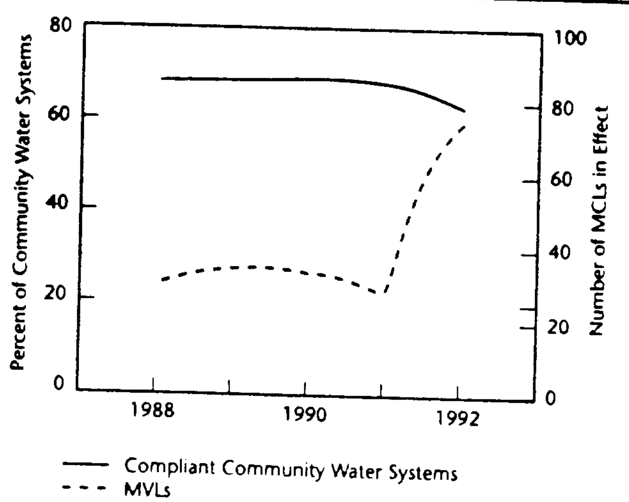
Water Objectives and Progress

The first of the three water-related objectives calls for a reduction in the number of outbreaks of waterborne diseases from infectious agents and chemical poisonings in drinking water to no more than 11 per year by the year 2000. The numbers of these rare events have fluctuated considerably since 1988 when 16 outbreaks were reported (see Figure 1). While public health officials work to maintain and improve the quality of drinking water, variations in physicians' reports to State Health Departments and the availability of resources to confirm the outbreak as waterborne hamper the monitoring of these outbreaks.

The second objective calls for an increase in the percentage of the population whose drinking water supply meets the Safe Drinking Water Act regulations. The data source for this objective is EPA's Federal Reporting Data System (FRDS). The proportions reported since the 1988 baseline appear to have changed little, but as Figure 2 indicates, the quantity and stringency of testing standards have continued to increase.

Third, *Healthy People 2000* monitors the quality of surface water using EPA's National Water Quality Inventory. As originally



Source: U.S. EPA, Federal Reporting Data System (FRDS).

Figure 2. Compliance with Safe Drinking Water Act Regulations, 1988-93.

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written, this objective called for a decrease in the proportion of impaired surface water (specifically, rivers, lakes, and estuaries). The data available to date are shown in Figure 3; however, there were several limitations on accurately monitoring this objective. In consultation with EPA, this objective has been revised and will focus on increases in the proportion of waters that meet the specific designated uses of fish consumption and swimming.

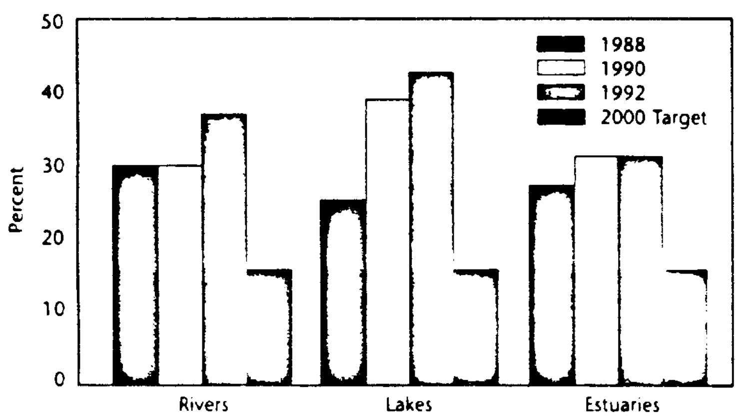

Figure 3. Proportion of Assessed Waters that Do Not Support Beneficial Uses, 1988-1992.

Data and Monitoring

Responsibility for aggregating the data for the 16 objectives is shared by the National Center for Environmental Health, the Agency for Toxic Disease Registry, and the National Center for Health Statistics, all of the Centers for Disease Control and Prevention. The National Institute of Health's National Institute of Environmental Health Sciences also shares the responsibility of monitoring these objectives. There has been extensive cooperation and data sharing with EPA on the beneficial use objective, which relies on data from the States, Tribes, and other jurisdictions. EPA and PHS are currently coordinating the development of EPA's National Environmental Goals and revising the *Healthy People 2000* Environmental Health objectives. The status of the *Healthy People 2000* objectives is reported annually in the *Healthy People 2000 Review*; environmental objectives are monitored using data from the Centers for Disease Control and Prevention, EPA, and other sources.

For further information:

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Mercury Contamination in Maine Lakes

EPA's Region 1 and the Maine Department of Environmental Protection have established a Regional Environmental Monitoring and Assessment Program (R-EMAP) project to study mercury contamination in Maine lakes. The Maine Department of Environmental Protection has found various populations of fish contaminated with heavy metals, PCBs, dioxin, and other chlorinated organic compounds, as stated in the EPA report *R-EMAP Regional Environmental Monitoring and Assessment Program*. Most of the contaminants have been associated with specific point source discharges. In addition, elevated levels of toxic contaminants (especially mercury) have been found in some lake biota at locations where there are no known discharges of toxic contaminants. Maine has issued a statewide advisory on the consumption of fish from any lake in the State. This and prior advisories have been very general and conservative.

Through the Regional Environmental Monitoring and Assessment Program, which uses the Environmental Monitoring and Assessment Program (EMAP) probability-based sampling grid and methodologies, the Maine Department of Environmental Protection has been able to conduct a statewide assessment of contaminated fish in Maine lakes. The project design and techniques adopted from EMAP are expected to enable scientists to conduct statistical analyses of the relationships of such intrinsic factors as age, size, and species of fish; limnological factors; and extrinsic factors (for example, land use or atmospheric deposition). The analyses are needed to issue more specific advisories identifying, in particular, high-risk lakes, species, and size classes. Also, this information is expected to be helpful in identifying future management needs to reduce mercury levels in the Maine lacustrine environment.

For further information:

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Bureau of Land and Water Quality
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(207) 287-7789

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Part III

Individual Section 305(b) Report Summaries and Recommendations

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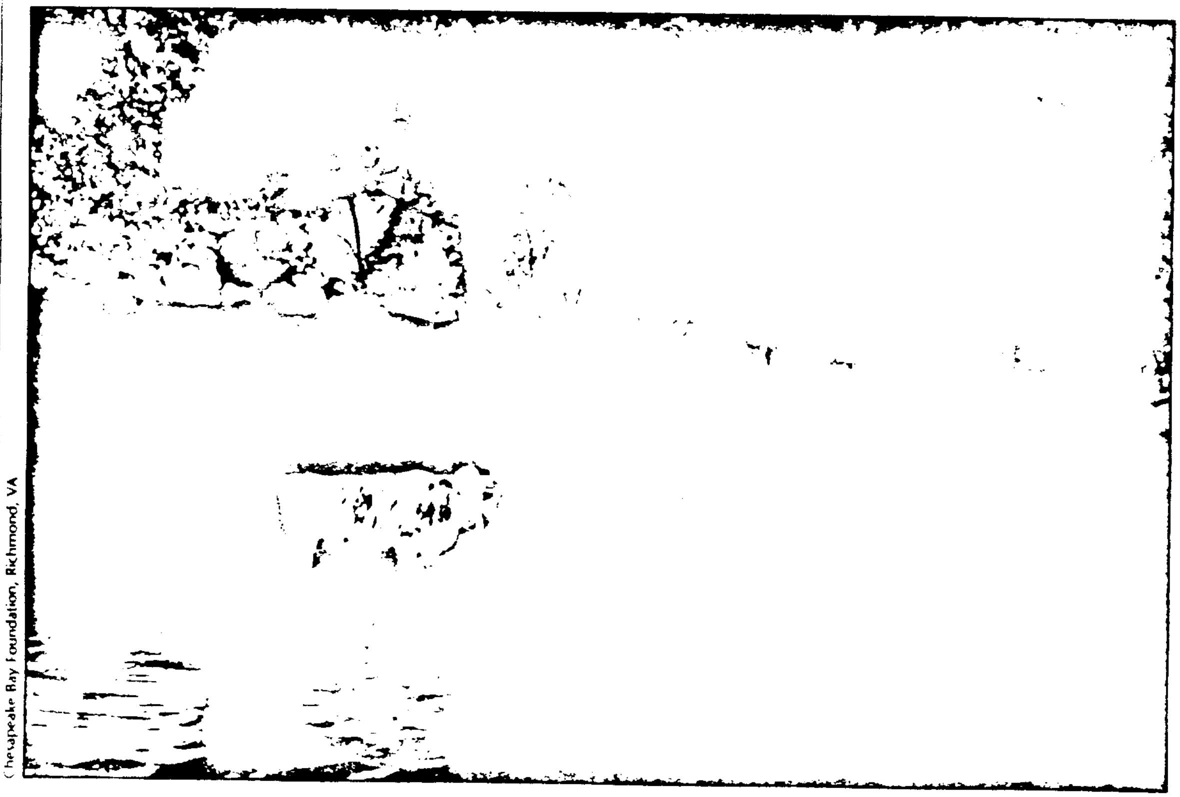

Chesapeake Bay Foundation, Richmond, VA

State and Tribal Recommendations

In their 1994 Section 305(b) reports, 40 States, Territories, and Tribes made recommendations for improving water quality management programs in order to achieve the goals of the CWA. The recommendations encompass a range of actions at the Congressional, Federal, State, Tribal, Territorial, and local levels and are often expressed in terms of State, Tribal, and Territorial objectives or continuing needs. It should be emphasized that the States, Tribes, and Territories reported the following recommendations and that this discussion does not attempt to assess the merits of their recommendations. Nor should this discussion be construed as an EPA or Administration endorsement of any State, Tribal, or Territorial recommendation. Many of the recommendations do, however, coincide with current EPA program concerns and priorities.

The most frequently reported recommendations address five major concerns:

- Nonpoint source abatement
- Financial and technical support from Federal agencies
- Interagency data sharing and management
- Watershed initiatives
- Ground water management.

Other concerns less frequently reported include toxic pollutants, lake management, public education, pollution prevention, waste management for animal and poultry operations, water quantity impacts on water quality, and multimedia cycling of pollutants among air, water, and soil. The following discussion summarizes the recommendations most frequently reported by the States, Tribes, and Territories. These recommendations are often linked and interdependent. For example, many States, Tribes, and Territories recommend that Federal agencies provide financial and technical support to implement watershed initiatives that provide a framework for monitoring and managing nonpoint source pollution. The following discussion touches on the connections between State, Tribal, and Territorial concerns and recommendations.

Nonpoint Source Abatement and Watershed Protection Initiatives

Recommendations most often cited by the States, Tribes, and Territories concern the identification, prevention, and control of nonpoint sources (NPSs) of pollution, such as agricultural runoff and runoff from construction sites. The States and other entities most frequently cite

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the need for additional funding for the development of better monitoring and assessment methods to detect NPS impacts, identify specific NPSs responsible for impacts, and measure the effectiveness of NPS controls. Many States reported that new monitoring methods are needed to distinguish point source impacts from NPS impacts and to identify specific nonpoint sources responsible for water quality degradation. For example, **Rhode Island**'s 305(b) report states:

> Decision makers at this time do not have adequate instream and site-specific water quality data. NPS management plans are currently based on generic nonpoint pollution source "types" (e.g., agriculture, urban stormwater, etc.) and cannot provide adequate prioritization of BMP controls on a specific watershed or subwatershed level.

Rhode Island suggests that a small percentage of CWA Section 319 NPS Federal funds be made available for wet weather NPS monitoring. Rhode Island reports that additional funding for NPS monitoring is needed to update their assessment of NPS impacts and determine the effectiveness of implemented BMPs.

Many States link nonpoint source monitoring and abatement to adoption of a watershed management approach. The States report that a watershed protection approach can be used to target waterbodies for intensive NPS monitoring and to integrate local, State, and Federal efforts to control NPS impacts. The watershed approach encourages local involvement and enables States to maximize efficient use of funds by coordinating point source controls and NPS management. For example, **New Jersey**'s 305(b) report states:

> A watershed approach can require intensive site-specific monitoring designed to assess pollution sources and loading and fill data gaps . . . Detailed assessments of pollution sources, both point and nonpoint, on a local basis, would allow management efforts to institute pollution controls on a finely detailed level. Working with local governmental agencies and environmental/citizen groups can provide the Department [of Environmental Protection] with enormous amounts of information regarding local activities, land uses, and point sources that either can potentially or are known to impair local water quality. These same agencies and groups can act to change land uses, zoning regulations, agricultural practices, etc.

Nebraska's 305(b) report suggests that States and other governing entities can use the watershed approach to prioritize watersheds for more efficient allocation of funds to implement NPS projects:

> The Nebraska Department of Environmental Quality should continue with its systematic assessment of watersheds identified as either suspected or unknown with regards to nonpoint source pollution impacts. These assessments

State and Tribal Recommendations

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The most frequently reported recommendations address five major concerns:

- Nonpoint source abatement
- Financial and technical support from Federal agencies
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Other concerns less frequently reported include toxic pollutants, lake management, public education, pollution prevention, waste management for animal and poultry operations, water quantity impacts on water quality, and multimedia cycling of pollutants among air, water, and soil. The following discussion summarizes the recommendations most frequently reported by the States, Tribes, and Territories. These recommendations are often linked and interdependent. For example, many States, Tribes, and Territories recommend that Federal agencies provide financial and technical support to implement watershed initiatives that provide a framework for monitoring and managing nonpoint source pollution. The following discussion touches on the connections between State, Tribal, and Territorial concerns and recommendations.

Nonpoint Source Abatement and Watershed Protection Initiatives

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should document the presence and quantify the magnitude of water quality impacts and beneficial use impairment due to nonpoint sources. Through the Nebraska Nonpoint Source Management Program, a listing of priority watersheds should be defined and action plans developed in order to expedite the funding and implementation process for nonpoint source projects.

The States, Tribes, and Territories also recommend implementing a watershed approach to address other water quality issues (in addition to NPS pollution) within a holistic strategy. **Illinois'** Section 305(b) report recommends that Federal agencies grant flexibility to the States so that they can incorporate numerous program elements into a watershed approach:

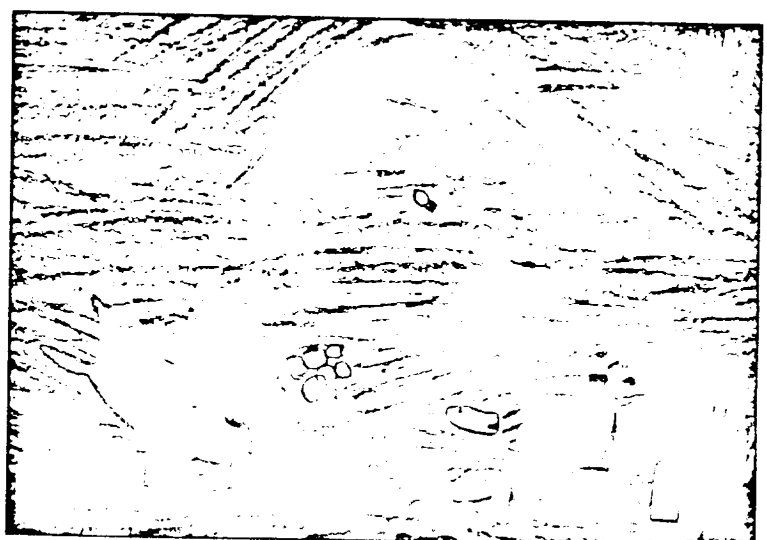
> As States' watershed planning and management efforts continue to evolve, Federal oversight of various program activities will need to provide States with flexibility needed to implement a watershed approach. Resources and incentives will need to be provided to assist States in making further progress, particularly in regard to: data availability/coordination; incorporating ground water resource issues; determination of those watersheds needing to develop watershed implementation plans based on available resources; and coordination with other agencies and the public.

Illinois' report also refers to the links between the availability of financial resources, implementation of a watershed approach, and management of NPS pollution:

> In approaching water quality from a watershed approach, there is an immediate need for assessment and planning related to correction and prevention of NPS pollution. This effort will require both resources and time to be accomplished correctly.

Although many States, Tribes, and Territories report that implementing a watershed approach may require additional financial support, several States recommend adopting the watershed approach to maximize efficient use of their declining budgets. **Massachusetts' 305(b)** report states:

Many States, Tribes, and Territories link NPS monitoring and abatement to adoption of a watershed management approach.



Steve Winward, age 8, Kings Park Elementary, Springfield, VA

> Better coordination and exchange of information with other agencies is needed because of the Department [of Environmental Protection]'s decreasing monitoring resources. To help alleviate this problem, the Commonwealth has adopted a watershed approach. This approach ensures interagency and intergovernmental coordination, allowing limited resources to be used to their fullest.

Many States and other governing entities report that shrinking budgets are a widespread problem that threatens existing water quality monitoring and assessment programs in addition to new initiatives.

Financial and Technical Support

Most States, Tribes, and Territories expressed a common concern that they will not be able to maintain current water quality monitoring and assessment activities if Federal funding shrinks. **Rhode Island's** 1994 305(b) report states:

> Federal funding for monitoring work is rapidly decreasing on an annual basis. At the same time, States are under severe fiscal constraints in their annual budget projections. Present funding does not provide for a long-term commitment to continue sampling such new water quality stations. There is no easy solution currently available to solve this fiscal dilemma. Citizens' monitoring groups will most likely become an important resource in the State's efforts to follow present water quality conditions over future years, but such efforts cannot replace State mandates to monitor trends and present water quality conditions.

Wisconsin's 305(b) report expresses the views reported by numerous States, Tribes, and Territories:

> With the shift in attention to problems more diverse and complex, it is essential that more and better uniform data collection and analysis procedures be established to accurately determine the condition of the Nation's waters and identify trends in water quality degradation and track progress . . . One problem with many water quality programs is there is no mechanism for funding the monitoring needed for good science.

New Mexico recommends full funding for all research programs related to water quality:

> The U.S. Congress should provide adequate funding to EPA, the USGS, and other appropriate Federal agencies to support basic ecological, hydrologic, medical, public health, and other research relevant to water quality protection and to support technical assistance and technology transfer to the States.

The States and other entities are also concerned about funding for water quality management

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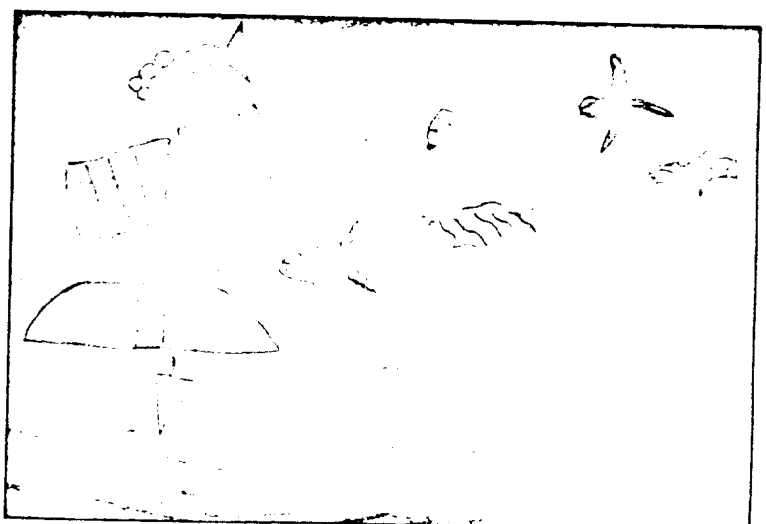
programs in general. Many States specifically request that Congress maintain funding for the CWA Section 314 Clean Lakes Program. In most States, lake monitoring lags behind monitoring of rivers and streams. Without Section 314 grants, many States could not support lake monitoring and assessment activities or restoration projects. Resources and incentives are also needed to address: data availability and coordination, ground water resource issues, wetlands issues, fish contamination, interagency coordination, public education, regulatory enforcement and compliance, biological criteria development, pollution prevention and source reduction, land management practices, and developing technologies.

Both Tribes and States recommend that Congress change funding allocation rules in the CWA that limit funds for Tribal water quality management programs. The **Campo Indian Reservation's** 305(b) report recommends that Congress revise CWA Section 518 to remove the cap on Federal funding for Tribal water programs:

> Although the CWA was amended in 1987 to treat Indian Tribes as States under certain CWA sections, funding available to Tribes has not followed the designation. A concern of paramount importance to the success of water quality management programs for the Campo Indian Reservation, and all other Indian Reservations pursuing authority under sections of the CWA, is the adequate amount of CWA (e.g., Sections 106 and 319) funding available for Indian Tribes. Under Section 518 of the CWA, a maximum budget for Indian Tribes has been set at less than 1% of the U.S. EPA's CWA Section budget. Considering that there are 345 Reservations in the U.S., the allocated funding falls far short of treating Indian Tribes as States for funding under CWA Sections. A more reasonable allocation for funding Indian Tribes under the CWA would be to replace the less than 1% maximum with minimum funding amounts.

New Mexico's 305(b) report also recommends expanding funding for Tribal water quality programs while maintaining State funding:

> The funding set aside for Indian Tribes in the CWA puts Tribes in direct competition with States



Kings Park Elementary, 3rd grade, Springfield, VA

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for the limited available Federal funding. The funding provided to Tribes is inadequate to develop or implement effective water quality programs. The U.S. Congress should provide sufficient dedicated funds to Indian Tribes so that they can develop and implement effective water quality programs. These funds should be in addition to, not in place of, monies allocated to the States.

Many States, Territories, and the District of Columbia stressed the need for continued appropriations to maintain or expand their Revolving Fund programs for wastewater treatment plant construction. The States and other governing entities are also concerned about the high cost of abating combined sewer overflows (CSOs). Michigan states that municipalities need funds to implement State CSO control strategies. Rhode Island suggests that EPA and Congress allocate special funding for implementing CSO mitigation measures that would be administered through the Revolving Loan programs.

The States, Tribes, and Territories also request that EPA continue to provide technical support and guidance on issues of national concern. Specifically, their recommendations include the following:

- Develop technical guidance for evaluating sources of runoff pollution
- Provide additional guidance for assessing waterbodies with biological and chemical data and establishing biological standards
- Provide guidance on stormwater and CSO permitting
- Finalize sediment contamination criteria
- Improve consistency in the implementation of whole effluent toxicity limits in the National Pollutant Discharge Elimination System (NPDES) program
- Continue to sponsor professional training courses for the States and other governing entities on the subjects of permit writing, compliance inspections and sampling, and enforcement
- Provide resources and technical support for geographic information systems.

In addition, the States and other governing entities look to EPA to improve coordination among water quality programs.

Interagency Data Sharing and Management

The need for better coordination among State, Tribal, Territorial, and Federal water quality programs is an underlying theme of many of the Section 305(b) reports. Coordination is needed among agencies as well as across programs in all areas of water quality concerns. Better coordination can eliminate duplicative monitoring activities (thereby stretching limited funds) and ensure that generated data are of adequate quality to be shared among programs. Improved coordination and data sharing are also essential elements of a watershed approach.

Twenty-one States, Tribes, and Territories expressed concern that data sharing is restricted by the lack of common protocols for data collection, analysis, and storage. Arizona's 305(b) report states:

> Water quality information is collected and disseminated by numerous Federal, State, and local governments throughout Arizona. The ability of different agencies to use this vast database is hampered by many issues, including data collection approaches, comparable methods, translation of databases, and policies on data and information sharing.

Several States reference the work of the Intergovernmental Task Force on Monitoring (ITFM) as a positive approach for addressing data comparability and sharing issues. In addition to ITFM participation, the States and other entities suggest that EPA work with them to develop national monitoring and assessment strategies. **Wisconsin** suggests that

- U.S. EPA should develop a national monitoring strategy for the assessment of the Nation's waters, including provisions for making funding of monitoring part of each program and accommodating State priorities for data collection and waterbody evaluation.

- U.S. EPA's monitoring programs should support ecosystem management by using certain flora and fauna from the ecosystem being evaluated as "ecosystem indicators" to set a standard for when a waterbody is in good health.

Data sharing is of special interest to Tribes because Tribal water quality is usually dependent upon water quality and watershed activities outside the jurisdiction of the Tribe. The Tribes need data from outside of their jurisdictions to identify sources of water quality degradation and to negotiate solutions with non-Tribal parties. The **Soboba Band of Mission Indians'** 305(b) report states:

> Negotiations are presently beginning with major off-Reservation water users, with the aim of fairly and finally apportioning the waters of the basin. Nondegradation of water quality will be the basic element of the Band's position in these negotiations. As part of these negotiations, sharing and cooperative analysis of data on the hydrology and water quality of the San Jacinto watershed will be necessary. It is the Band's hope and intent that this affirmative approach to water management should lead to a systematic, integrated water quality monitoring program for the basin that will be of lasting benefit to all water users.

Ground Water Concerns

Many of the States and other governing entities recommend that EPA develop a comprehensive framework for coordinating programs and eliminating inconsistencies among Federal programs that address ground water. However, the States also suggest that they should continue to play the primary role in

Many States

managing and implementing ground water protection programs. For example, New Mexico's 305(b) report states:

> Existing Federal statutes including the CWA, the Safe Drinking Water Act, the Resource Conservation and Recovery Act, the Insecticide, Fungicide and Rodenticide Act, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) establish differing criteria and procedures to control ground water quality . . . These programs have not addressed ground water in a coordinated manner and have created administrative and statutory inconsistencies which may be obstacles to effective ground water quality management. Inconsistencies between Federal laws relating to ground water quality should be removed . . . The U.S. Congress should adopt legislation providing that once a State adopts ground water quality standards satisfying national minimum criteria, then those State standards become the basis for cleanup or control of any and all Federal programs relating to protection of ground water in the State.

Other States concur that EPA should coordinate ground water management and provide technical support to States and other jurisdictions implementing specific ground water protection and restoration measures at the local level. Wisconsin's 305(b) report states:

> U.S. EPA should develop a coordinated ground water management strategy in conjunction with other appropriate Federal agencies that includes a drought strategy and allocation scheme. U.S. EPA should serve as a resource agency that provides technical assistance for ground water quality issues as opposed to mandating a process and administrative oversight. U.S. EPA needs to provide guidance and regional consistency on the use of nitrogen fertilizers due to increasing concentrations of harmful nitrate-nitrogen in ground water nationwide.

Michigan's 305(b) report states:

> The State is restricted in some areas of ground water program development by a lack of action at the Federal level. To avoid preemption problems, the State relies on the Federal government to set certain standards that are later incorporated into State programs. The State is also relying on the Federal government for basic scientific data relating to the health impacts of the synergistic effects of the chemical combinations most often found in contaminated water supplies.

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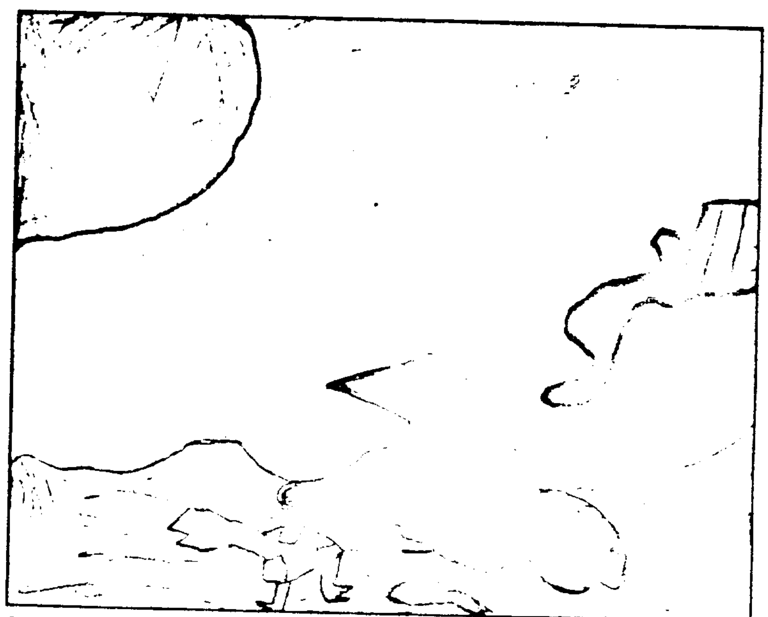
A number of States, Tribes, and Territories expressed concerns about the continued ability to fund State and Federal ground water research and protection programs. Tribes express numerous concerns about ground water quality because many Tribal lands lack reliable surface water supplies due to upstream withdrawals, arid climates, or a lack of surface waters within Tribal boundaries. Even Tribes in non-arid climates rely on ground water to supply large portions of their domestic water supply. The Tribes recommend that ground water monitoring be enhanced on Tribal lands and development of wellhead protection programs move forward.

Conclusions

In general, the States, Tribes, and Territories recommend that EPA continue to provide general guidance for establishing minimum program elements while allowing the States flexibility for developing and implementing specific programs tailored to their individual conditions and needs. The States and other governing entities also recommend that Congress continue to fund the development and distribution of technical support by EPA and other Federal agencies, including the USGS. Many States, Tribes, and Territories reported that funding for water quality monitoring should be maintained, if not increased, because monitoring plays a critical role in defining water quality issues and measuring the effectiveness of water quality management programs.

The States and other entities also recommend that EPA continue to advocate the watershed approach for integrating monitoring activities, data sharing, ground and surface water management, wetlands management, interagency activities, and point and nonpoint source management. However, the States and other entities suggest that they should maintain control over the development and implementation of the watershed approach within their jurisdictions.



Chris Inghram, age 8, Bruner Elementary, North Las Vegas, NV

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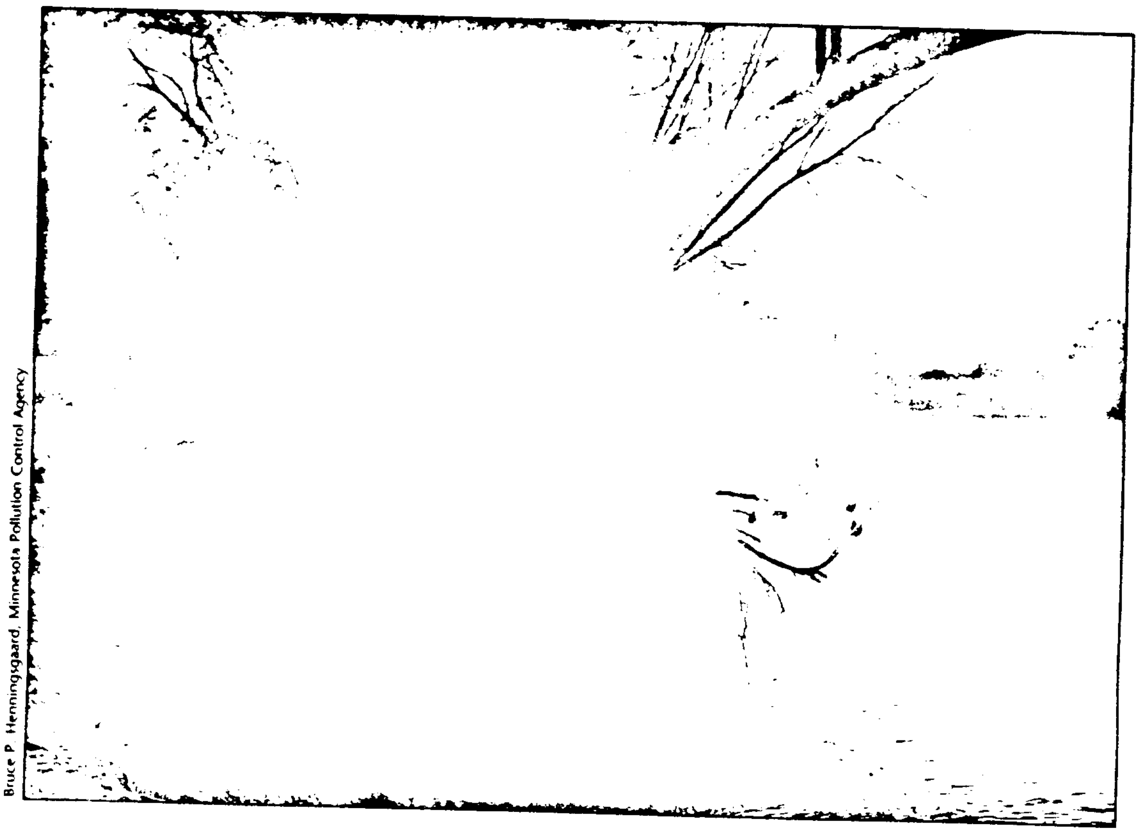

Bruce P. Henningsgaard, Minnesota Pollution Control Agency

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Individual State and Territorial Summaries

This section provides individual summaries of the water quality survey data reported by the States and Territories in their 1994 Section 305(b) reports. The summaries provide a general overview of water quality conditions and the most frequently identified water quality problems in each State and Territory. However, the use support data contained in these summaries are not comparable because the States and Territories do not use comparable criteria and monitoring strategies to measure their water quality. States and Territories with strict criteria for defining healthy waters are more likely to report that a high percentage of their waters are in poor condition. Similarly, States with progressive monitoring programs are more likely to identify water quality problems and to report that a high percentage of their waters do not fully support designated uses. As a result, one cannot assume that water quality is worse in those States and Territories that report a high percentage of impacted waters in the following summaries.

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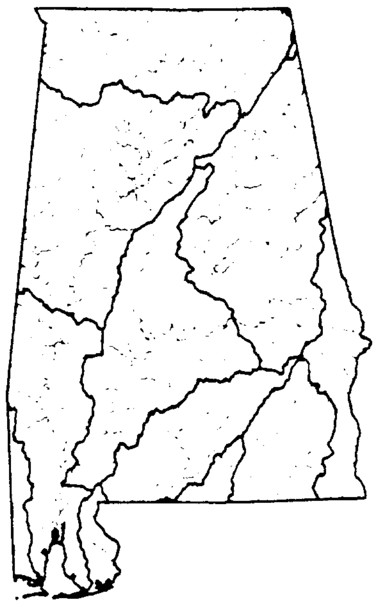
Alabama



For a copy of the Alabama 1994 305(b) report, contact:

Michael J. Rief
Alabama Department of
Environmental Management
Water Quality Branch
P.O. Box 301463
Montgomery, AL 36130-1463
(334) 271-7829

Surface Water Quality

Since enactment of the Clean Water Act of 1972, water quality has substantially improved near industrial and municipal facilities. However, pollution still prevents about 29% of the surveyed stream miles, 15% of the surveyed lake acres, and 20% of the surveyed estuaries from fully supporting aquatic life use. Oxygen-depleting wastes and nutrients are the most common pollutants impacting rivers and coastal waters. The leading sources of river pollution include agriculture, municipal wastewater treatment plants, and resource extraction. In coastal waters, the leading sources of pollution are urban runoff and storm sewers, municipal sewage treatment plants, and combined sewer overflows.

Toxic priority organic chemicals impact the most lake acres, usually in the form of a fish consumption advisory. These pollutants may accumulate in fish tissue at a concentration that greatly exceeds the concentration in the surrounding water. Unknown sources and industrial dischargers are responsible for the greatest acreage of impaired lake waters.

Special State concerns include impacts from the poultry broiler industry, forestry activities, animal waste runoff, and hydroelectric generating facilities.

Ground Water Quality

The Geological Survey of Alabama monitoring well network indicates relatively good ground water quality. However, the number of ground water contamination incidents has increased significantly in the past few years due to better reporting under the Underground Storage Tank Program and increased public awareness of ground water issues. Alabama has established pesticide monitoring and a Wellhead Protection Program to identify nonpoint sources of ground water contamination and further protect public water supplies.

Programs to Restore Water Quality

In 1992, the Alabama Department of Environmental Management (ADEM) initiated the Flint Creek watershed project to simultaneously manage the many sources degrading Flint Creek, including intensive livestock and poultry operations, crop production, municipal dischargers, household septic systems, widespread littering, and urban runoff. Numerous Federal, State, and local agencies play a role in the watershed project, which includes data collection activities, public education and outreach, and development of a total maximum daily load (TMDL) model for the watershed. The model output will show the mix of point and nonpoint loadings that can be permitted without violating instream water quality standards. ADEM expects to increase use of the watershed protection approach.

Programs to Assess Water Quality

Alabama's surface water monitoring program includes a fixed station ambient network, reservoir sampling, fish tissue sampling, intensive wasteload allocation surveys, water quality demonstration surveys, and compliance monitoring of point source discharges. As a first step in establishing biological criteria, ADEM is assessing the habitats and corresponding resident biota at several candidate reference streams.

Individual Use Support in Alabama

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 77,274)[b]	Total Miles Surveyed					
	11,873	70	1	16	10	3
	43	0	0	0	100	0
	3,364	78	0	17	5	0
Lakes (Total Acres = 490,472)	Total Acres Surveyed					
	465,316	77	8	15	0	0
	450,019	79	5	13	3	0
	318,295	81	19	0	0	0
Estuaries (Total Square Miles = 610)	Total Square Miles Surveyed					
	606	80	0	20	0	0
	606	100	0	0	<1	0
	449	68	0	0	32	0
	579	100	0	0	<1	0

[a] A subset of Alabama's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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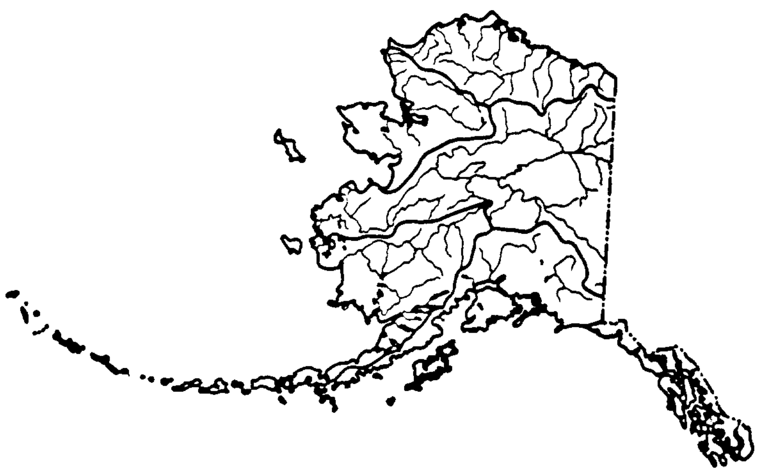
Alaska



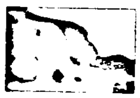
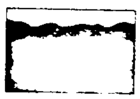
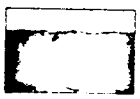
— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For information about water quality in Alaska, contact:

Eric Decker
Alaska Department of Environmental Conservation
410 Willoughby Street - Suite 105
Juneau, AK 99801-1795
(907) 465-5328

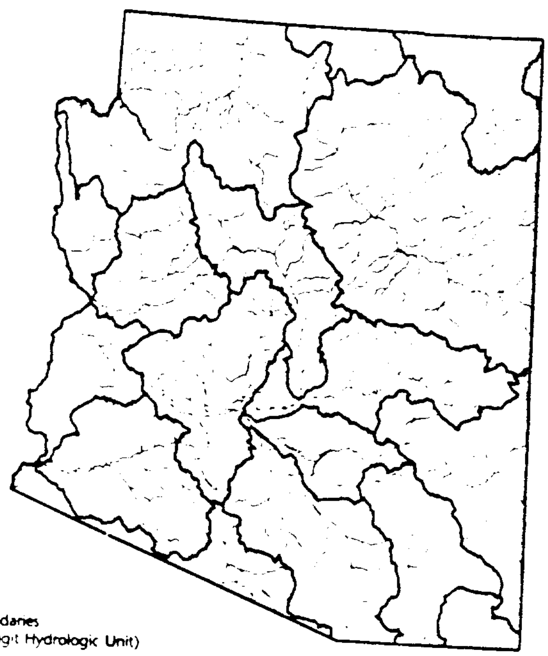
The State of Alaska did not submit a 305(b) report to EPA in 1994.

Overall[a] Use Support in Alaska (1992)

	Total Surveyed	Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
		Percent				
Rivers and Streams (Total Miles = 365,000) 	Total Miles Surveyed: 2,889	29	-	32	39	-
Lakes (Total Acres = 12,787,200) 	Total Acres Surveyed: -	-	-	-	-	-
Estuaries (Total Square Miles = Unknown) 	Total Square Miles Surveyed: -	-	-	-	-	-

[a] Overall use support data from 1992 are presented because Alaska did not submit a 305(b) report to EPA in 1994.

Arizona



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Arizona 1994 305(b) report, contact:

Diana Marsh
Arizona Department of
Environmental Quality
3033 North Central Avenue
Phoenix, AZ 85012
(602) 207-4545

Surface Water Quality

Good water quality fully supports swimming uses in 59% of Arizona's surveyed river miles and 94% of their surveyed lake acres. However, Arizona reported that 51% of their surveyed stream miles and 28% of their surveyed lake acres do not fully support aquatic life uses. Arizona reported that metals, turbidity, salinity, and suspended solids were the stressors most frequently identified in streams. The leading stressors in lakes were salinity, metals, inorganics, and low dissolved oxygen. Natural sources, agriculture, and hydrologic modification (stream bank destabilization, channelization, dam construction, flow regulation, and removal of shoreline vegetation) were the most common sources of stressors in both streams and lakes, followed by resource extraction (mining) in streams and urban runoff in lakes. Nonpoint sources played a role in degrading 96% of the impaired river miles and 93% of the impaired lake acres.

Ground Water Quality

Arizona is gradually establishing a network of water quality index wells in principal aquifers to measure ground water quality conditions and document future trends. Existing data indicate that ground water generally supports drinking water uses, but nitrates, petroleum products, volatile organic chemicals, heavy metals, pesticides, radioactive elements, and bacteria cause localized contamination in Arizona. Both natural sources and human sources (including agriculture, leaking underground storage tanks, and septic tanks) generate these contaminants.

The State has established 50 ground water basin boundaries, four of which are designated Active Management Areas because they encompass the largest population centers with the greatest ground water demands. A Comprehensive State Groundwater Protection Program has been initiated as a demonstration project in Tucson. Under this program, the State will work with all interested parties to set priorities for ground water management and mitigate existing water quality problems.

Programs to Restore Water Quality

Arizona's nonpoint source control program integrates regulatory controls with nonregulatory education and demonstration projects. Regulatory programs include the Aquifer Protection Permit Program, the Pesticide Contamination Program, and best management requirements for controlling nitrogen at concentrated animal feeding operations. The State is also developing best management practices for timber activities, grazing activities, urban runoff, and sand and gravel operations. Arizona's point source control program encompasses planning, facility construction loans, permits, pretreatment, inspections, permit compliance, and enforcement.

Programs to Assess Water Quality

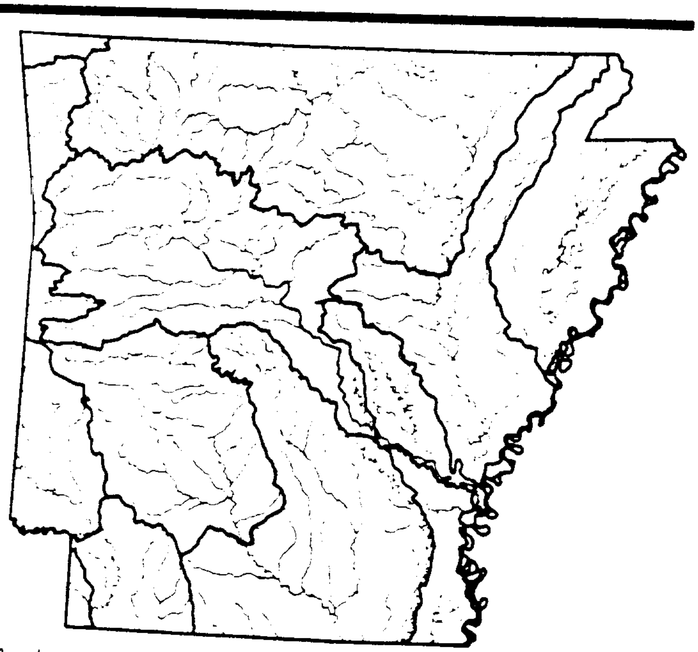
Recently, Federal and State agencies increased efforts to coordinate monitoring, provide more consistent monitoring protocols, and provide mechanisms to share data, spurred by tightened budgets. Monitoring programs in Arizona include a fixed station network, complaint investigations and special studies, priority pollutant monitoring, and monitoring to support biocriteria development. ADEQ will develop narrative biological criteria with biological, physical, and chemical data collected at over 100 biological reference sites in 1992, 1993, and 1994.

Individual Use Support in Arizona

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 104,200)[b]	Total Miles Surveyed					
	5,472	33	16	26	25	0
	4,442	58	11	29	2	0
	4,818	51	8	26	15	0
Lakes (Total Acres = 302,000)	Total Acres Surveyed					
	55,109	21	51	27	1	0
	44,881	41	39	19	<1	0
	55,065	52	42	6	0	0

[a] A subset of Arizona's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Arkansas



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Arkansas 1994 305(b) report, contact:

Bill Keith
Arkansas Department of Pollution Control and Ecology
P.O. Box 8913
Little Rock, AR 72219-8913
(501) 562-7444

Surface Water Quality

The Arkansas Department of Pollution Control and Ecology (DPCE) reported that 56% of their surveyed rivers and streams and 100% of their surveyed lake acres have good water quality that fully supports aquatic life uses. Good water quality also fully supports swimming use in 81% of the surveyed river miles and 100% of the surveyed lake acres. Siltation and turbidity are the most frequently identified pollutants impairing Arkansas' rivers and streams, followed by bacteria and nutrients. Agriculture is the leading source of pollution in the State's rivers and streams and has been identified as a source of pollution in four lakes. Municipal wastewater treatment plants, mining, and forestry also impact rivers and streams. Arkansas has limited data on the extent of pollution in lakes.

Special State concerns include the protection of natural wetlands by mechanisms other than discharge permits and the development of more effective methods to identify nonpoint source impacts. Arkansas is also concerned about impacts from the expansion of confined animal production operations and major sources of turbidity and silt including road construction, road maintenance, riparian land clearing, streambed gravel removal, and urban construction.

Ground Water Quality

Nitrate contamination was detected in some domestic wells sampled in portions of the State undergoing rapid expansion of poultry and livestock operations, including northwest Arkansas, the Arkansas River Valley, and southwest Arkansas. In northwest Arkansas, nitrate contamination was documented in 5% to 7% of the domestic wells sampled. Wells sampled in pristine areas of northwest Arkansas were not contaminated.

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Programs to Restore Water Quality

Arkansas has focused nonpoint source management efforts on controlling waste from confined animal production operations. Arkansas utilizes education, technical assistance, financial assistance, and voluntary and regulatory activities to control nonpoint source pollution from poultry, swine, and dairy operations. Liquid waste systems are regulated by permit and dry waste systems are controlled by voluntary implementation of BMPs in targeted watersheds. Water quality is monitored during watershed projects to evaluate the effectiveness of the BMPs.

Programs to Assess Water Quality

Arkansas classifies its water resources by ecoregion with similar physical, chemical, and biological characteristics. There are seven ecoregions including the Delta, Gulf Coastal, Ouchita Mountain, Arkansas River Valley, Boston Mountain, and Ozark Mountain Regions. By classifying water resources in this manner, Arkansas can identify the most common land uses within each region and address the issues that threaten the water quality.

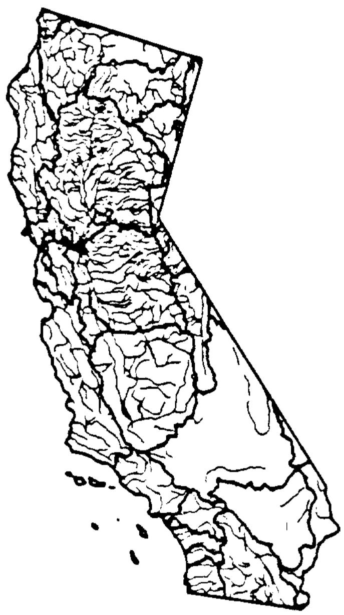
The State has increased surface water and ground water monitoring to determine the fate of animal waste applied to pastures. Arkansas also conducted 10 water quality surveys in watersheds throughout the State to determine point and nonpoint sources of pollution impacting water quality.

Individual Use Support in Arkansas

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 87,617)[b]	Total Miles Surveyed					
	7,231	56	0	32	12	0
	7,234	94	0	5	1	0
	6,497	81	0	1	18	0
Lakes (Total Acres = 514,245)	Total Acres Surveyed					
	356,254	100	0	0	0	0
	356,254	94	0	6	0	0
	356,254	100	0	0	0	0

[a] A subset of Arkansas' designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

California



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the California 1994 305(b) report, contact:

Nancy Richard
California State Water Resources
Control Board, M&A
Division of Water Quality
P.O. Box 944213
Sacramento, CA 94244-2130
(916) 657-0642

Surface Water Quality

Siltation, pesticides, nutrients, and bacteria impair the most river miles in California. The leading sources of degradation in California's rivers and streams are agriculture, unspecified nonpoint sources, forestry activities, urban runoff and storm sewers, and resource extraction. In lakes, siltation, metals, and nutrients are the most common pollutants. Construction and land development pose the greatest threat to lake water quality, followed by urban runoff and storm sewers, forestry, and land disposal of wastes.

Metals, pesticides, trace elements, and unknown toxic contaminants are the most frequently identified pollutants in estuaries, harbors, and bays. Urban runoff and storm sewers are the leading source of pollution in California's coastal waters, followed by municipal sewage treatment plants, agriculture, hydrologic and habitat modifications, resource extraction, and industrial dischargers. Oceans and open bays are degraded by urban runoff and storm sewers, agriculture, and atmospheric deposition.

Ground Water Quality

California assigns beneficial uses to its ground water. Salinity, total dissolved solids, and chlorides are the most frequently identified pollutants impairing use of ground water in California. The State also reports that trace inorganic elements, flow alterations, and nitrates degrade over 1,000 square miles of ground water aquifers.

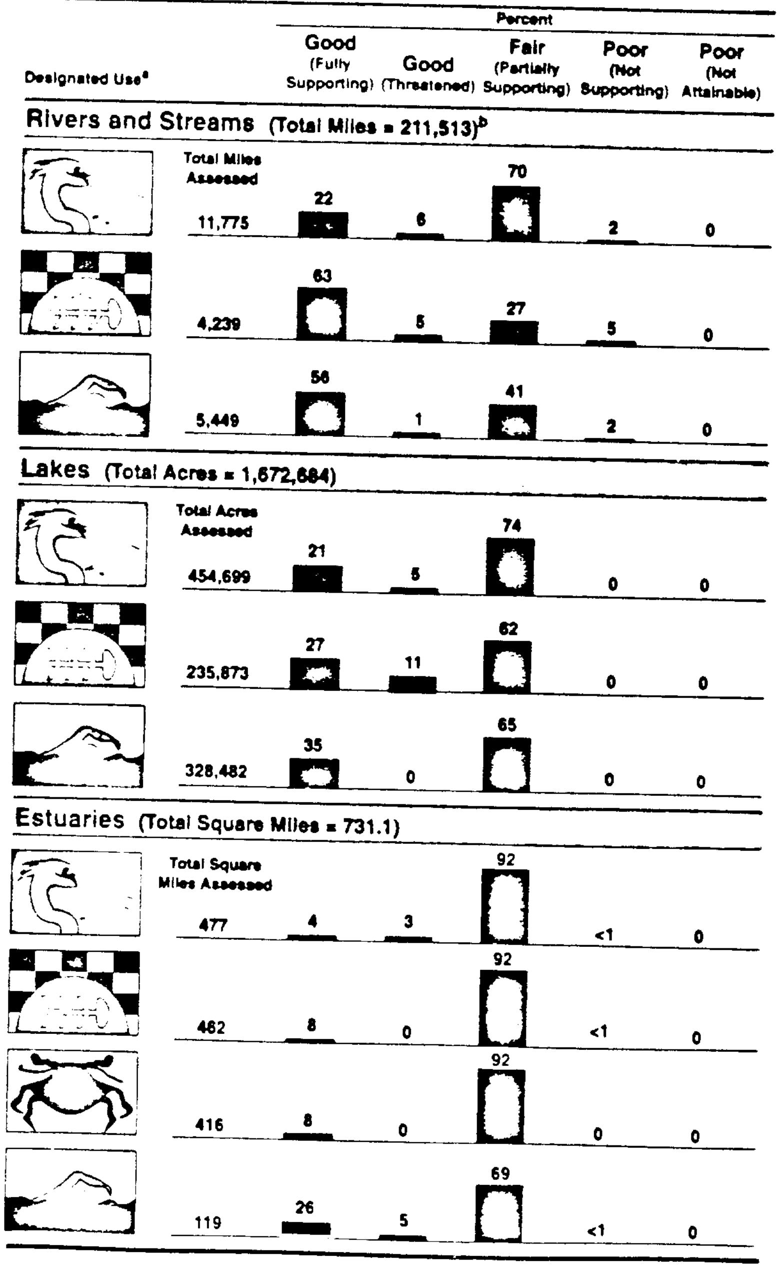
Programs to Restore Water Quality

No information was provided in the 1994 305(b) report.

Programs to Assess Water Quality

No information was provided in the 1994 305(b) report.

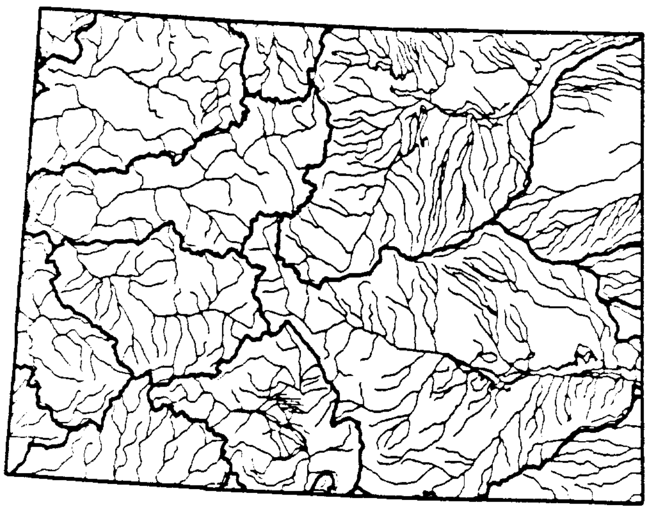
Individual Use Support in California



[a] A subset of California's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Colorado



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Colorado 1994 305(b) report, contact:

John Farrow
Colorado Department of Public Health and Environment
Water Quality Control Division
4300 Cherry Creek Drive, South
Denver, CO 80222-1530
(303) 692-3575

Surface Water Quality

Colorado reports that 89% of its surveyed river miles and 91% of its surveyed lake acres have good water quality that fully supports designated uses. Metals are the most frequently identified pollutant in rivers and lakes. High nutrient concentrations also degrade many lake acres. Agriculture and mining are the leading sources of pollution in rivers. Agriculture, construction, urban runoff, and municipal sewage treatment plants are the leading sources of pollution in lakes.

Ground Water Quality

Ground water quality in Colorado ranges from excellent in mountain areas where snow fall is heavy, to poor in alluvial aquifers of major rivers. Naturally occurring soluble minerals along with human activities are responsible for significant degradation of some aquifers. Nitrates and salts from agricultural activities have contaminated many of Colorado's shallow aquifers. In mining areas, acidic water and metals contaminate aquifers. Colorado protects ground water quality with statewide numeric criteria for organic chemicals, a narrative standard to maintain ambient conditions or Maximum Contaminant Levels of inorganic chemicals and metals, and specific use classifications and standards for ground water areas. Colorado also regulates discharges to ground water from wastewater treatment impoundments and land application systems with a permit system.

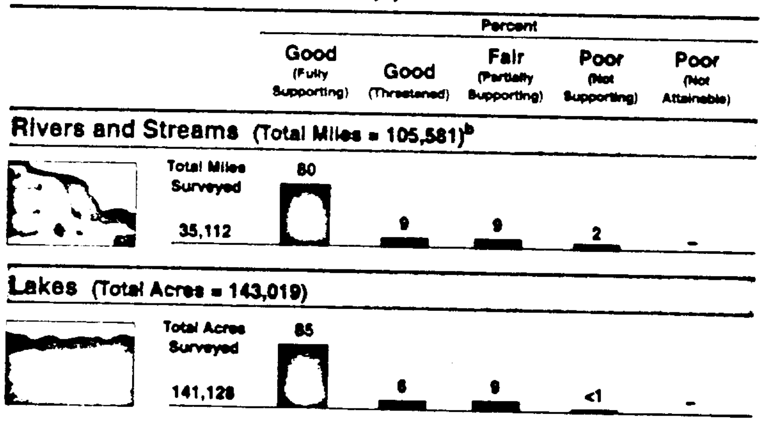
Programs to Restore Water Quality

Colorado's nonpoint source program supports a wide range of projects. Ten projects were funded to identify appropriate treatment options for waters polluted by abandoned mines. Several projects identified and funded implementation of good management practices for riparian (streamside) areas. Under another project, Colorado developed agreements with the U.S. Bureau of Land Management and the U.S. Forest Service to ensure that these agencies apply effective best management practices to control nonpoint runoff from grazing, timber harvesting, and road construction activities on Federal lands.

Programs to Assess Water Quality

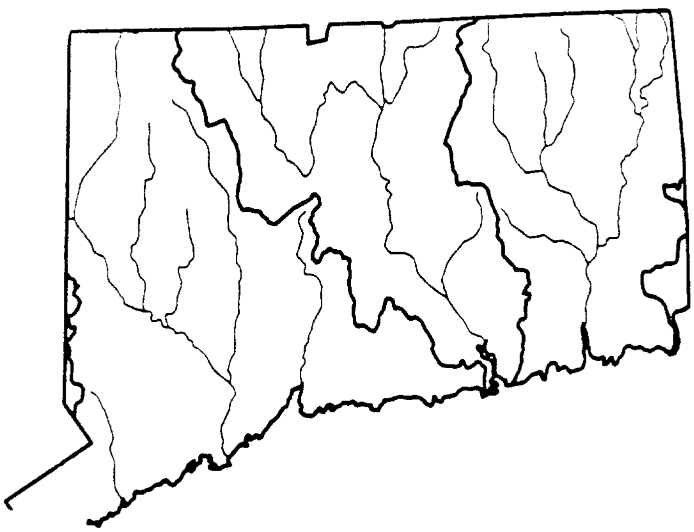
During the 1994 305(b) reporting cycle, Colorado switched over from a statewide monitoring program to a basinwide monitoring strategy. The basinwide monitoring strategy allows that State to intensify monitoring in one basin per year, rather than perform infrequent sampling statewide. Colorado retained some of the old fixed-station sampling sites to monitor statewide trends in water quality conditions.

Overall[a] Use Support in Colorado



- Not reported.
[a] Overall use support is presented because Colorado did not report individual use support in their 1994 Section 305(b) report.

Connecticut



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Connecticut 1994 305(b) report, contact:

Donald Gonyea
Bureau of Water Management, PERD
Connecticut Department of
Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
(860) 424-3827 or (860) 424-3020

Surface Water Quality

Connecticut has restored over 300 miles of large rivers since enactment of Connecticut's State Clean Water Act in 1967. Back in 1967, about 663 river miles (or 74% of the State's 893 miles of large rivers and streams) were unfit for fishing and swimming. In 1994, Connecticut reported that 222 river miles (25%) do not fully support aquatic life uses and 248 miles (28%) do not support swimming due to bacteria, PCBs, metals, oxygen-demanding wastes, ammonia, nutrients, and habitat alteration. Sources of these pollutants include urban runoff and storm sewers, industrial dischargers, municipal sewage treatment plants, and in-place contaminants. Threats to Connecticut's reservoir and lake quality include failing septic systems, erosion and sedimentation from construction and agriculture, agricultural wastes, fertilizers, and stormwater runoff.

Hypoxia (low dissolved oxygen) is the most widespread problem in Connecticut's estuarine waters in Long Island Sound. Bacteria also prevent shellfish harvesting and an advisory restricts consumption of bluefish and striped bass contaminated with PCBs. Connecticut's estuarine waters are impacted by municipal sewage treatment plants, combined sewer overflows, industrial discharges and runoff, failing septic systems, urban runoff, and atmospheric deposition. Historic waste disposal practices also contaminated sediments in Connecticut's harbors and bays.

Ground Water Quality

The State and USGS have identified about 1,600 contaminated public and private wells since the Connecticut Department of Environmental Protection (DEP) began keeping records in 1980. Connecticut's Wellhead Protection Program incorporates water supply planning, discharge permitting, water diversion, site remediation, prohibited activities, and numerous nonpoint source controls.

Programs to Restore Water Quality

Ensuring that all citizens can share in the benefits of clean water will require continued permit enforcement, additional advanced wastewater treatment, combined sewer separation, continued aquatic toxicity control, and resolution of nonpoint source issues. To date, 14 sewage treatment facilities have installed advanced treatment to remove nutrients. Nonpoint source management includes education projects and a permitting program for land application of sewage, agricultural sources, and solid waste management facilities.

Wetlands are protected by the State's Clean Water Act and Standards of Water Quality. Each municipality has an Inland Wetlands Agency that regulates filling and establishes regulated buffer areas with DEP training and oversight. Connecticut's courts have strongly upheld enforcement of the wetlands acts and supported regulation of buffer areas to protect wetlands.

Programs to Assess Water Quality

Connecticut samples physical and chemical parameters at 27 fixed stream sites and biological parameters at 47 stream sites. Other activities include intensive biological surveys, toxicity testing, and fish and shellfish tissue sampling for accumulation of toxic chemicals.

Individual Use Support in Connecticut

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 5,830)[b]	Total Miles Surveyed					
	893	69	6	22	3	0
	-	-	-	-	-	-
	893	64	8	18	10	<1
Lakes (Total Acres = 64,973)	Total Acres Surveyed					
	24,941	95	1	4	0	0
	24,293	88	0	12	0	0
	24,941	63	36	1	0	0
Estuaries (Total Square Miles = 600)	Total Square Surveyed					
	600	63	0	37	0	0
	600	100	0	0	0	0
	600	81	0	0	19	0
	600	90	0	10	0	0

- Not reported

[a] A subset of Connecticut's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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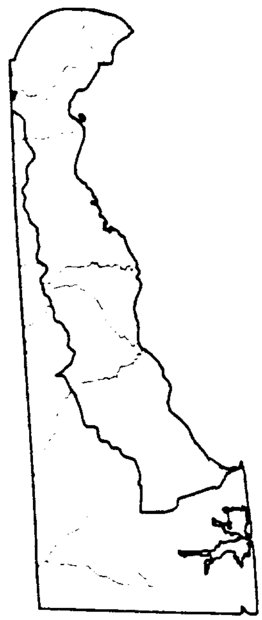
Delaware



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Delaware 1994 305(b) report, contact:

Brad Smith
Delaware Department of Natural Resources and Environmental Control
Division of Water Resources
P.O. Box 1401
Dover, DE 19903
(302) 739-4590

Surface Water Quality

Delaware's rivers and streams generally meet standards for aquatic life uses, but 93% of the surveyed stream miles and 76% of the surveyed lake acres do not meet bacteria criteria for swimming. Bacteria are the most widespread contaminant in Delaware's surface waters, but nutrients and toxics pose the most serious threats to aquatic life and human health. Excessive nutrients stimulate algal blooms and growth of aquatic weeds. Toxics result in six fish consumption restrictions in three basins, including Red Clay Creek, Red Lion Creek, the St. Jones River, and the Delaware Estuary. Agricultural runoff, septic systems, urban runoff, municipal sewage treatment plants, and industrial dischargers are the primary sources of nutrients and toxics in Delaware's surface waters.

Ground Water Quality

High-quality ground water provides two-thirds of Delaware's domestic water supply. However, nitrates, synthetic organic chemicals, saltwater, and iron contaminate isolated wells in some areas. In the agricultural areas of Kent and Sussex counties, nitrates in ground water are a potential health concern and a potential source of nutrient contamination in surface waters. Synthetic organic chemicals have entered some ground waters from leaking industrial underground storage tanks, landfills, abandoned hazardous waste sites, chemical spills and leaks, septic systems, and agricultural activities.

Programs to Restore Water Quality

The Department of Natural Resources and Environmental Control (DNREC) adopted a watershed approach to determine the most effective and efficient methods for protecting water quality or abating existing problems. Under the watershed approach, DNREC will evaluate all sources of pollution that may impact a waterway and target the most significant sources for management. The Appoquinimink River subbasin, the Nanticoke River subbasin, the Delaware's Inland Bays subbasin, and the Christina River subbasin are priority watersheds targeted for development of integrated pollution control strategies.

Delaware's Wellhead Protection Program establishes cooperative arrangements with local governments to manage sources of ground water contamination. The State may assist local governments in enacting zoning ordinances, site plan reviews, operating standards, source prohibitions, public education, and ground water monitoring.

Programs to Assess Water Quality

Delaware's Ambient Surface Water Quality Program includes fixed-station monitoring and biological surveys employing rapid bioassessment protocols. Delaware is developing and testing new protocols for sampling biological data in order to determine whether specific biological criteria can be developed to determine support of designated uses.

Individual Use Support in Delaware

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 3,158)[b] — Total Miles Surveyed						
	894	80	0	9	11	0
	19	0	0	0	100	0
	836	7	0	14	75	4
Lakes (Total Acres = 4,499) — Total Acres Surveyed						
	2,605	85	1	8	6	0
	227	19	0	0	81	0
	2,605	24	0	37	39	0
Estuaries (Total Square Miles = 29)[c] — Total Square Miles Surveyed						
	28.9	0	0	0	100	0
	-	-	-	-	-	-
	25.0	26	0	38	26	10
	28.9	45	0	41	14	0

- Not reported.
[a] A subset of Delaware's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Excludes waters under jurisdiction of the Delaware River Basin Commission.

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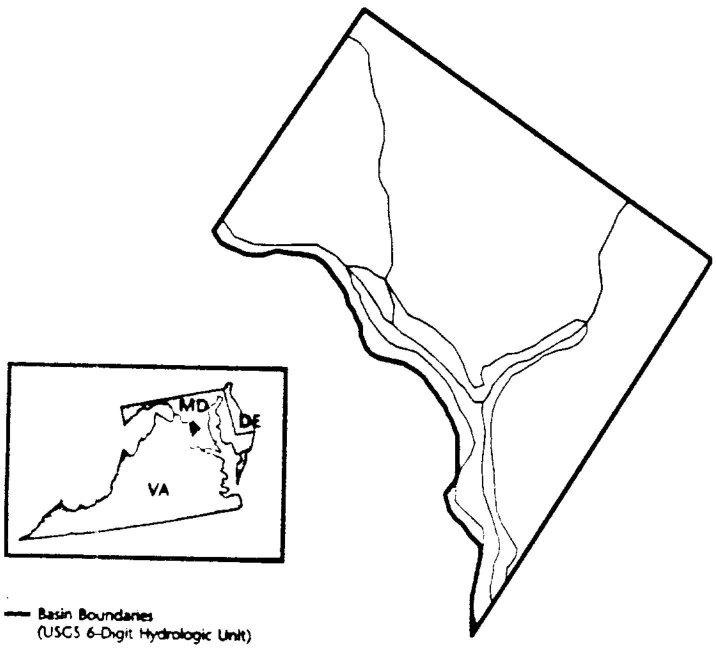
District of Columbia



For a copy of the District of Columbia 1994 305(b) report, contact:

Dr. Hamid Karimi
Department of Consumer and Regulatory Affairs
Environmental Regulation Administration
Water Quality Monitoring Branch
2100 Martin Luther King Jr. Avenue, SE
Washington, DC 20020
(202) 645-6601

Surface Water Quality

Poor water quality still characterizes the District's surface waters, but water quality has stabilized and is improving in some areas. The recovery of submerged aquatic vegetation and fish communities in the Anacostia and Potomac Rivers provides qualitative evidence that water quality is improving. However, a fish consumption advisory and a swimming ban remain in effect for all District surface waters, and sediment contamination degrades aquatic life on the Anacostia River. Combined sewer overflows are the main source of bacterial pollution that causes unsafe swimming conditions. Urban runoff may be the source of high concentrations of cadmium, mercury, lead, PCBs, PAHs, and DDT found in sediment samples.

Ground Water Quality

During the 1994 305(b) assessment period, the District initiated ground water monitoring. The first round of sampling revealed that the ground water is potable. Some pollutants were detected at low concentrations in isolated cases. Ground water is not a public drinking water source in the District, but the District has a comprehensive State ground water protection program to assess and manage the resource. The program includes an ambient ground water sampling network, ground water quality regulations (including numerical and narrative criteria), and guidelines for preventing and remediating ground water quality degradation.

Programs to Restore Water Quality

The District is implementing innovative stormwater runoff controls for urban areas and promoting the watershed protection approach to clean up waterbodies that cross political boundaries, such as the Anacostia River. The District needs Maryland's cooperation to control pollution entering upstream tributaries located in Maryland. Additional funds will be needed to implement urban stormwater retrofits, CSO controls, and revegetation projects in both the District and Maryland to improve water quality in the Anacostia River.

Programs to Assess Water Quality

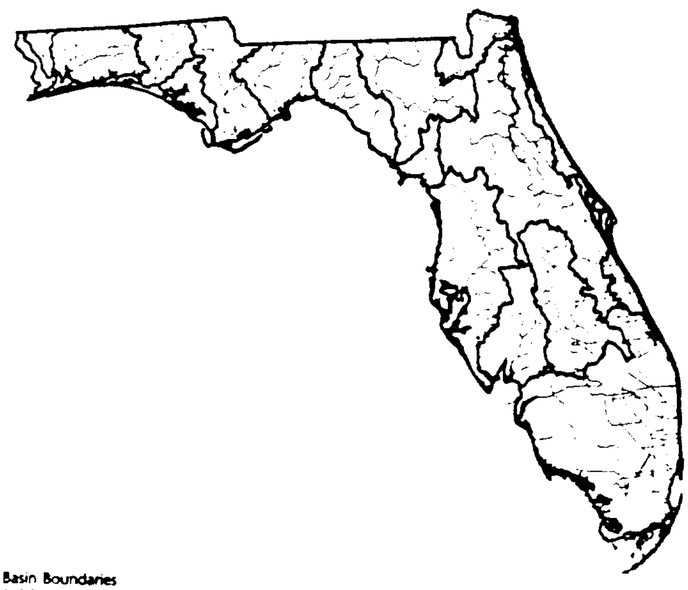
The District performs monthly physical and chemical sampling at 80 fixed stations on the Potomac River, the Anacostia River, and their tributaries. The District samples phytoplankton (microscopic plants) monthly at 15 stations and zooplankton at 3 stations. The District samples metals in the water column four times a year and analyzes toxic pollutants in fish tissue once a year. In 1992 and 1993, the District conducted rapid bioassessments on 29 waterbodies.

Individual Use Support in District of Columbia

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 39)[b] — Total Miles Surveyed						
	37	38	0	0	62	0
	32	0	0	100	0	0
	27	4	0	0	96	0
Lakes (Total Acres = 251) — Total Acres Surveyed						
	239	57	0	0	43	0
	211	0	0	100	0	0
	238	0	0	0	100	0
Estuaries (Total Square Miles = 5.8) — Total Square Miles Surveyed						
	5.8	86	0	9	5	0
	5.8	0	0	100	0	0
	-	-	-	-	-	-
	5.8	0	0	0	100	0

[a] A subset of District of Columbia's designated uses appear in this figure. Refer to the District's 305(b) report for a full description of the District's uses.
[b] Includes nonperennial streams that dry up and do not flow all year

Florida



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Florida 1994 305(b) report, contact:

Joe Hand
Florida Dept. of Environmental Regulation
Twin Towers Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400
(904) 921-9926

Surface Water Quality

Overall, the majority of Florida's surface waters are of good quality, but problems exist around densely populated urban areas, primarily in central and southern Florida. In rivers, nutrient enrichment, low dissolved oxygen, high bacteria counts, turbidity, and suspended solids degrade water quality. In lakes, the leading problems include algal blooms, turbidity, and nutrient enrichment. In estuaries, algal blooms, nutrient enrichment, low dissolved oxygen, and turbidity degrade quality. Urban stormwater, agricultural runoff, domestic wastewater, industrial wastewater, and hydrologic modifications are the major sources of water pollution in Florida.

Special State concerns include massive fish kills (as much as 20 tons of fish) in the Pensacola Bay system, widespread toxic contamination in sediments, widespread mercury contamination in fish, bacterial contamination in the Miami River, and algal blooms and extensive die-off of mangroves and seagrasses in Florida Bay.

Ground Water Quality

Data from 1,919 wells in Florida's ambient monitoring network indicate generally good water quality, but local ground water contamination problems exist. Agricultural chemicals, including aldicarb, alachlor, bromacil, simazine, and ethylene dibromide (EDB) have caused local and regional (in the case of EDB) problems. Other threats include petroleum products from leaking underground storage tanks, nitrates from dairy and other livestock operations, fertilizers and pesticides in stormwater runoff, and toxic chemicals in leachate from hazardous waste sites. The State requires periodic testing of all community water systems for 118 toxic organic chemicals.

Programs to Restore Water Quality

Florida controls point source pollution with its own discharge permitting process similar to the NPDES program. The State permits about 4,600 ground water and surface water discharge facilities. The State also encourages reuse of treated wastewater (primarily for irrigation) and discharge into constructed wetlands as an alternative to direct discharge into natural surface waters and ground water.

Florida's Stormwater Rule and implementing regulations are the core of the State's nonpoint source program. These regulations require all new developments to retain the first inch of runoff water in ponds to settle out sediment and other pollutants. Ongoing contracts focus on best management practices for other nonpoint sources, including agriculture, septic tanks, landfills, mining, and hydrologic modification.

Programs to Assess Water Quality

Florida's Surface Water Assessment Program (SWAMP) will identify ecoregion subregions and develop community bioassessment protocols; develop and implement a sampling network to monitor water quality trends and determine current conditions; and perform special water quality assessments if funds are available. The State defined 13 ecological subregions for the State and has established 66 reference stream sites for developing bioassessment protocols.

Individual Use Support in Florida

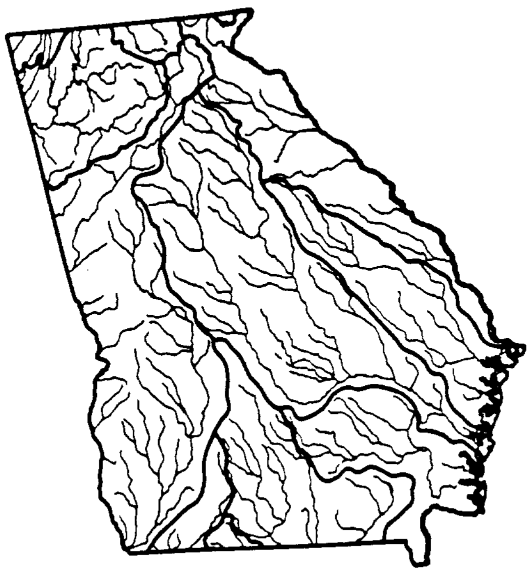
Designated Use[a]	Total Assessed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 51,858)[b]	Total Miles Assessed					
	11,880	46	19	27	8	0
	-	-	-	-	-	-
	11,880	46	19	27	8	0
Lakes (Total Acres = 2,085,120)	Total Acres Assessed					
	1,240,960	36	5	40	19	0
	-	-	-	-	-	-
	1,240,960	36	5	40	19	0
Estuaries (Total Square Miles = 4,298)	Total Square Miles Assessed					
	3,706	52	11	33	5	0
	-	-	-	-	-	-
	1,717	59	9	30	2	0
	3,706	52	11	33	4	0

- Florida does not designate waterbodies for this use.

[a] A subset of Florida's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Georgia



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Georgia 1994 305(b) report, contact:

W.M. Winn, III
Georgia Environmental Protection Division
Water Quality Management Program
Floyd Towers, East
205 Butler Street, SE
Atlanta, GA 30334
(404) 656-4905

Surface Water Quality

Improvements in wastewater treatment by industries and municipalities have made it possible for Georgians to fish and swim in areas where water quality conditions were unacceptable for decades. Water quality in Georgia streams, lakes, and estuaries during 1992 and 1993 was good, but the number of stream miles and lake acres not fully supporting designated uses increased. The number of fish advisories also grew from four to nine during 1992-1994. However, this is a result of more stringent stream standards, increased sampling, and access to additional data. Persistent problems include mud, litter, bacteria, pesticides, fertilizers, metals, oils, suds, and other pollutants washed into rivers and lakes by stormwater.

Ground Water Quality

Georgia's ambient Ground Water Monitoring Network consists of 150 wells sampled periodically. To date, increasing nitrate concentrations in the Coastal Plain are the only adverse trend detected by the monitoring network, but nitrate concentrations are still well below harmful levels in most wells. Additional nitrate sampling in 500 wells revealed that nitrate concentrations exceeded EPA's Maximum Contaminant Level (MCL) in less than 1% of the tested wells. Pesticide monitoring indicates that pesticides do not threaten Georgia's drinking water aquifers at this time.

Programs to Restore Water Quality

Comprehensive river basin management planning will provide a basis for integrating point and nonpoint source water protection efforts within the State and with neighboring States. In 1992, the Georgia General Assembly passed Senate Bill 637, which requires the

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Department of Natural Resources to develop management plans for each river basin in the State. The State began developing comprehensive plans for the Chattahoochee and Flint River Basins in 1992 and the Oconee and Coosa River Basins in 1993. Georgia is also participating in a Tri-State Comprehensive Study with the Corps of Engineers, Alabama, and Florida to develop interstate agreements for maintaining flow and allocating assimilative capacity. Other interstate basin projects include the Savannah Watershed Project with South Carolina and the Suwannee River Basin Planning Project with the Georgia and Florida Soil Conservation Services.

Programs to Assess Water Quality

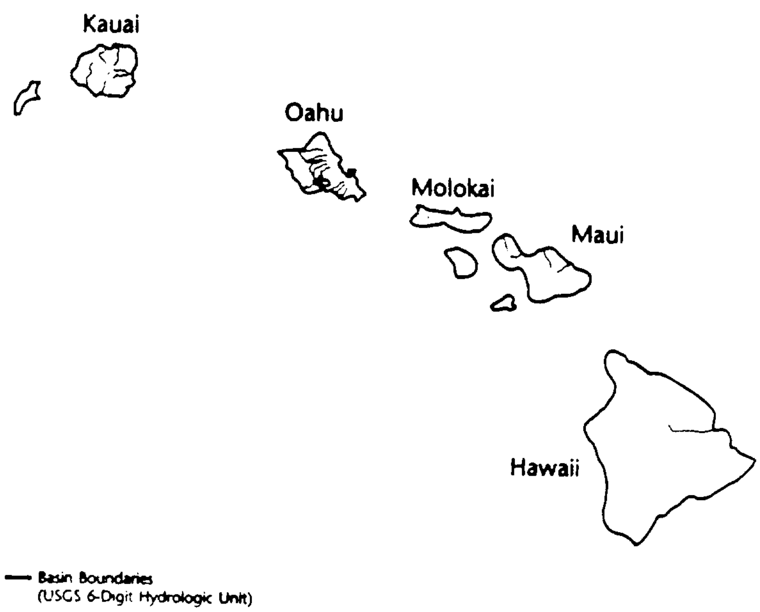
Georgia continued sampling at 145 fixed monitoring stations, conducted 14 intensive surveys, and performed over 600 compliance sampling inspections during 1992 and 1993. Georgia also sampled toxic substances in effluent from point source dischargers, streams, sediment, and fish tissues at selected sites throughout the State. The State assessed the overall toxicity in wastewater effluent with both acute and chronic aquatic toxicity tests.

Individual Use Support in Georgia

Designated Use[a]		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 70,150)[b]	Total Miles Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
Lakes (Total Acres = 425,382)	Total Acres Surveyed					
	380,665	50	0	23	27	0
	371,906	78	0	0	22	0
	380,665	95	0	1	3	0
Estuaries (Total Square Miles = 854)	Total Square Miles Surveyed					
	754	88	0	<1	11	0
	2	0	0	0	100	0
	-	-	-	-	-	-
	854	100	0	<1	0	0

- Not reported.
[a] A subset of Georgia's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Hawaii



For a copy of the Hawaii 1994 305(b) report, contact:

Eugene Akazawa, Monitoring Supervisor
Hawaii Department of Health
Clean Water Branch
919 Ala Moana Blvd.
Honolulu, HI 96814
(808) 586-4309

Surface Water Quality

Most of Hawaii's waterbodies have variable water quality due to stormwater runoff. During dry weather, most streams and estuaries have good water quality that fully supports beneficial uses, but the quality declines when stormwater runoff carries pollutants into surface waters. The most significant pollution problems in Hawaii are siltation and turbidity, nutrients, fertilizers, toxics, pathogens, and pH from nonpoint sources, including agriculture and urban runoff. Very few point sources discharge into Hawaii's streams; most industrial facilities and wastewater treatment plants discharge into coastal waters. Other concerns include explosive algae growth in West Maui and Kahului Bay, a fish consumption advisory for lead in talipia caught in Manoa Stream, and sediment contamination from discontinued wastewater discharges at Wailoa Pond and Hilo Bay.

Ground Water Quality

Compared to mainland States, Hawaii has very few ground water problems due to a long history of land use controls for ground water protection. Prior to 1961, the State designated watershed reserves to protect the purity of rainfall recharging ground water. The Underground Injection Control Program also prohibits wastewater injection in areas surrounded by "no-pass" lines. However, aquifers outside of reserves and no-pass lines may be impacted by injection wells, household wastewater disposal systems, such as seepage pits and cesspools, landfills, leaking underground storage tanks, and agricultural return flows.

Programs to Restore Water Quality

County governments are required to set erosion control standards for various types of soil and land uses. These standards include criteria, techniques, and methods for controlling sediment erosion from land-disturbing activities. The State would like to enact ordinances that require the rating of pesticides on their potential to migrate through soil into ground water. The State would regulate the use of pesticides that pose a threat to ground water. Until more stringent ordinances can be enacted, the State recommends using alternatives to pesticides, such as natural predators and other biological controls. The State also encourages the use of low-toxicity, degradable chemicals for home gardens, landscaping, and golf courses.

Programs to Assess Water Quality

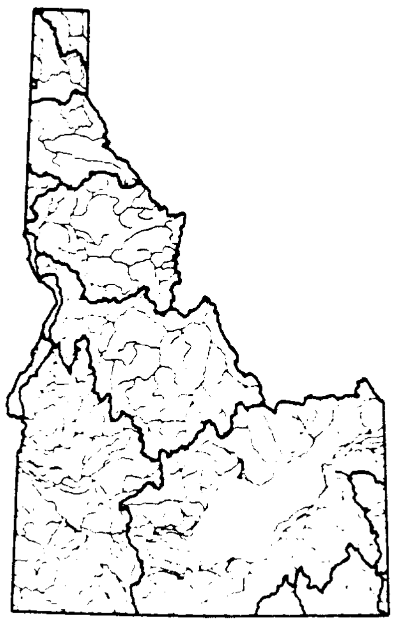
Hawaii has scaled back its water quality monitoring program because of budgetary constraints. The State has halted toxics monitoring, fish tissue contamination monitoring, and biological monitoring and eliminated sampling at numerous fixed monitoring stations. The State also reduced the frequency of bacterial monitoring at coastal beaches. The State does not expect conditions to change in the near future.

Overall[a] Use Support in Hawaii

	Total Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 249)[b] — Total Miles Surveyed	32	0	0	69	25	6
Lakes (Total Acres = 2,168) — Total Acres Surveyed	-	-	-	-	-	-
Estuaries (Total Square Miles = 380) — Total Square Miles Surveyed	76	36	1	30	33	-
Oceans (Total Miles = 1,053) — Total Shoreline Miles Surveyed	943	88	2	7	3	<1

- Not reported.
[a] Overall use support is presented because Hawaii did not report individual use support in their 1994 Section 305(b) report.
[b] Includes nonperennial streams that dry up and do not flow all year.

Idaho



For a copy of the Idaho 1994 305(b) report, contact:

Don Zaroban
Idaho Department of Health and Welfare
Division of Environmental Quality
1410 North Hilton
Statehouse Mall
Boise, ID 83720
(208) 334-5860

Surface Water Quality

Idaho omitted its water quality assessment for surface waters in their 1994 305(b) report because the State is in the middle of a major overhaul of its water quality management program. Idaho is restructuring its program around the watershed protection approach. As a first step, Idaho is redesignating its waterbodies and expanding its assessment database to include smaller streams that previously were not assessed. The State postponed its water quality assessment until all surface waters are designated and classified under a consistent system.

Idaho's Department of Environmental Quality (DEQ) identified several waterbodies with significant problems. Heavy metals and nutrients impact the Coeur d'Alene River drainage, while nutrients and sediment impact Henry's Fork. The middle Snake River exhibits severe eutrophication from nutrient enrichment. Mercury contaminates fish tissue in Brownlee Reservoir, and the Cascade Reservoir does not support agricultural uses due to overenrichment with nutrients.

Ground Water Quality

The Idaho Statewide Monitoring Program for Ground Water samples over 800 wells. This program and other specific projects have indicated that nitrates, petroleum products, solvents, and pesticides are the most prevalent pollutants in ground water. The Idaho Legislature adopted the Ground Water Quality Plan in 1992. This plan sets four priority issues: (1) evaluation of existing ground water programs, (2) development of State ground water standards, (3) development of a State wellhead protection program, and (4) classification of Idaho's aquifers. Ground water quality protection programs in Idaho include underground injection control, ground water vulnerability mapping, and management for animal waste, landfills, pesticides application, underground storage tanks, and sewage disposal.

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Programs to Restore Water Quality

EPA has primary responsibility for issuing NPDES permits in Idaho. Idaho's DEQ is concerned that EPA is not issuing permits for minor point source dischargers, and inspections of permitted and unpermitted dischargers are rare. Neither DEQ or EPA have sufficient staff to conduct compliance inspections. Without oversight, there are no assurances that these facilities are being properly operated and meet water quality standards.

Programs to Assess Water Quality

DEQ operates a water quality monitoring program that measures biological, physical, and chemical parameters. Data collection varies in intensity, from desktop reviews of existing data (Basic or Level I), through qualitative surveys and inventories that cannot be repeated with confidence (Reconnaissance or Level II), to quantitative measurements that can be repeated and yield data suitable for statistical analysis (Intensive or Level III).

Individual Use Support in Idaho

Designated Use[a]		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 115,595)[b]						
	Total Miles Surveyed -	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
Lakes (Total Acres = 700,000)						
	Total Acres Surveyed -	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

- Not reported.
[a] A subset of Idaho's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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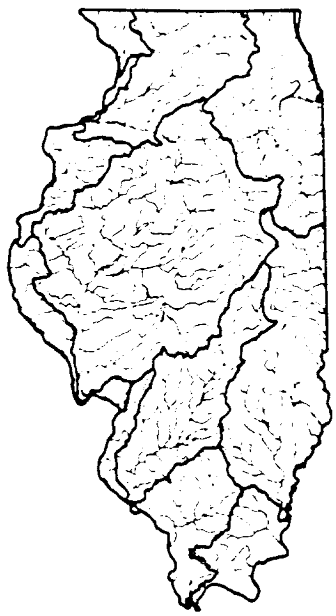
Illinois



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Illinois 1994 305(b) report, contact:

Mike Branham
Illinois Environmental Protection Agency
Division of Water Pollution Control
P.O. Box 19276
Springfield, IL 62794-9276
(217) 782-3362

Surface Water Quality

Overall water quality has steadily improved over the past 24 years since enactment of the Illinois Environmental Protection Act. Trend analysis generally indicates stable or improving trends in stream concentrations of dissolved oxygen, oxygen-depleting wastes, and ammonia consistent with the continued decline in point source impacts. However, dissolved oxygen depletion and ammonia still impair streams, as do nutrients, siltation, habitat/flow alterations, metals, and suspended solids. The State is also concerned about upward trends in nutrient concentrations detected in several basins that probably result from nonpoint sources. Other major sources of river pollution include persistent point sources, hydrologic/habitat modification, urban runoff, and resource extraction.

Trend analysis also indicates improving water quality in lakes. The most prevalent causes of remaining pollution in lakes include nutrients, suspended solids, and siltation. The most prevalent sources of pollution in lakes include contaminated sediments, agriculture, and hydrologic/habitat alterations.

Water quality also continues to improve in the Illinois portion of Lake Michigan. Trophic status improved from mesotrophic/eutrophic conditions in the 1970s to oligotrophic conditions today.

Ground Water Quality

Ground water quality is generally good, but past and present activities contaminate ground water in isolated areas. Ground water is contaminated around leaking underground gasoline storage tanks, large aboveground petroleum storage facilities, agricultural chemical operations, salt piles, landfills, and waste treatment, storage, and disposal facilities.

Programs to Restore Water Quality

The Illinois Environmental Protection Agency (IEPA), Bureau of Water, is committed to implementing a Targeted Watershed Approach in which high-risk watersheds are identified, prioritized, and selected for integrated and cooperative assessment and protection. This approach represents an expansion

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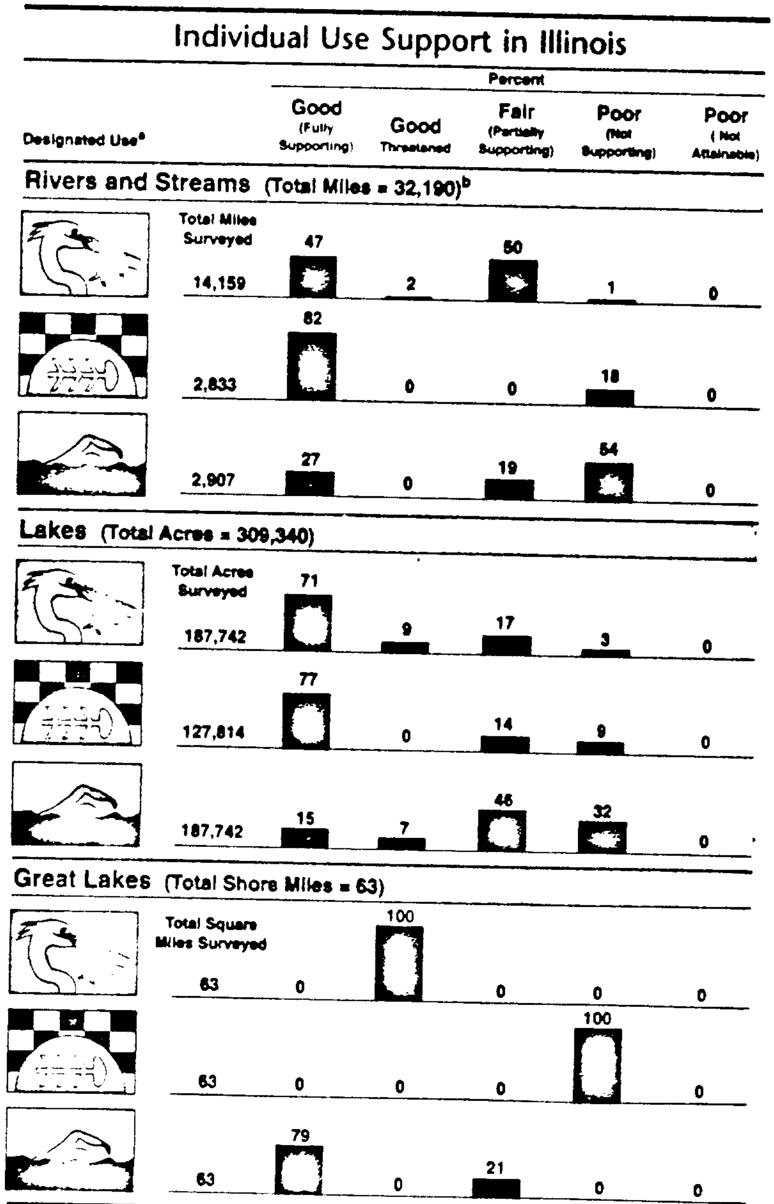
and evolution of their previous efforts in geographic targeting. Current nonpoint source program activities focus on improving public awareness and adding land use data to the nonpoint source database available statewide.

Illinois established a Great Lakes Program Office in FY93 to oversee all Lake Michigan programs on a multimedia basis. Activities include promotion of pollution prevention for all sources of toxics in all media (such as air and water).

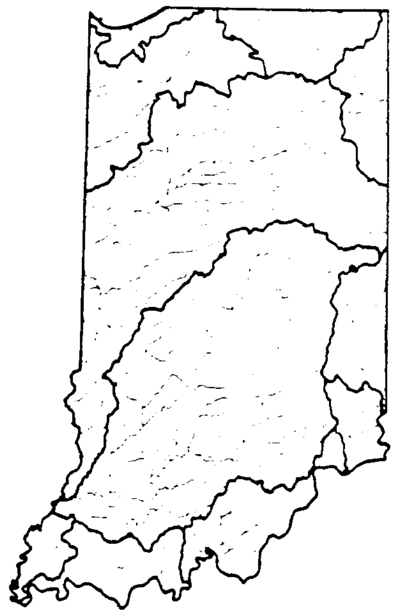
Programs to Assess Water Quality

The Division of Water Pollution Control spent $5.5 million on a diverse set of monitoring programs during 1992 and 1993. These programs include ambient and toxicity monitoring, pesticide monitoring, intensive river basin surveys, fish contaminant monitoring, and volunteer lake monitoring. These programs generate a rich inventory of monitoring data for assessing water quality conditions across the State. IEPA based their 1994 assessments on data from nearly 3,500 stations.



[a] A subset of Illinois designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Indiana



For a copy of the Indiana 1994 305(b) report, contact:

Dennis Clark
Indiana Department of Environmental Management
Office of Water Management
P.O. Box 6015
Indianapolis, IN 46206-6015
(317) 243-5037

Surface Water Quality

Over 99% of the surveyed lake acres and 79% of the surveyed river miles have good water quality that fully supports aquatic life. However, only 18% of the surveyed river miles support swimming due to high bacteria concentrations. A fish consumption advisory impairs all of Indiana's Lake Michigan shoreline. The pollutants most frequently identified in Indiana waters include bacteria, priority organic compounds, oxygen-depleting wastes, pesticides, metals, cyanide, and ammonia. The sources of these pollutants include industrial facilities, municipal/semipublic wastewater systems, combined sewer overflows, and agricultural nonpoint sources.

Indiana identified elevated concentrations of toxic substances in about 8% of the river miles monitored for toxics. High concentrations of PCBs, pesticides, and metals were most common in sediment samples and in fish tissue samples. Less than 1% of the surveyed lake acres contained elevated concentrations of toxic substances in their sediment.

Ground Water Quality

Indiana has a plentiful ground water resource serving 60% of its population for drinking water and filling many of the water needs of business, industry, and agriculture. Although most of Indiana's ground water has not been shown to be adversely impacted by human activities, the State has documented over 863 sites of ground water contamination. Nitrates are the most common pollutant detected in wells, followed by volatile organic chemicals and heavy metals. In agricultural regions, data indicate that 7% to 10% of the rural drinking water wells contain unacceptable nitrate concentrations and some detectable quantity of pesticides. Heavy metal contamination is associated with waste disposal sites.

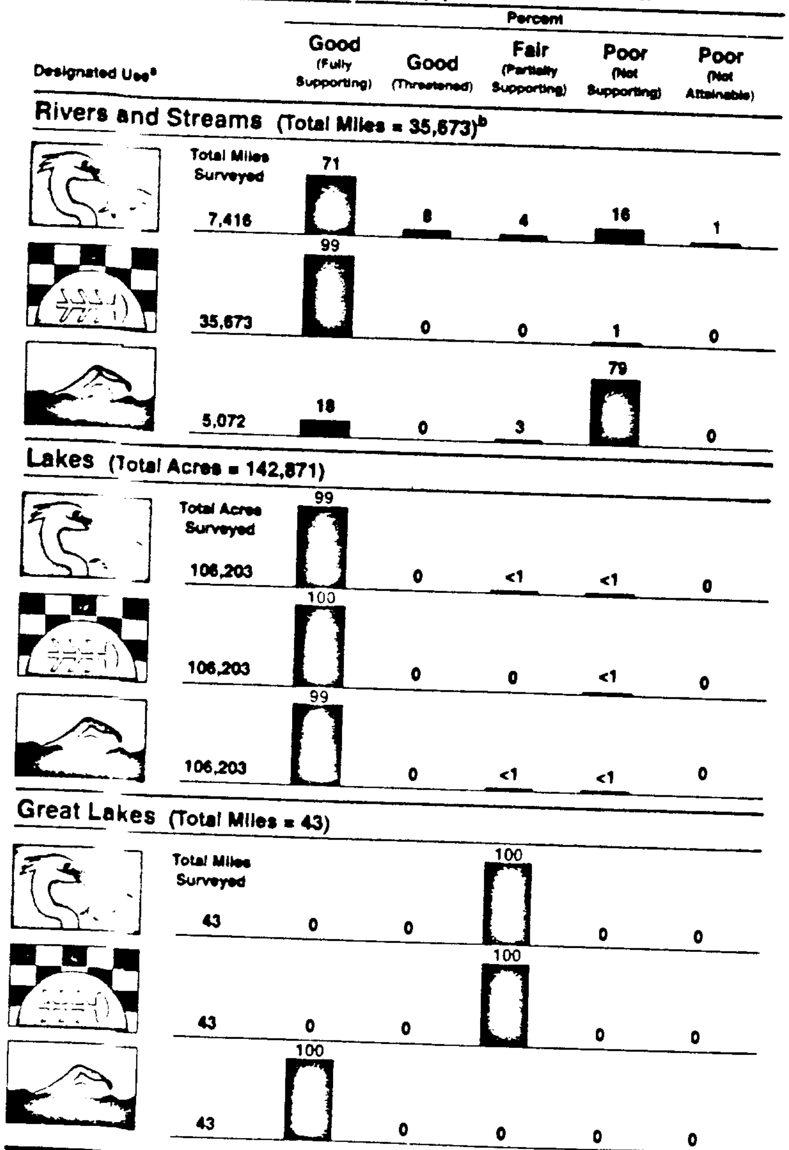
Programs to Restore Water Quality

Since 1972, Indiana has spent over $1.4 billion in Federal construction grants, $207 million in State funds, and $190 million in matching local funds to construct or upgrade sewage treatment facilities. As a result of these expenditures, 53% of Indiana's population is now served by advanced sewage treatment. The State issues NPDES permits to ensure that these new and improved facilities control pollution. Indiana is increasing enforcement activities to ensure compliance with permit requirements.

Programs to Assess Water Quality

Indiana initiated a 5-year baseline biological sampling program in 1989. As of 1994, the State had collected 2,000 aquatic insect samples at 439 sites representing 81% of the State's geographical area. In the future, the State will be able to detect deviations from the baseline dataset. Indiana and EPA Region 5 are also developing fish community measurements for evaluating biological integrity in Indiana's rivers and streams.

Individual Use Support in Indiana



[a] A subset of Indiana's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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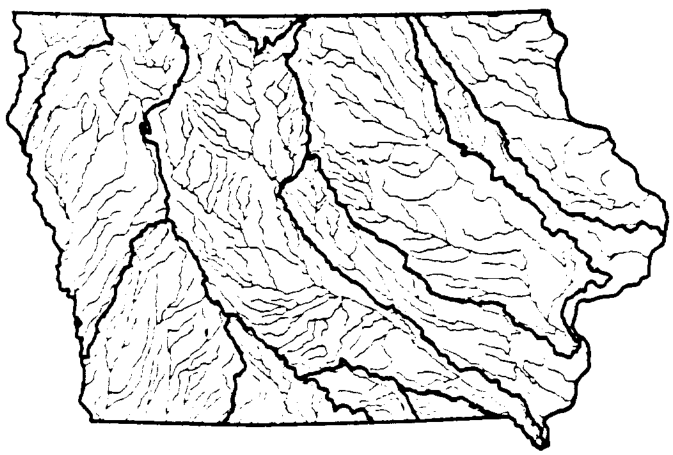
Iowa



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Iowa 1994 305(b) report, contact:

John Olson
Iowa Department of Natural Resources
Water Resources Section
900 East Grand Avenue
Wallace State Office Building
Des Moines, IA 50319
(515) 281-8905

Surface Water Quality

Sediment and plant nutrients from agricultural sources, modifications to stream habitat and hydrology, and natural conditions (such as shallowness in lakes) impair aquatic life uses in 48% of the surveyed rivers, 35% of the surveyed lakes, and 33% of the surveyed flood control reservoirs. Swimming use is impaired in 92% of the 556 surveyed river miles and 27% of the surveyed lakes, ponds, and reservoirs. Saylorville, Coralville, and Rathburn Reservoirs have good water quality that fully supports all designated uses, but siltation severely impacts Red Rock Reservoir. Point sources still pollute about 5% of the surveyed stream miles and one lake.

Ground Water Quality

Ground water supplies about 80% of all Iowa's drinking water. Agricultural chemicals, underground storage tanks, agricultural drainage wells, livestock wastes, and improper management of hazardous substances all contribute to some degree to ground water contamination in Iowa. Nitrate concentrations exceed the EPA's Maximum Contaminant Level in 10 of the State's 1,140 public ground water supplies. Several studies have detected low levels of common agricultural pesticides and synthetic organic compounds, such as solvents and degreasers, in both untreated and treated ground water. In most cases, the contaminants appear in small concentrations thought to pose no immediate threat to public health, but little is known about the health effects of long-term exposure to low concentrations of these chemicals.

Programs to Restore Water Quality

In 1979, Iowa began implementing its agricultural nonpoint control strategy with education projects and cost-share programs to control sediment, the greatest pollutant, by volume, in the State. Later, Iowa adopted rules that require that land disposal of animal wastes not contaminate surface and ground waters. Landfill rules establish specific siting, design, operation, and monitoring criteria, and require annual inspections and permit renewals every 3 years. Iowa also regulates construction in floodplains to limit soil erosion and impacts on aquatic life.

Programs to Assess Water Quality

Iowa's DNR maintains a fixed sampling network and conducts special intensive studies at selected sites. The State routinely monitors metals, ammonia, and residual chlorine at the fixed sampling sites, but not pesticides. However, pesticides were monitored for special studies examining the fate of pesticides in Iowa rivers and levels of pesticides in water supply reservoirs. Limited monitoring for toxics in sediment was conducted as part of a special study in 1992 and 1993. Routine sampling has not included biological sampling in the past, but the role of biological sampling continues to grow. In 1994, Iowa initiated a pilot study to establish biologically based water quality criteria for wadeable streams in each ecoregion.

Individual Use Support in Iowa

Rivers and Streams (Total Miles = 71,666)[b]

Designated Use[a]	Total Miles Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
	5,702	0	52	47	1	0
	767	76	22	0	2	0
	556	1	7	92	0	0

Lakes (Total Acres = 129,666)[c]

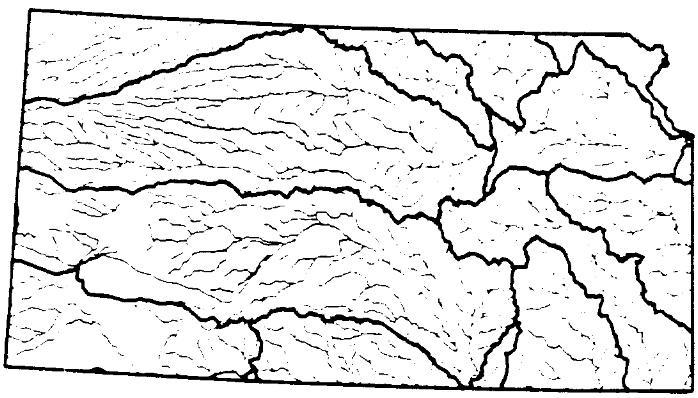
Designated Use[a]	Total Acres Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
	41,118	23	42	28	7	0
	18,838	94	6	0	0	<1
	38,194	25	48	24	3	0

Flood Control Reservoirs (Total Acres = 31,700)

Designated Use[a]	Total Acres Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
	31,700	35	32	33	0	0
	31,700	100	0	0	0	0
	31,700	65	35	0	0	0

[a] A subset of Iowa's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Excludes flood control reservoirs.

Kansas



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Kansas 1994 305(b) report, contact:

Mike Butler
Kansas Department of Health and Environment
Office of Science and Support
Forbes Field, Building 740
Topeka, KS 66620
(913) 296-5580

Surface Water Quality

Suspended solids and dissolved solids impair aquatic life uses in 93% of Kansas' surveyed streams. Bacteria also prevent 95% of the surveyed streams from fully supporting swimming uses. Runoff from feedlots, animal holding areas, and pastureland introduce pathogen bacteria into rivers and streams. Discharges of undertreated or untreated wastewater from sewage treatment plants also elevate pathogen bacteria levels in Kansas waters. Erosion of farmland soils and urban runoff are the principal sources of suspended solids. Irrigation return flows, oil and natural gas extraction activities, and natural sources introduce dissolved solids.

Cultural eutrophication is responsible for 34% of poor water quality conditions in Kansas' surveyed lakes, and pesticides impair an additional 23% of the surveyed lakes. Overall, agricultural activities are responsible for almost half of the pollution in the State's lakes. Agricultural activities and hydromodification are the major sources of impacts in wetlands.

Ground Water Quality

The Kansas Department of Health and Environment (DHE) has documented ground water contamination from human activities at nearly 350 sites in the State. Underground storage tanks, oil and natural gas operations, and agriculture are the most significant sources of ground water contamination in Kansas. Kansas maintains a ground water monitoring network of 242 wells. During 1990-1993, nitrate concentrations exceeded EPA's Maximum Contaminant Level in 11% of 618 ground water samples. A State Wellhead Protection Program is still under development, and several Kansas communities are developing local plans.

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Programs to Restore Water Quality

Kansas requires permits for livestock operations that utilize wastewater control facilities (such as manure pits, ponds, or lagoons); confine 300 or more head of cattle, hogs, sheep, or a combination of all three; or house a commercial poultry flock of 1,000 or more birds. DHE may also require permits for other livestock operations that have the potential to create pollution problems, such as open lots located adjacent to creeks or operations with a history of improper wastewater disposal practices. The major elements of the Kansas Nonpoint Source Pollution Control Program include interagency coordination, information and education, technical assistance, enforcement, and water quality certification.

Programs to Assess Water Quality

Every year, DHE collects and analyzes about 1,500 surface water samples, 50 aquatic insect samples, and 40 composite fish tissue samples from stations located throughout the State. Wastewater samples are collected at about 50 municipal sewage treatment plants, 20 industrial facilities, and 3 Federal facilities to evaluate compliance with discharge permit requirements. DHE also conducts special studies and prepares about 100 site-specific water quality summaries at the request of private citizens or other interested parties.

Individual Use Support in Kansas

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 134,338)[b]	Total Miles Surveyed					
	16,827	7	0	9	84	0
	-	-	-	-	-	-
	16,843	5	0	17	78	0
Lakes (Total Acres = 173,801)	Total Acres Surveyed					
	173,801	16	0	20	64	0
	-	-	-	-	-	-
	161,468	77	0	15	8	0

- Not reported.

[a] A subset of Kansas' designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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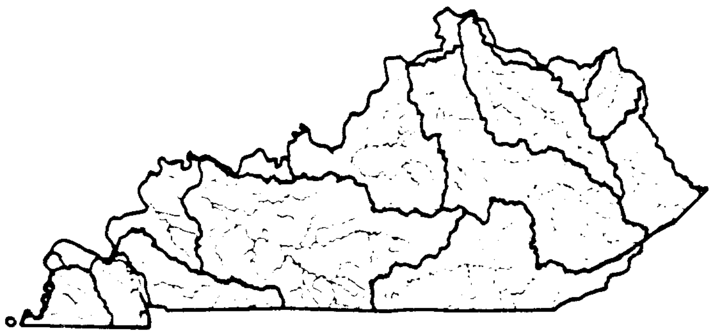
Kentucky



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Kentucky 1994 305(b) report, contact:

Tom VanArsdall
Department for Environmental Protection
Division of Water
14 Reilly Road
Frankfort Office Park
Frankfort, KY 40601
(502) 564-3410

Surface Water Quality

About 83% of Kentucky's surveyed rivers (including the Ohio River) and 95% of surveyed lake acres have good water quality that fully supports aquatic life. Swimming use is fully supported in 100% of the surveyed lake acres, but 52% of the surveyed river miles do not fully support swimming due to elevated bacteria levels. Fecal coliform bacteria, siltation, and oxygen-depleting substances are the most common pollutants in Kentucky rivers. Sewage treatment facilities are still a leading source of fecal coliform bacteria and oxygen-depleting substances, followed by agricultural runoff, septic tanks, and straight pipe discharges. Surface mining and agriculture are the major sources of siltation. Nutrients from agricultural runoff and septic tanks have the most widespread impacts on lakes.

Declining trends in chloride concentrations and nutrients provide evidence of improving water quality in Kentucky's rivers and streams. The State also lifted a swimming advisory on 76 miles of the North Fork Kentucky River, although the advisory remains in effect on 86 miles. Fish consumption advisories remain posted on three creeks for PCBs and on the Ohio River for PCBs and chlordane. The State issued new advisories for the Green River Lake because of PCB spills from a gas pipeline compressor station and for five ponds on the West Kentucky Wildlife Management Area because of mercury contamination from unknown sources.

Ground Water Quality

Underground storage tanks, septic tanks, abandoned hazardous waste sites, agricultural activities, and landfills are estimated to be the top five sources of ground water contamination in Kentucky. Bacteria is the major pollutant in ground water. The State is concerned about the lack of ground water data, absence of ground water regulations, and the potential for ground water pollution in karst regions of the State.

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Programs to Restore Water Quality

Kentucky's revolving fund program supported 26 wastewater treatment projects completed in 1992-93 and another 25 ongoing projects. These projects either replaced outdated or inadequate treatment facilities or provided centralized treatment for the first time. Kentucky requires toxicity testing of point source discharges and permits for stormwater outfalls and combined sewer overflows. The nonpoint source program oversees projects addressing watershed remediation, education, training, technical assistance, and evaluation of best management practices.

Programs to Assess Water Quality

Kentucky sampled 44 ambient monitoring stations characterizing about 1,432 stream miles during the reporting period. The State performed biological sampling at 24 of these stations. Seven lakes were sampled to detect eutrophication trends and 2 lakes were sampled to analyze the impact of suspended solids on recreational activities. The State also performed five intensive studies to evaluate point source and nonpoint source impacts, establish baseline water quality measurements, and reevaluate water quality in several streams.

Individual Use Support in Kentucky

Designated Use[a]		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 89,431)[b]	Total Miles Surveyed					
	14,936	83	<1	7	10	0
	14,937	99	0	0	1	0
	4,564	48	0	10	42	0
Lakes (Total Acres = 228,385)	Total Acres Surveyed					
	215,008	72	23	4	1	0
	217,250	96	0	4	0	0
	217,250	100	0	<1	0	0

[a] A subset of Kentucky's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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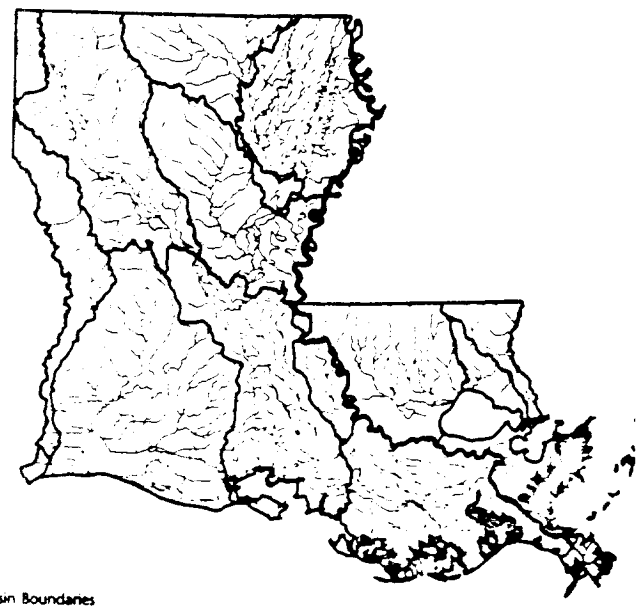
Louisiana



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Louisiana 1994 305(b) report, contact:

Albert E. Hindrichs
Louisiana Department of Environmental Quality
Office of Water Resources
Water Quality Management Division
P.O. Box 82215
Baton Rouge, LA 70884-2215
(504) 765-0511

Surface Water Quality

About 49% of the surveyed stream miles, 40% of the surveyed lake acres, and 70% of the surveyed estuarine waters have good water quality that fully supports aquatic life. Fecal coliform bacteria continue to be the most common pollutant in Louisiana's rivers and streams, followed by low dissolved oxygen concentrations and nutrients. As a result of violation of fecal coliform bacteria standards, 55% of the surveyed river miles do not fully support swimming and other contact recreational activities. Thirty-six percent of the surveyed lake acres and 28% of the surveyed estuarine waters also do not fully support swimming. Sources of bacteria include sewage discharges from municipal treatment plants, subdivisions, trailer parks, and apartment complexes. Septic tanks, sewage/stormwater overflows, pastures, and rangeland also generate bacterial pollution. Agricultural runoff generates oxygen-depleting substances and nutrients.

In lakes, noxious aquatic plants (which result from high nutrient loads) are the most common problem, followed by bacteria, low dissolved oxygen, nutrients, and oil and grease. Upstream sources of pollutants impact the most lake acres (primarily in Lake Pontchartrain), followed by municipal point sources, industrial point sources, and petroleum extraction activities. In estuaries, oil and grease, nutrients, and bacteria are the most common pollutants. Upstream sources of contamination, petroleum extraction activities, municipal discharges, sewer/stormwater overflow, and septic tanks are the leading sources of pollution in estuaries. Hydrologic modification impacts one surveyed wetland.

Ground Water Quality

The quality of water in the State's major aquifer systems remains excellent. Of special concern, however, are the shallow aquifers and the water-bearing zones that are not used as major sources of water. These strata contribute significantly to the water balance of the deeper aquifers, but the shallow aquifers are increasingly threatened.

Programs to Restore Water Quality

Currently, most reductions in nonpoint source pollution result from cooperative demonstration projects due to a lack of regulatory authority in Louisiana to control nonpoint source pollution. These projects have demonstrated alternative rice farming management practices to reduce sediment and nutrients in the Mermentau River Basin, advocated lawn care management to reduce erosion and runoff in the Bayou Vermilion watershed, and reduced fecal coliform concentrations in the Tangipahoa River by implementing septic tank and dairy waste lagoon education programs and upgrading municipal wastewater treatment systems.

Programs to Assess Water Quality

The surface water monitoring program consists of a fixed-station monitoring network, intensive surveys, special studies, and wastewater discharge compliance sampling. The fixed network includes at least one long-term trend analysis station on the major stream in each basin of the State. The State positioned other fixed sampling sites to monitor targeted sources of pollution or waterbodies. Louisiana does not maintain a regular fish tissue sampling program.

- Not reported

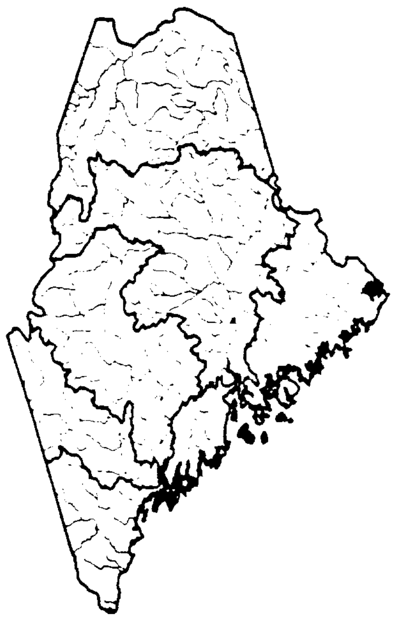
[a] A subset of Louisiana's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Individual Use Support in Louisiana

Designated Use[a]	Total Assessed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 66,294)[b]	Total Miles Assessed					
	9,164	49	0	29	22	0
	-	-	-	-	-	-
	9,165	45	0	28	27	0
Lakes (Total Acres = 1,078,031)	Total Acres Assessed					
	602,170	40	0	25	35	0
	-	-	-	-	-	-
	602,170	64	0	34	2	0
Estuaries (Total Square Miles = 7,656)	Total Square Miles Assessed					
	4,942	70	0	30	0	0
	-	-	-	-	-	-
	-	-	-	-	-	-
	4,942	72	0	28	0	0

Maine



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Maine 1994 305(b) report, contact:

Phil Garwood
Maine Department of Environmental Protection
Bureau of Water Quality Control
State House Station 17
Augusta, ME 04333
(207) 287-7695

Surface Water Quality

Maine's water quality has significantly improved since enactment of the Clean Water Act in 1972. Atlantic salmon and other fish now return to Maine's rivers, and waters that were once open sewers are now clean enough to swim in. Ninety-nine percent of the State's river miles, 81% of the lake acres, and 90% of the estuarine waters have good water quality that fully supports aquatic life uses. Dioxin in fish tissue is the most significant problem in major rivers. Oxygen-depleting substances from nonpoint sources and bacteria from inadequate sewage treatment are the most significant problem in smaller rivers and streams. Lakes are impacted by oxygen-depleting substances from nonpoint sources, including urban runoff, agriculture, and forestry activities. Bacteria from municipal treatment plants and small dischargers contaminate shellfish beds in estuarine waters.

Ground Water Quality

The most significant ground water impacts include petroleum compounds from leaking underground and aboveground storage tanks, other organic chemicals from leaking storage facilities or disposal practices, and bacteria from surface disposal systems or other sources. Maine requires that all underground tanks be registered and that inadequate tanks be removed. About 23,000 tanks have been removed since 1986. Maine also regulates installation of underground storage tanks and closure of landfills to protect ground water resources from future leaks.

Programs to Restore Water Quality

Maine restored designated uses in 20 miles of rivers by working with Kraft pulp and paper mills to reduce the levels of dioxin in their discharges. Construction of small wastewater treatment systems also eliminated some bacteria problems and dissolved oxygen problems on small streams. However, as the State makes progress in restoring waters impacted by point sources, new water quality problems emerge from nonpoint sources. Therefore, the most important water quality initiatives for the future include implementing pollution prevention, nonpoint source management, watershed-based planning, coordinated land use management, and water quality monitoring. The State is linking pollution prevention with the watershed protection approach in a pilot project within the Androscoggin River basin. The State is providing local officials and citizen groups with technical assistance to identify problem areas and develop local solutions for reducing pollution generation throughout the watershed.

Programs to Assess Water Quality

Maine's surface water monitoring program includes ambient water quality monitoring, assimilative capacity and wasteload allocation studies, diagnostic studies, treatment plant compliance monitoring, and special investigations. Due to budgetary constraints, some of these activities are much more limited in scope than is desirable for accurately characterizing water quality conditions in Maine.

- Not reported

[a] A subset of Maine's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses

[b] Includes nonperennial streams that dry up and do not flow all year

Individual Use Support in Maine

Designated Use[a]	Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 31,672)[b]	Total Miles Surveyed					
	31,656	99	0	0	<1	0
	31,697	99	0	1	0	0
	31,691	99	0	0	<1	0
Lakes (Total Acres = 986,776)	Total Acres Surveyed					
	958,776	75	6	19	0	0
	958,776	100	0	0	0	0
	958,776	84	11	5	0	0
Estuaries (Total Square Miles = 1,633)	Total Square Mile Surveyed					
	1,633	90	0	2	8	0
	-	-	-	-	-	-
	434	65	0	<1	32	3
	1,634	100	0	0	<1	0

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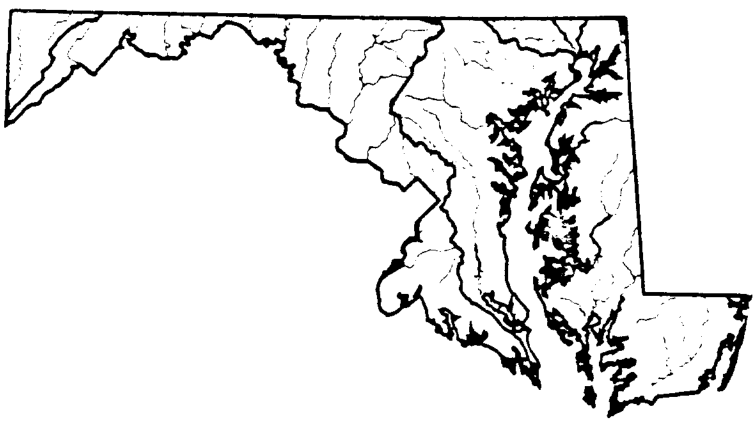
Maryland



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Maryland 1994 305(b) report, contact:

Sherm Garrison
Maryland Department of Natural Resources
Chesapeake Bay and Watershed Program
Tawes State Office Building
Annapolis, MD 21401
(410) 974-2951

Surface Water Quality

Overall, Maryland's surface waters have good quality, but excess nutrients, suspended sediments, bacteria, toxic materials, or stream acidity impact some waters. The most serious water quality problem in Maryland is the continuing accumulation of nutrients in estuaries and lakes from agricultural runoff, urban runoff, natural nonpoint source runoff, and point source discharges. Excess nutrients stimulate algal blooms and low dissolved oxygen levels that adversely impact water supplies and aquatic life.

Sources of sediment include agricultural runoff, urban runoff, construction activities, natural erosion, dredging, forestry, and mining operations. In western Maryland, abandoned coal mines release acidic waters that severely impact some streams. Agricultural runoff, urban runoff, natural runoff, and failing septic systems elevate bacteria concentrations and cause continuous shellfish harvesting restrictions in about 104 square miles of estuarine waters and cause temporary restrictions in another 72.3 square miles after major rainstorms.

Ground Water Quality

Maryland's ground water resource is of generally good quality. Localized problems include excess nutrients (nitrates) from fertilizers and septic systems; bacteria from septic systems and surface contamination; saline water intrusion aggravated by ground water withdrawals in the coastal plain; toxic compounds from septic tanks, landfills, and spills; petroleum products from leaking storage facilities; and acidic conditions and metals from abandoned coal mine drainage in western Maryland. Control efforts are limited to implementing agricultural best management practices and enforcing regulations for septic tanks, underground storage tanks, land disposal practices, and well construction.

Programs to Restore Water Quality

Maryland manages nonpoint sources with individual programs for each individual nonpoint source category. Urban runoff is addressed through stormwater and sediment control laws that require development projects to maintain predevelopment runoff patterns through implementation of best management practices (BMPs), such as detention ponds or vegetated swales. The Agricultural Water Quality Management Program supports many approaches, including Soil Conservation and Water Quality Plans, implementation of BMPs, and education. The Agricultural Cost Share Program has provided State, and some Federal, funds to help offset the costs of implementing almost 8,000 agricultural BMPs since 1983. An Animal Waste Permit Program requires discharge permits for facilities that will have a definable discharge to waters of the State.

Programs to Assess Water Quality

Maryland's monitoring program includes a fixed-station network, compliance sampling at point source discharges, bioassay tests of effluent toxicity, special intensive sampling programs on the Potomac and Patuxent Rivers, acid deposition monitoring, fish tissue and shellstock sampling, bacterial sampling in shellfish waters, phytoplankton sampling, biological monitoring, and habitat assessments.

Individual Use Support in Maryland

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 17,000)[b]	Total Miles Surveyed					
	6,000	69	0	29	2	0
	6,000	100	0	0	0	0
	6,000	100	0	0	<1	0
Lakes (Total Acres = 77,965)	Total Acres Surveyed					
	21,009	83	0	17	<1	0
	21,010	99	0	1	0	0
	5,687	100	0	0	0	0
Estuaries (Total Square Miles = 2,522)	Total Square Miles Surveyed					
	2,522	0	3	97	0	0
	2,522	99	0	1	0	0
	1,828	90	0	4	6	0
	2,522	1[illegible]	0	<1	<1	0

[a] A subset of Maryland's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow a year.

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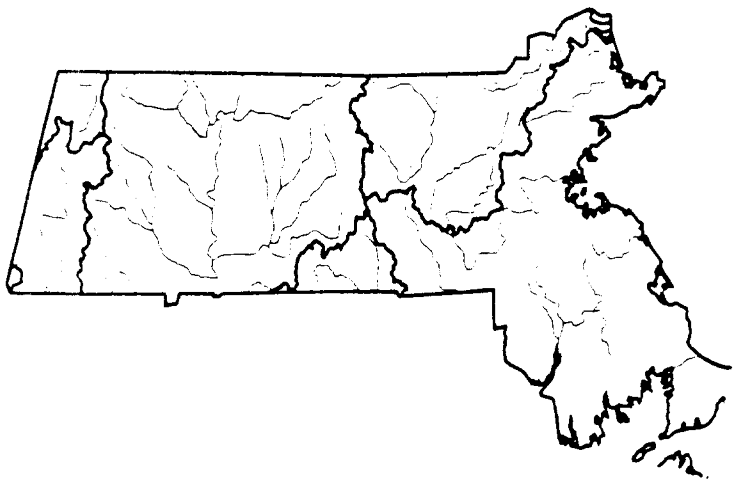
Massachusetts



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Massachusetts 1994 305(b) report, contact:

Warren Kimball
Massachusetts Department of Environmental Protection
Office of Watershed Management
40 Institute Road
North Grafton, MA 01536
(508) 792-7470

Surface Water Quality

The 1994 report does not reflect the progress made in cleaning up Massachusetts' rivers and lakes because reporting total miles free of all contaminants obscures progress in removing some contaminants from many waters. The method of reporting survey results obscures the statewide reduction in oxygen-depleting wastes because bacteria, nutrients, toxic pollutants, ammonia, and acidity still impact about half of the surveyed river miles, lake acres, and estuarine waters in the State. The leading sources of contamination in Massachusetts' surface waters are stormwater runoff, combined sewer overflows, and municipal sewage treatment plants.

Quabbin Reservoir's 25,000 acres support swimming and aquatic life, but high levels of mercury in sport fish restrict fish consumption. Unlike other waterbody types, coastal water bacterial quality has deteriorated over the past 10 years, especially in areas such as Cape Cod where nonpoint source pollution has resulted in a tenfold increase in shellfish bed closures.

Ground Water Quality

Contaminants have been detected in at least 206 ground water suppy wells in 87 municipalities. Organic chemicals (especially TCE) contaminate 60% of these wells. Other contaminants include metals, chlorides, bacteria, inorganic chemicals, radiation, nutrients, turbidity, and pesticides. Since 1983, Massachusetts has required permits for all industrial discharges into ground waters and sanitary wastewater discharges of 15,000 gallons or more per day. The permits require varying degrees of wastewater treatment based on the quality and use of the receiving ground water. Additional controls are needed to eliminate contamination from septic systems and sludge disposal.

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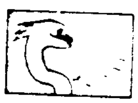
Programs to Restore Water Quality

Wastewater treatment plant construction has resulted in significant improvements in water quality, but $7 billion of unfunded wastewater needs remain. The Nonpoint Source Control Program has implemented 35 projects to provide technical assistance, implement best management practices, and educate the public. The State has also adopted a combined sewer overflow policy that provides engineering targets for cleanup and is presently addressing several CSO abatement projects.

Programs to Assess Water Quality

The Department of Environmental Protection (DEP) adopted a watershed planning approach to coordinate stream monitoring with wastewater discharge permitting, water withdrawa permitting, and nonpoint source control on a 5-year rotating schedule. The DEP is also adapting its monitoring strategies to provide information on nonpoint source pollution. For example, DEP will focus more on wet-weather sampling and biological monitoring and less on chemical monitoring during dry periods in order to gain a more complete understanding of the integrity of water resources.

Individual Use Support in Massachusetts

Designated Use[a]	Total Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 8,229)[b]	Total Miles Surveyed					
	1,360	60	13	11	16	0
	725	56	1	0	43	0
	1,337	40	9	24	27	0
Lakes (Total Acres = 151,173)[c]	Total Acres Surveyed					
	16,480	40	32	24	4	0
	2,292	59	12	0	29	0
	22,157	36	24	35	5	0
Estuaries (Total Square Miles = 223)	Total Square Miles Surveyed					
	198	54	1	13	32	0
	54	16	0	0	84	0
	126	58	0	18	24	0
	214	46	0	44	10	0

[a] A subset of Massachusetts's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Excluding Quabbin Reservoir.

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Michigan

For a copy of the Michigan 1994 305(b) report, contact:

Greg Goudy
Michigan Department of Natural Resources
Surface Water Quality Division
P.O. Box 30028
Lansing, MI 48909-7528
(517) 335-3310

Surface Water Quality

Ninety-eight percent of Michigan's surveyed river miles and 99% of Michigan's surveyed lake acres fully support aquatic life uses. Swimming use is also fully supported in 98% of the surveyed rivers and all of the surveyed lake acres. Priority organic chemicals (in fish) are the major cause of nonsupport in more river miles than any other pollutant, followed by siltation and sedimentation, metals, and bacteria. Leading sources of pollution in Michigan include unspecified nonpoint sources, agriculture, municipal and industrial discharges, combined sewers, and atmospheric deposition.

Very few lakes in Michigan completely fail to support fishing and swimming, but there is no doubt that both point and nonpoint sources have increased the rate of eutrophication (overenrichment), altered biological communities, and degraded the overall aesthetic and recreational quality of a great number of Michigan's fragile lake resources. Many more lakes are threatened by long-term, cumulative pollutant loads, especially in the rapidly growing communities on northern lower Michigan.

Four of the five Great Lakes border Michigan. The open waters of Lakes Superior, Michigan, and Huron have good quality. Poor water quality is restricted to a few degraded locations near shore. Lake Erie's water quality has improved dramatically in the last two decades. Once declared dead, Lake Erie now supports the largest walleye sport fishery on the Great Lakes. The dramatic improvements are due primarily to nutrient controls applied to sewage treatment plants, particularly in the Detroit area.

Ground Water Quality

Most of the ground water resource is of excellent quality, but certain aquifers have been contaminated with toxic materials leaking from waste disposal sites, businesses, or government facilities. The Michigan Ground Water Protection Strategy and Implementation Plan identifies specific program initiatives, schedules, and agency responsibilities for protecting the State's ground water resources.

Programs to Restore Water Quality

Major point source reductions in phosphorus and organic material loads have reduced or eliminated water quality problems in many Michigan waters. However, expanded efforts are needed to control nonpoint source pollution, eliminate combined sewer overflows, and reduce toxic contamination. Michigan has implemented an industrial pretreatment program, promulgated rules on the discharge of toxic substances, and regulated hazardous waste disposal facilities, but many toxicity problems are due to past activities that contaminated sediments.

Programs to Assess Water Quality

Between 1989 and 1993, the Department of Natural Resources devoted a significant amount of staff time to documenting water quality impacts from nonpoint sources of pollution and verifying information in the Michigan Nonpoint Source Assessment. Chemical, biological, and physical surveys were conducted to identify water quality standards violations and degraded biological communities in numerous watersheds.

Individual Use Support in Michigan

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 51,438)[b]	Total Miles Surveyed					
	20,575	98	-	-	2	0
	20,575	97	-	-	3	0
	20,575	98	-	-	2	0
Lakes (Total Acres = 887,019)	Total Acres Surveyed					
	489,825	99	1	-	<1	0
	489,825	0	95	-	5	0
	489,825	100	0	-	0	0
Great Lakes (Total Miles = 3,288)	Total Miles Surveyed					
	3,288	0	-	-	100	0
	3,288	0	-	-	100	0
	3,288	100	-	-	<1	0

[a] A subset of Michigan's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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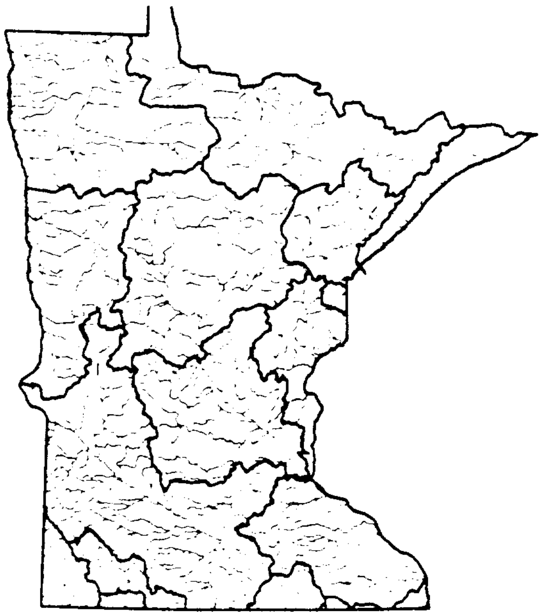
Minnesota



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Minnesota 1994 305(b) report, contact:

Elizabeth Brinsmade
Minnesota Pollution Control Agency
Water Quality Division
520 Lafayette Road North
St. Paul, MN 55155
(612) 296-8861

Surface Water Quality

About 73% of the surveyed river miles have good quality that fully supports aquatic life uses and 39% of the surveyed rivers fully support swimming. Seventy-nine percent of the surveyed lake acres fully support swimming. The most common pollutants identified in rivers were bacteria, oxygen-depleting substances, pH (acidity), salinity/total dissolved solids/chlorides, and metals. Nonpoint sources generate most of the pollution in rivers. Minnesota's 272 miles of Lake Superior shoreline have fish consumption advisories. These advisories recommend some limits on fish meals consumed for certain species and size classes. Most of the pollution originated from point sources has been controlled, but runoff (especially in agricultural regions) still degrades water quality.

Ground Water Quality

The State maintains a Ground Water Monitoring and Assessment Program to evaluate the quality of ground waters that supply domestic water to 70% of Minnesota's population. The Program sampled 368 wells in the southeastern and southwestern regions of the State during 1992 and 1993. The samples were analyzed for 43 inorganic parameters and 68 volatile organic compounds. Monitoring detected nitrates in 62% of the wells and low levels of VOCs in 41 wells. Seven percent of the sampled wells contained nitrate concentrations exceeding EPA's Maximum Contaminant Level. Natural sources of manganese, iron, and arsenic also interfere with uses of ground water.

Programs to Restore Water Quality

During the 1994 reporting cycle, Minnesota revised its Nonpoint Source (NPS) Management Program with new strategies for addressing agricultural sources, forestry, urban runoff, contaminated sediments, feedlots, mining, and septic systems. The State also revised strategies for monitoring and assessing NPS impacts, educating the public, implementing BMPs, and applying the watershed protection approach to NPS management.

Minnesota adopted rules to implement the State's Wetlands Conservation Act and developed wetlands water quality standards during 1992 and 1993. The Wetland Conservation Act rules require that local governments regulate drain and fill activities in wetlands that are not designated public waters wetlands, which are listed on the Protected Waters Inventory. The rules allow the local governments to grant one or more of 25 exemptions for proposed activities on smaller wetlands with less inundation.

Programs to Assess Water Quality

Minnesota maintains an Ambient Stream Monitoring Program with 78 sampling stations. The State also performs fish tissue sampling, sediment monitoring, intensive surveys, biological surveys, and lake assessments and supports a citizen lake monitoring program. In 1994, the State completed the Minnesota River Assessment Project, a comprehensive study involving over 30 Federal, State, and local agencies. The project incorporated intensive biological monitoring and habitat assessments with traditional chemical monitoring to identify multiple sources and their impacts. A pilot use support methodology was used for rivers in the Minnesota River basin that reflected this comprehensive monitoring.

Individual Use Support in Minnesota

Designated Use[a]	Total Miles/Acres Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 91,944)[b]	Total Miles Surveyed					
	3,440	27	46	8	17	2
	-	-	-	-	-	-
	2,745	39	0	21	37	3
Lakes (Total Acres = 3,290,101)	Total Acres Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	1,751,205	63	16	9	12	0
Great Lakes (Total Miles = 272)	Total Miles Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

- Not reported.

[a] A subset of Minnesota's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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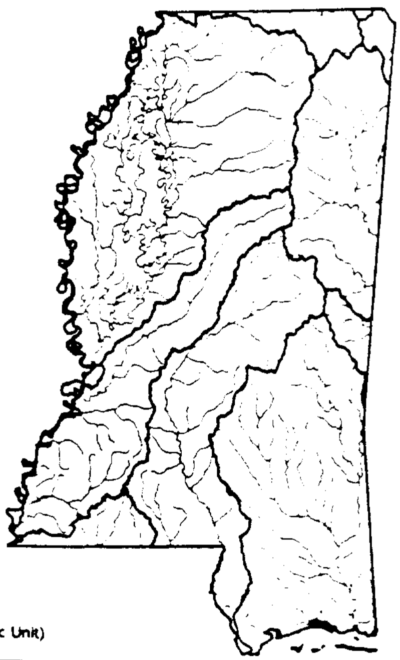
Mississippi



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Mississippi 1994 305(b) report, contact:

Randy Reed
Mississippi Department of
Environmental Quality
P.O. Box 10385
Jackson, MS 39289-0385
(601) 961-5158

Surface Water Quality

Mississippi reported that 81% of its surveyed rivers have fair water quality that periodically does not support aquatic life uses and another 5% have poor water quality that does not support aquatic life uses. About 35% of the surveyed rivers do not fully support swimming. The most common pollutants identified in Mississippi's rivers include nutrients, pesticides, siltation, oxygen-depleting substances, and bacteria. Agriculture is the most common source of pollution in rivers, followed by municipal sewage treatment plants.

About 65% of the surveyed lake acres have good water quality that fully supports aquatic life uses and 97% of the surveyed lake acres fully support swimming. Nutrients, siltation, pesticides, and oxygen-depleting substances are the most common pollutants in Mississippi lakes. Agriculture is also the dominant source of pollution in Mississippi's lakes.

In estuaries, 74% of the surveyed waters have good quality that fully supports aquatic life uses, but shellfishing activities are impaired in all of the surveyed estuarine waters. Bacteria and metals cause most of the impacts observed in estuaries. High bacteria levels are associated with shellfish harvesting restrictions. The State attributes impacts in estuarine waters to urban runoff/storm sewers, septic systems, and land disposal activities.

The State has posted six fish consumption advisories, including three commercial fishing bans due to elevated concentrations of PCBs, PCP, and dioxins detected in fish tissues.

Ground Water Quality

Extensive contamination of drinking water aquifers and public water supplies remains uncommon in Mississippi although localized ground water contamination has been detected at various facilities across the State. The most frequently identified sources of contamination are leaky underground storage tanks and faulty septic systems. Brine contamination is also a problem near oil fields. Little data exist for domestic wells that are seldom sampled. Ground water protection programs include the Pesticide Container Recycling Program, the Underground Storage Tank Program, the Underground Injection Control Program, the Agrichemical Ground Water

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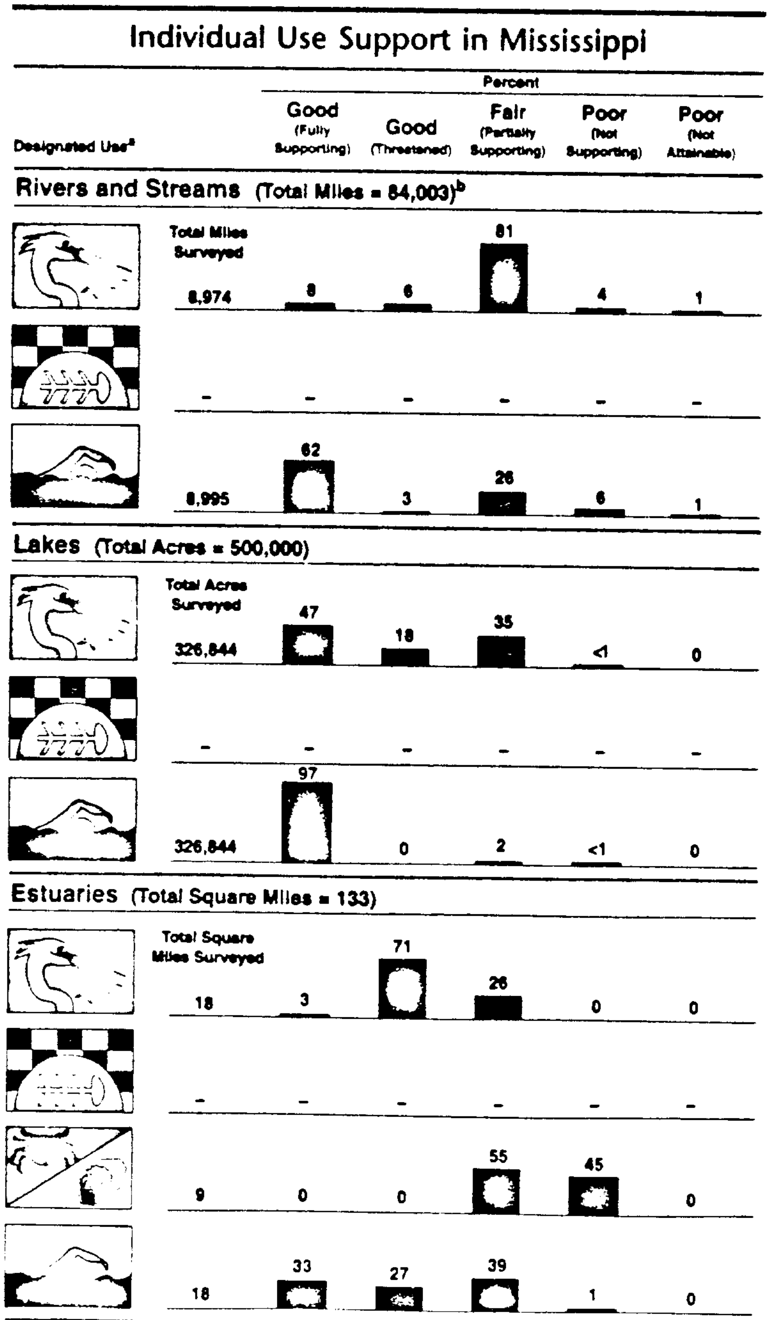
Monitoring Program, and the Wellhead Protection Program (approved by EPA in 1993).

Programs to Restore Water Quality

During 1993 and 1994, Mississippi developed regulations for conducting Section 401 Water Quality Certifications. The regulations enable the State to review Federal licenses and permits for compliance with State water quality standards. The comprehensive regulations went through public review and were adopted in February 1994. Mississippi also expanded its definition of waters of the State to include wetlands and ground waters.

Programs to Assess Water Quality

Each year, the State samples about 25 of their 57 historical fixed monitoring stations on a rotating schedule. The State monitors physical and chemical parameters bimonthly, metals in the water column twice a year, and biological parameters once a year. The development and implementation of a rapid bioassessment methodology has significantly increased coverage of State waters beyond the historic fixed stations. Several stations are also sampled annually for metals and pesticides in fish tissues. The State monitoring program is supplemented by a network of 27 stations operated by the USGS.



- Not reported

[a] A subset of Mississippi's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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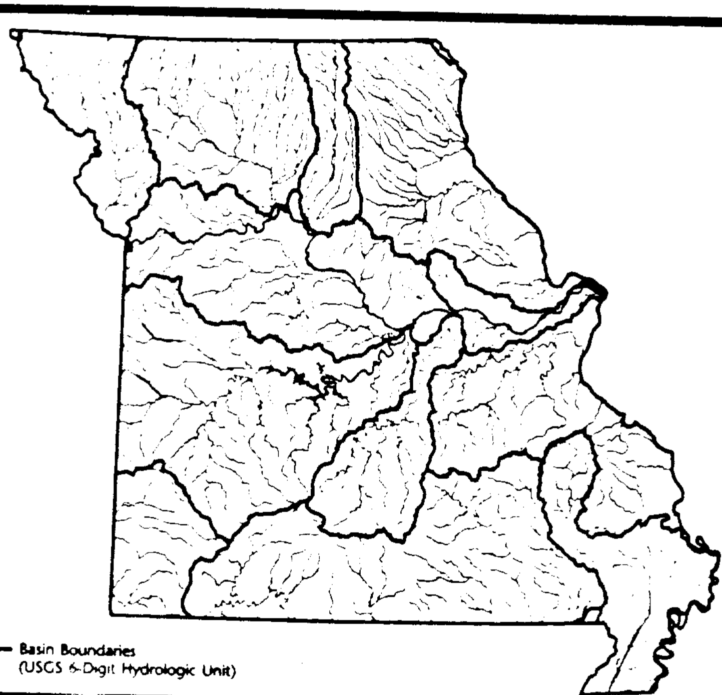
Missouri



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Missouri 1994 305(b) report, contact:

John Ford
Missouri Department of Natural Resources
Water Pollution Control Program
P.O. Box 176
Jefferson City, MO 65102-0176
(314) 751-7024

Surface Water Quality

Almost half of Missouri's rivers and streams have impaired aquatic habitat due to a combination of factors, including natural geology, climate, and agricultural land use. As a result of these factors, many streams suffer from low water volume, low dissolved oxygen concentrations, high water temperatures, and excessive siltation. In lakes, low dissolved oxygen from upstream dam releases, taste and odor problems, and pesticides are the most common ailments. Agriculture, urban runoff, and reservoir releases are the leading sources of lake degradation.

The Missouri Department of Health advises that the public restrict consumption of bottom-feeding fish (such as catfish, carp, and suckers) from non-Ozark streams or lakes to 1 pound per week due to high concentrations of chlordane, PCBs, and other contaminants in these fish.

Ground Water Quality

In general, ground water quantity and quality increases from north to south and west to east. Deep ground water aquifers in northern and western Missouri are not suitable for drinking water due to high concentrations of natural minerals. Nitrates and, to a much lesser extent, pesticides also contaminate wells in this region. About one-third of the private wells exceed drinking water standards for nitrates, and about 2% of private wells exceed drinking water standards for either atrazine or alachlor. Statewide, the highest priority concerns include ground water contamination from septic tanks, feedlots and pastureland, and underground storage tanks.

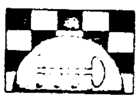
Programs to Restore Water Quality

Sewage treatment plant construction has restored many surface waters in Missouri, but overloaded older facilities still impact about 62 stream miles. Nonpoint source efforts have been less successful at restoring water quality. To date, the most successful activity has been the reclamation of abandoned coal mine lands, which is funded by a tax on coal that generates $1 million to $2 million annually. Stream miles impacted by abandoned coal mines fell from 100 miles to 42 miles as a result of reclamation projects.

Programs to Assess Water Quality

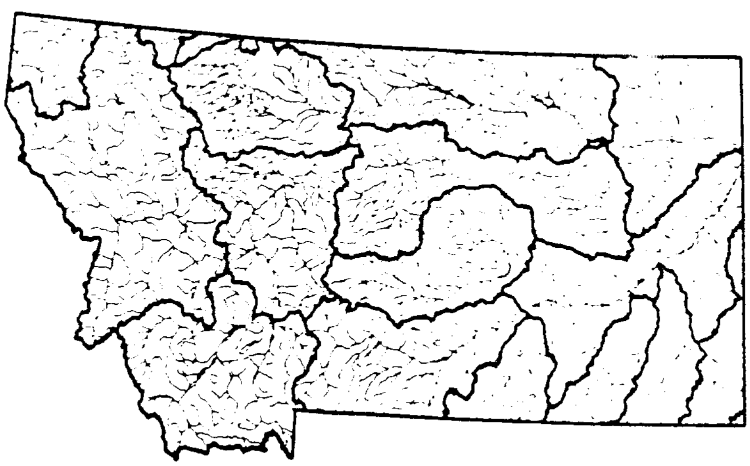
Missouri's water quality monitoring strategy features fixed-station chemical sampling, short-term intensive chemical surveys, rapid visual/bioassessments, and detailed biological monitoring to advance the development of biological criteria. The State also conducts toxicity testing and samples fish tissues for toxic chemicals. During 1992-94, four watershed projects featured concentrated monitoring activities designed to answer specific questions about animal waste management and farm chemical reduction options.

Individual Use Support in Missouri

Designated Use[a]	Total Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 51,015)[b]	Total Miles Surveyed					
	21,005	53	0	46	1	0
	21,015	100	0	0	<1	0
	5,370	100	0	0	0	0
Lakes (Total Acres = 288,315)	Total Acres Surveyed					
	288,315	61	38	1	<1	0
	288,315	100	0	0	<1	0
	261,227	62	38	0	<1	0

[a] A subset of Missouri's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Montana



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Montana 1994 305(b) report, contact:

Christian J. Levine
Montana Department of Health
and Environmental Science
Water Quality Bureau
Cogswell Building
1400 Broadway
Helena, MT 59620
(406) 444-5342

Surface Water Quality

Most of Montana's rivers and streams (74%) have fair water quality that periodically fails to support aquatic life uses. Another 5% have poor water quality that consistently fails to support aquatic life uses. About 14% of the surveyed lake acres have good water quality that fully supports fish and aquatic life, 57% fully support swimming, and 62% fully support drinking water use. Agriculture (especially irrigated crop production and rangeland) impairs 60% of the surveyed stream miles and 45% of the surveyed lake acres. In general, nonpoint sources are a factor in 90% of the impaired rivers and 80% of the impaired lakes. Resource extraction, forestry, and municipal sewage treatment plants have less widespread impacts on water quality.

Ground Water Quality

More than 50% of Montanans get their domestic water supply from ground water sources. Ground water is plentiful and the quality is generally excellent, but Montana's aquifers are very vulnerable to pollution from human activities that will expand as the population expands throughout the river valleys. The Department of Health and Environmental Sciences and the Department of Natural Resources and Conservation are jointly preparing a Comprehensive Ground Water Protection Plan to protect ground water quality and quantity.

Programs to Restore Water Quality

Montana is actively pursuing interagency/interdisciplinary watershed planning and management. Currently, five large watershed projects are under way in Montana: the Flathead Lake Watershed Management Plan, the Blackfoot River Watershed Management Project, the Grassroots Planning Process for the Upper Clark Fork Basin, the Tri-State Clark Fork Pend Oreille Watershed Management Plan, and the Kootenai River Basin Program. Each program advocates collaboration by all interested parties to devise comprehensive management options that simultaneously address all major factors threatening or degrading water quality.

Programs to Assess Water Quality

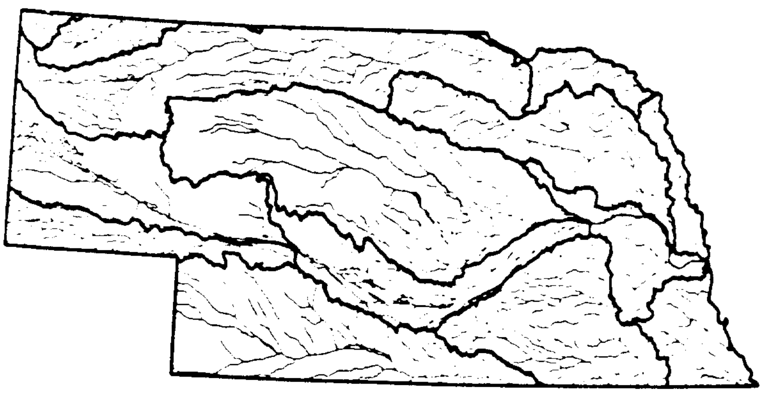
Montana will need to expand its monitoring and assessment program to adequately measure the effectiveness of the State's nonpoint source control program and other watershed management programs. To date, only 10% of the State's stream miles and 2% of the lakes have been assessed. Fixed-station monitoring is limited to three of the State's 16 river basins: the Flathead and upper and lower Clark Fork basins. The Department will ask the State Legislature to fund additional staff and operating expenses to expand ambient monitoring in the State. The State is also concerned that the U.S. Geological Survey may discontinue trend monitoring in Montana.

Individual Use Support in Montana

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 176,750)[b]	Total Miles Surveyed					
	17,680	20	1	74	5	0
	-	-	-	-	-	-
	17,692	68	<1	29	3	0
Lakes (Total Acres = 844,802)	Total Acres Surveyed					
	797,190	14	0	86	0	0
	-	-	-	-	-	-
	798,584	57	0	42	<1	0

- Not reported.
[a] A subset of Montana's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Nebraska



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Nebraska 1994 305(b) report, contact:

Steven Walker
Nebraska Department of
Environmental Quality
Water Quality Division,
Surface Water Section
P.O. Box 98922, State House Station
Lincoln, NE 68509-8922
(402) 471-2875

Surface Water Quality

Agriculture is the most widespread source of water quality problems in Nebraska, but urban runoff also impacts the State's rivers and streams. Agricultural runoff introduces excess silt, bacteria, suspended solids, pesticides, and nutrients into surface waters. Municipal and industrial facilities may contribute ammonia, bacteria, and metals. Channelization and hydrologic modifications have impacted aquatic life in Nebraska streams by reducing the diversity and availability of habitat.

Elevated concentrations of metals, primarily arsenic, were the most common water quality problem identified in lakes, followed by siltation, low dissolved oxygen, and nutrients. Pesticides, primarily atrazine, also degraded 18 lakes. Nebraska applies more atrazine to crops than any other State in the United States. Sources of pollution in lakes include municipal sewage treatment plants, agriculture, construction, urban runoff, and hydrologic habitat modifications.

Ground Water Quality

Although natural ground water quality in Nebraska is good, hundreds of individual cases of ground water contamination have been documented in Nebraska and the number of contaminated wells increases every year. Major sources of ground water contamination include agricultural activities, industrial facilities, leaking underground storage tanks, oil or hazardous substance spills, solid waste landfills, wastewater lagoons, brine disposal pits, and septic systems.

Programs to Restore Water Quality

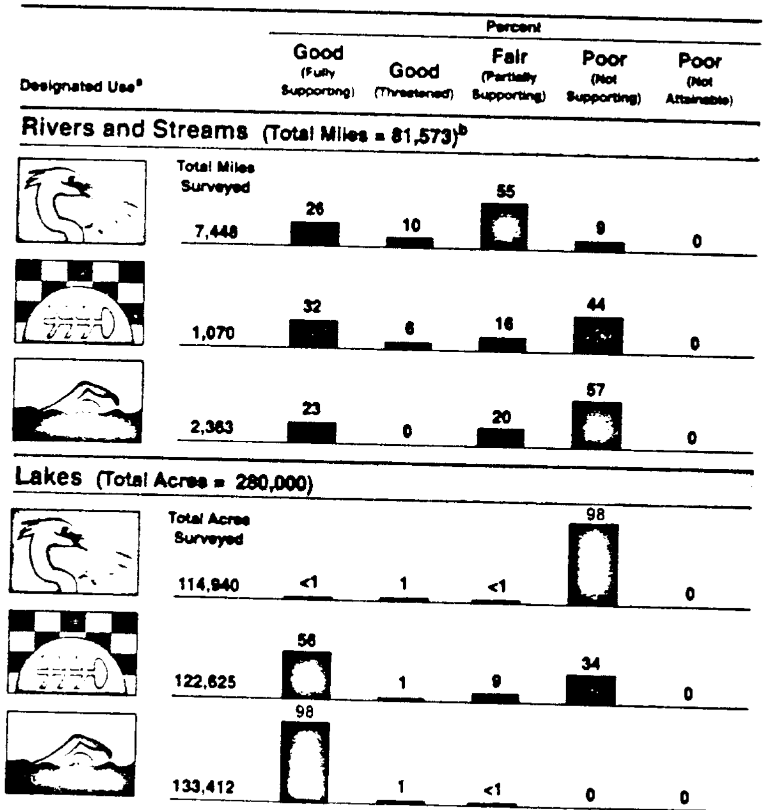
Until recently, Nebraska's Nonpoint Source (NPS) Management Program concentrated on protecting ground water resources. Surface water protection efforts consisted primarily of two federally funded demonstration projects on Long Pine Creek and Maple Creek. Now, Nebraska is evaluating the role of NPS pollution statewide. In 1994, Nebraska supported 35 NPS projects throughout the State.

Nebraska recently revised wetlands water quality standards to protect beneficial uses of aquatic life, aesthetics, wildlife, and agricultural water supply. The State also protects wetlands with the water quality certification program, permit requirements for underground injection activities and mineral exploration, and water quality monitoring.

Programs to Assess Water Quality

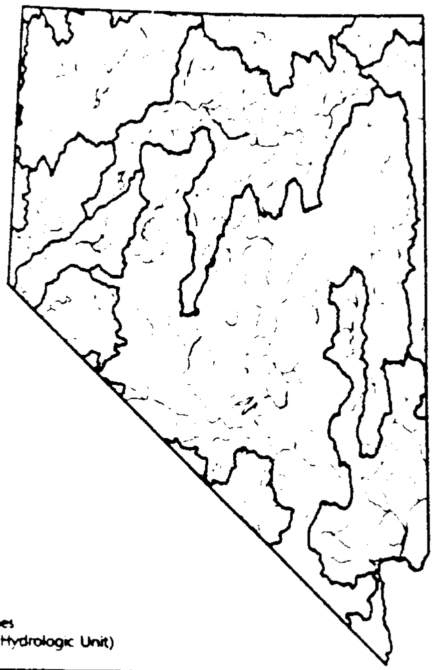
The State's Nonpoint Source Management Program cannot be effective without monitoring information to identify and prioritize waters impacted by NPS, develop NPS control plans, and evaluate the effectiveness of implemented best management practices. In response to this need, Nebraska developed an NPS surface water quality monitoring strategy to guide NPS monitoring projects. During 1992 and 1993, the State conducted 100 NPS screening assessments; 2 followup intensive NPS watershed assessments; BMP effectiveness studies in 10 watersheds; and a pesticide reconnaissance survey in the Big and Little Blue River Basin.

Individual Use Support in Nebraska



[a] A subset of Nebraska's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Nevada



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Nevada 1994 305(b) report, contact:

Glen Gentry
Bureau of Water Quality Planning
Division of Environmental Protection
123 West Nye Lane
Carson City, NV 89710
(702) 687-4670

Surface Water Quality

Only 10% (about 15,000 miles) of Nevada's rivers and streams flow year round, and most of these waters are inaccessible. For this reporting period, Nevada surveyed 1,440 miles of the 3,000 miles of accessible perennial streams with designated beneficial uses. Thirty percent of the surveyed stream miles have good water quality that fully supports aquatic life uses; 18% have fair water quality that sometimes does not support aquatic life uses; and 52% have poor water quality that does not support aquatic life uses. Thirty-eight percent of the surveyed streams fully support swimming and 62% do not fully support swimming. In lakes, 29% of the surveyed acres fully support aquatic life and swimming, and 71% partially support these uses.

Agricultural practices (irrigation, grazing, and flow regulation) have the greatest impact on Nevada's water resources. Agricultural sources generate large sediment and nutrient loads. Urban drainage systems contribute nutrients, heavy metals, and organic substances that deplete oxygen. Flow reductions also have a great impact on streams, limiting dilution of salts, minerals, and pollutants.

Ground Water Quality

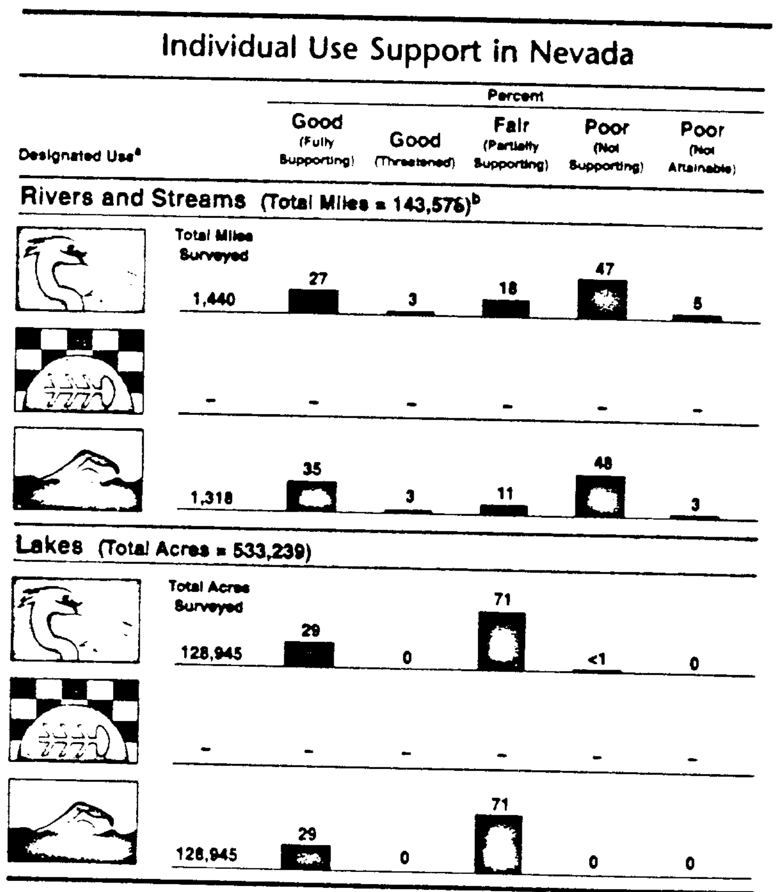
Nevada lacks comprehensive ground water protection legislation, but the State does have statutes that control individual sources of contamination, including mining, underground storage tanks, septic systems, handling of hazardous materials and waste, solid waste disposal, underground injection wells, agricultural practices, and wastewater disposal. Land use statutes also enable local authorities to implement Wellhead Protection Plans by adopting zoning ordinances, subdivision regulations, and site plan review procedures. Local authorities can implement certain source control programs at the local level.

Programs to Restore Water Quality

Nevada's Nonpoint Source Management Plan aims to reduce NPS pollution with interagency coordination, education programs, and incentives that encourage voluntary installation of best management practices. During 1992-1994, the State continued updating the *Handbook of Best Management Practices* and supported NPS assessment activities in each of the State's six major river basins. The State also completed a Wellhead Protection Plan for the State and began developing a State Ground Water Protection Policy.

Programs to Assess Water Quality

Several State, Federal, and local agencies regularly sample chemical and physical parameters at over 100 sites in the 14 hydrologic regions of the State. Nevada hopes to add biological monitoring at several routine sampling sites after the State adapts rapid bioassessment protocols to the arid conditions in Nevada. The State also coordinates intensive field studies on Nevada's major river systems, the Truckee River Basin, Carson River Basin, Walker River Basin, and the Humboldt River Basin. The State also monitors a number of lakes and reservoirs in conjunction with the Section 314 Clean Lakes Program.

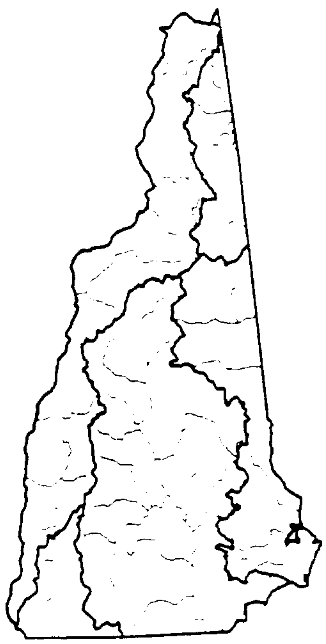


- Not reported.

[a] A subset of Nevada's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

New Hampshire



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the New Hampshire 1994 305(b) report, contact:

Gregg Comstock
State of New Hampshire
Department of Environmental Services
Water Supply & Pollution Control Division
64 North Main Street
Concord, NH 03301
(603) 271-2457

Surface Water Quality

Overall, the quality of New Hampshire's surface waters is excellent. Over 99% of the State's river miles and 95% of the lake acres have excellent or good water quality that fully supports aquatic life uses and swimming. Poor water quality conditions are more widespread in estuaries; high bacterial levels interfere with shellfish harvesting in 66% of the estuarine waters. Bacteria is also the leading cause of impairment in rivers where high bacteria levels indicate unsafe swimming conditions. Nutrients are the major cause of impairment in lakes and ponds. The State suspects that nonpoint sources are responsible for most of the pollution entering the State's waters.

New Hampshire advises the public to restrict consumption of fish caught in the Androscoggin River below Berlin, the Connecticut River, Horseshoe Pond, and the Great Bay Estuary. One fish consumption advisory is posted on the Androscoggin River below Berlin due to elevated concentrations of dioxins in fish tissue. The James River Corporation paper mill in Berlin is the suspected source of the dioxins.

Ground Water Quality

New Hampshire's overall ground water quality is very good. In some localized areas, naturally occurring arsenic, fluoride, and radionuclides (principally radon) exceed drinking water standards. Releases from petroleum facilities, industrial operations, and landfills have contaminated isolated areas with petroleum or volatile organic compounds. Sodium is the only contaminant that has exhibited an increasing presence in ground water due to the widespread application of road salts in winter. New Hampshire is developing a Comprehensive State Ground Water Protection Program to coordinate their various ground water assessment, prevention, and restoration programs.

Programs to Restore Water Quality

Over the past 20 years, New Hampshire has eliminated or abated all significant untreated municipal and industrial wastewater discharges in State waters. Recently, the Department of Environmental Services (DES) initiated a watershed protection approach to identify and resolve remaining pollution problems. DES will compile watershed maps and land use data, identify major sources of pollution, model total maximum daily loads for pollutants, and revise discharge permits as needed in the State's five basins. DES estimates that each basin assessment will require 2 years to complete at current funding levels.

Programs to Assess Water Quality

DES implemented a rotating watershed monitoring program in 1989. In 1993, the rotation was temporarily halted so that the State could intensify monitoring at sites violating standards. During 1994 and 1995, DES will investigate sources of violations confirmed by the 1993 data.

Individual Use Support in New Hampshire

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 10,881)[b]	Total Miles Surveyed					
	10,881	99	0	<1	<1	0
	10,881	100	0	<1	0	0
	10,881	99	0	<1	<1	0
Lakes (Total Acres = 163,012)	Total Acres Surveyed					
	154,693	89	6	3	2	0
	160,952	100	-	-	-	-
	154,693	89	6	3	2	0
Estuaries (Total Square Miles = 28)	Total Square Miles Surveyed					
	28	99	0	1	0	0
	28	100	0	0	0	0
	28	34	0	0	66	0
	28	100	0	0	0	0

- Not reported

[a] A subset of New Hampshire's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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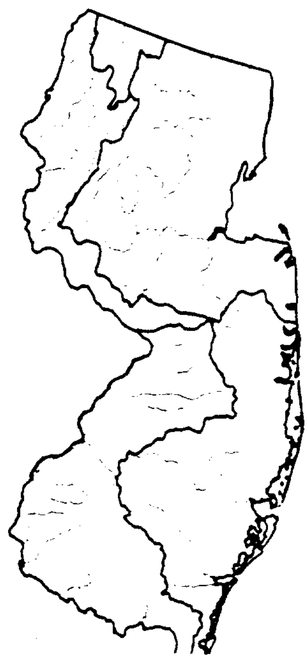
New Jersey



For a copy of the New Jersey 1994 305(b) report, contact:

Kevin Berry
NJ DEP
Office of Environmental Planning
401 East State St.
Trenton, NJ 08625
(609) 633-1179

Surface Water Quality

Sixty-eight percent of the 1,617 surveyed stream miles have good water quality that fully supports aquatic life, but New Jersey's high population density threatens these waters. Bacteria (which indicates unsafe swimming conditions) and nutrients are the most common pollutants in rivers and streams. All of the State's lakes are believed to be threatened or actively deteriorating. Bacterial contamination is the most widespread problem in estuaries, impairing both shellfish harvesting and swimming. Other problems include nutrients, low dissolved oxygen concentrations, pesticides, and priority organic chemicals. Major sources impacting New Jersey's waters include municipal treatment plants, industrial facilities, combined sewers, urban runoff, construction, agriculture, and land disposal of wastes (including septic tanks).

Ground Water Quality

There are currently over 6,000 ground water pollution investigations under way in New Jersey. The most common pollutants found in ground water are volatile organic compounds, metals, base neutral chemicals, acid-extractable chemicals, PCBs, and pesticides. Underground storage tanks are the most common source of ground water contamination, followed by landfills, surface spills, and industrial/commercial septic systems. New Jersey adopted new ground water quality standards in 1993 that revise the ground water classification system and establish numerical criteria for many pollutants. The standards also protect good ground water quality from degradation by future activities.

Programs to Restore Water Quality

New Jersey's Department of Environmental Protection (DEP) is adopting a watershed approach to water quality and quantity management. The watershed approach coordinates monitoring, modeling, planning, permitting, and enforcement activities within a geographic area that drains into a major river, lake, or estuary. The watershed approach allows all interested parties to participate in the development of consensus-based management options. DEP is currently conducting a watershed protection pilot project in the Whippany River watershed with local governments, permittees, regional interest groups, and private citizens.

Programs to Assess Water Quality

DEP's current monitoring program is centered around physical and chemical sampling at fixed stations designed to monitor long-term trends. Unfortunately, the fixed-station network cannot provide data to address other management needs, such as identifying specific sources of pollution and measuring the effectiveness of specific pollution control actions. Therefore, DEP recommends supplementing the fixed-station monitoring program with intensive watershed surveys to support watershed protection management projects. Intensive surveys would collect data to profile water quality over 24-hour periods, identify pollution sources, quantify pollution impacts, compare water quality data to flow conditions, model wasteload allocations, and determine assimilative capacity of waterbodies.

Individual Use Support in New Jersey

Designated Use[a]	Total Surveyed	Percent Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 6,450)[b]	Total Miles Surveyed					
	1,617	0	68	19	13	0
	-	-	-	-	-	-
	525	0	15	8	77	0
Lakes (Total Acres = 24,000)	Total Acres Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
Estuaries (Total Square Miles = 420)	Total Square Miles Surveyed					
	614[c]	79	0	21	0	0
	-	-	-	-	-	-
	614[c]	73	0	20	7	0
	-	-	-	-	-	-

[a] A subset of New Jersey's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Includes tidal portions of coastal rivers.

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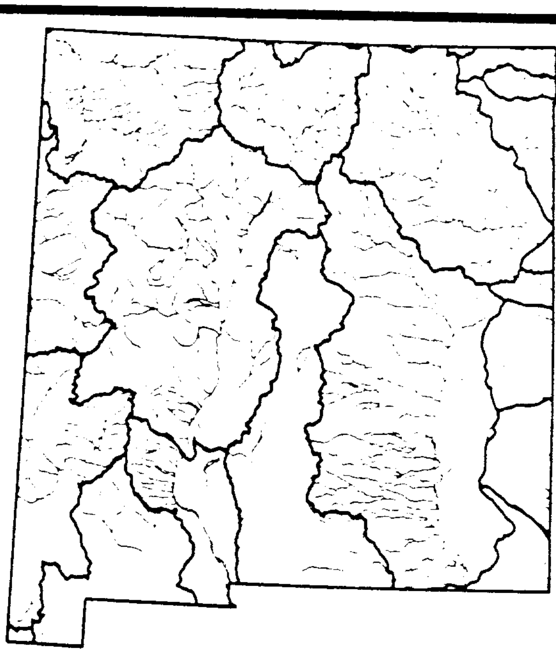
New Mexico



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the New Mexico 1994 305(b) report, contact:

Erik Galloway
New Mexico Environment Department
Surface Water Quality Bureau
Evaluation and Planning Section
P.O. Box 26110
Santa Fe, NM 87502-6110
(505) 827-2923

Surface Water Quality

About 93% of New Mexico's surveyed stream miles have good water quality that fully supports aquatic life uses. Ninety-nine percent of the surveyed river miles fully support swimming. The leading problems in streams include habitat alterations (such as removal of streamside vegetation), siltation, metals, and nutrients. Nonpoint sources are responsible for over 93% of the degradation in New Mexico's 3,255 impaired stream miles. Municipal wastewater treatment plants impair about 4% of the degraded waters (124 stream miles).

Agriculture and recreational activities are the primary sources of nutrients, siltation, reduced shoreline vegetation, and bank destabilization that impairs aquatic life use in 91% of New Mexico's surveyed lake acres. Mercury contamination from unknown sources appears in fish caught at 22 reservoirs. However, water and sediment samples from surveyed lakes and reservoirs have not detected high concentrations of mercury. Fish may contain high concentrations of mercury in waters with minute quantities of mercury because the process of biomagnification concentrates mercury in fish tissue.

Ground Water Quality

About 88% of the population of New Mexico depends on ground water for drinking water. The Environment Department has identified at least 1,745 cases of ground water contamination since 1927. The most common source of ground water contamination is small household septic tanks and cesspools. Leaking underground storage tanks, injection wells, landfills, surface impoundments, oil and gas production, mining and milling, dairies, and miscellaneous industrial sources also contaminate ground water in New Mexico. New Mexico operates a ground water discharger permit program that includes ground water standards for intentional discharges and a spill cleanup provision for other discharges.

Programs to Restore Water Quality

New Mexico's Nonpoint Source Management Program contains a series of implementation milestones that were designed to establish goals while providing a method to measure progress and success of the program. Implementation consists of the coordination of efforts among NPS management agencies, promotion and implementation of best management practices, coordination of watershed projects, inspection and enforcement activities, consistency reviews, and education and outreach activities.

Programs to Assess Water Quality

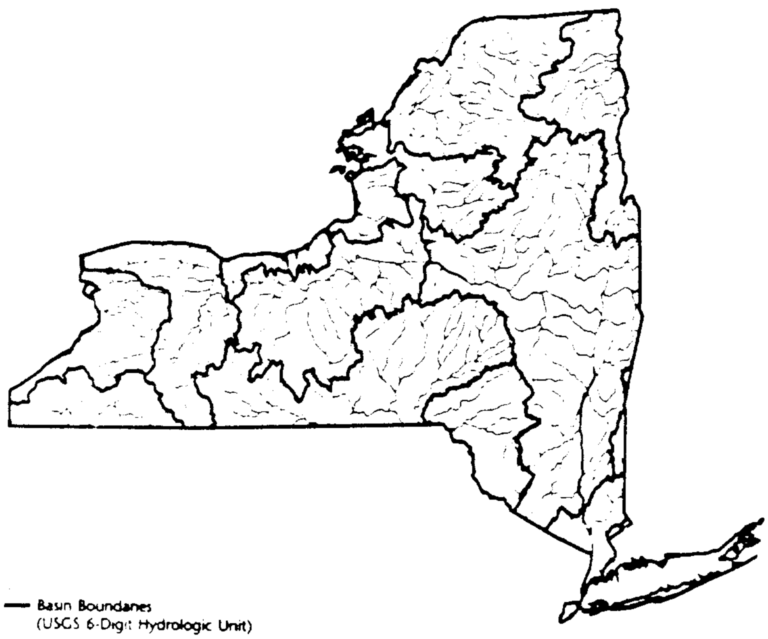
New Mexico relies heavily on chemical and physical data to assess water quality. Fish tissue data became available in 1991, and data from biological surveys and bioassay tests were incorporated into the 1994 assessments where possible. The State also conducts extensive monitoring to determine the effectiveness of best management practices implemented under the Nonpoint Source Management Program. During the current 305(b) reporting cycle, New Mexico completed two special water quality surveys along the Rio Hondo and the Red River in Taos County.

Individual Use Support in New Mexico

Designated Use[a]		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 110,741)[b]	Total Miles Surveyed					
	4,310	93	0	1	6	0
	93	0	0	100	0	0
	4,360	99	0	<1	<1	0
Lakes (Total Acres = 151,320)	Total Acres Surveyed					
	143,718	<1	9	91	<1	0
	119,391	0	0	100	0	0
	-	-	-	-	-	-

[a] A subset of New Mexico's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

New York



For a copy of the New York 1994 305(b) report, contact:

George K. Hansen, P.E.
New York State Department of Environmental Conservation
Bureau of Monitoring and Assessment
50 Wolf Road
Albany, NY 12233
(518) 457-8819

Surface Water Quality

Ninety-one percent of New York's rivers and streams, 74% of the State's lake acres, 97% of the State's Great Lakes shoreline, and 99% of the bays and tidal waters have good water quality that fully supports aquatic life uses. Swimming is fully supported in 99% of the surveyed rivers, 78% of the surveyed lakes, 80% of the Great Lakes shoreline, and 93% of the surveyed estuarine waters. Eighty-five percent of New York's Great Lake's shoreline does not fully support fish consumption use because of a fish consumption advisory.

Agriculture is a major source of nutrients and silt that impair New York's rivers, lakes, and reservoirs. Hydrologic modification and habitat modification are also a major source of water quality impairment in rivers and lakes. Urban runoff is a major source of pollution in the State's estuaries. Bacteria from urban runoff and other sources close about 200,000 acres (16%) of potential shellfishing beds.

Contaminated sediments are the primary source of 7% of the impaired rivers and lakes, 76% of the impaired Great Lake's shoreline, and 27% of the impaired estuarine waters in New York State. Sediments are contaminated with PCBs, chlorinated organic pesticides, mercury, cadmium, mirex, and dioxins that bioconcentrate in the food chain and result in fish consumption advisories.

Sewage treatment plant construction and upgrades have had a significant impact on water quality. Since 1972, the size of rivers impacted by municipal sewage treatment facilities has declined from about 2,000 miles to 300 miles.

Ground Water Quality

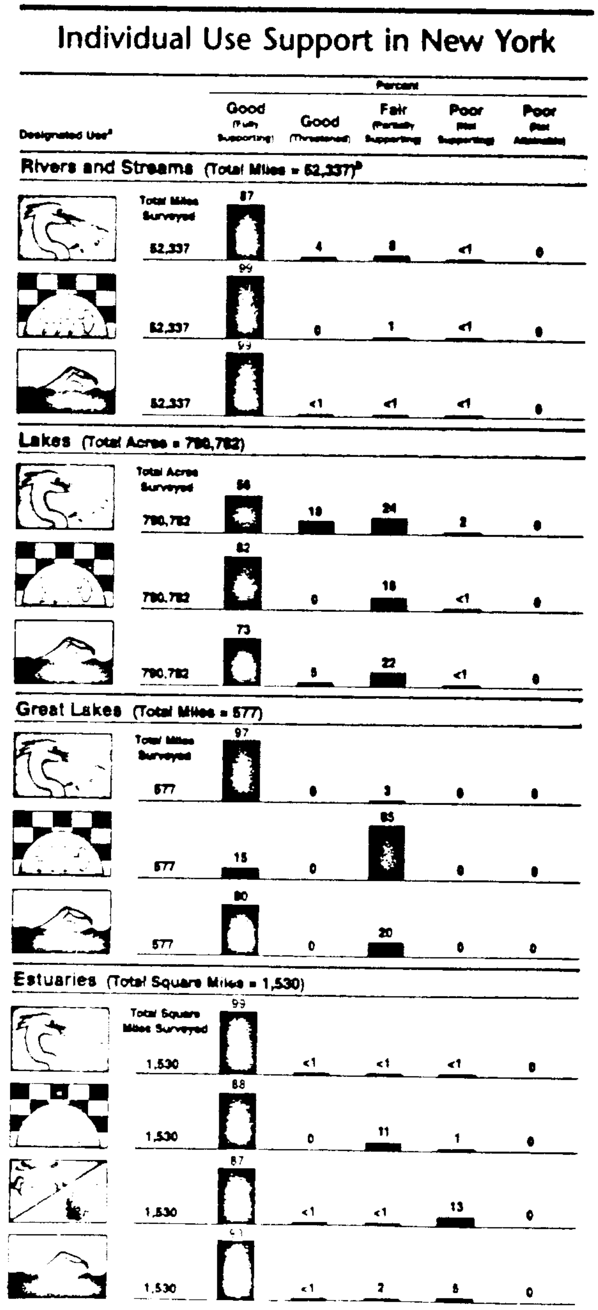
About 3% of the State's public water supply system wells (160 wells) are closed or abandoned due to contamination from organic chemicals. The most common contaminants are synthetic solvents and degreasers, gasoline and other petroleum products, and agricultural pesticides and herbicides (primarily aldicarb and carbofuran). The most common sources of organic solvents in ground water are spills, leaks, and improper handling at industrial and commercial facilities.

Programs to Restore Water Quality

Virtually every county of the State has a county water quality coordinating committee composed of local agencies (such as Cornell Cooperative Extension and soil and water conservation districts), local representatives from State and Federal agencies, and public interest groups. The county committees meet regularly to discuss local priorities and fashion local strategies to address nonpoint source pollution.

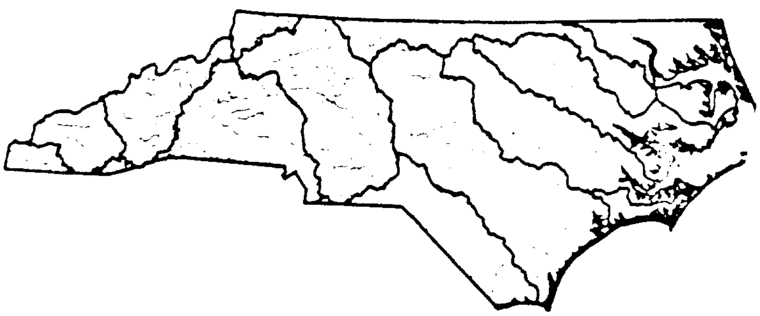
Programs to Assess Water Quality

In 1987, New York State implemented the Rotating Intensive Basin Studies (RIBS), an ambient monitoring program that concentrates monitoring activities on one-third of the State's hydrologic basins for 2-year periods. The DEC monitors the entire State every 6 years. Intensive monitoring clarifies cause-and-effect relationships between pollutants and water quality, measures the effectiveness of implemented pollution controls, and supports regulatory decisions.



[a] A subset of New York's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

North Carolina



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the North Carolina 1994 305(b) report, contact:

Carol Metz
NC DEHNR
Division of Environmental Management
P.O. Box 29535
Raleigh, NC 27626-0535
(919) 733-5083

Surface Water Quality

About 70% of the State's surveyed freshwater rivers and streams have good water quality that fully supports aquatic life uses, 25% have fair water quality that partially supports aquatic life uses, and 5% have poor water quality that does not support aquatic life uses. Eighteen percent of the surveyed rivers do not fully support swimming. The major sources of impairment are agriculture (responsible for 56% of the impaired river miles), urban runoff (responsible for 13%), point sources (responsible for 12%), and construction (responsible for 11%). These sources generate siltation, bacteria, and organic wastes that deplete dissolved oxygen.

Only 3% of the surveyed lakes in North Carolina are impaired for swimming and aquatic life uses. A few lakes are impacted by dioxin, metals, and excessive nutrient enrichment. The Champion Paper mill on the Pigeon River is the source of dioxin contamination in Waterville Lake. The State and the mill implemented a dioxin minimization program in the mid-1980s and completed a modernization program in 1993 that will reduce water usage and discharges.

About 93% of the estuaries and sounds in North Carolina fully support designated uses. Agriculture, urban runoff, septic tanks, and point source discharges are the leading sources of nutrients, bacteria, and low dissolved oxygen that degrade estuaries.

Ground Water Quality

About half of the people in North Carolina use ground water as their primary supply of drinking water. Ground water quality is generally good, but new cases of ground water contamination affected 276 public water supplies during 1992-1993. The leading source of ground water contamination is leaking underground storage tanks, which contaminate ground water with gasoline, diesel fuel, and heating oil. During 1992 and 1993, North Carolina adopted new regulations for administering Leaking Underground Storage Tank funds and amended ground water standards.

Programs to Restore Water Quality

In 1992-1993, North Carolina continued its aggressive program to control nonpoint source pollution. North Carolina adopted a nondischarge rule for animal waste management implemented an innovative nutrient trading program between point and nonpoint sources in the Tar-Pamlico river basin, signed 2,500 new contracts under the Agricultural Cost Share Program to implement best management practices, and reclassified about 200 water supply watersheds for special protection.

Programs to Assess Water Quality

Surface water quality in North Carolina was primarily evaluated using physical and chemical data collected by the Division of Environmental Management (DEM) from a statewide fixed-station network and biological assessments. These include macroinvertebrate (aquatic insect) community surveys, fish community structure analyses, phytoplankton analyses, bioassays, and limnological review of lakes and watersheds. Other sources of information were point source monitoring data, shellfish closure reports, lake trophic state studies, and reports prepared by other local, State, and Federal agencies.

Individual Use Support in North Carolina

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 37,600)[b]	Total Miles Surveyed					
	26,063	37	33	25	5	-
	-	-	-	-	-	-
	1,280	57	25	16	2	-
Lakes (Total Acres = 306,584)	Total Acres Surveyed					
	306,584	70	27	3	0	0
	306,584	97	0	3	0	0
	204,145	100	0	0	0	0
Estuaries (Total Square Miles = 3,122)	Total Square Miles Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

[a] A subset of North Carolina's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

VOL 12

5569

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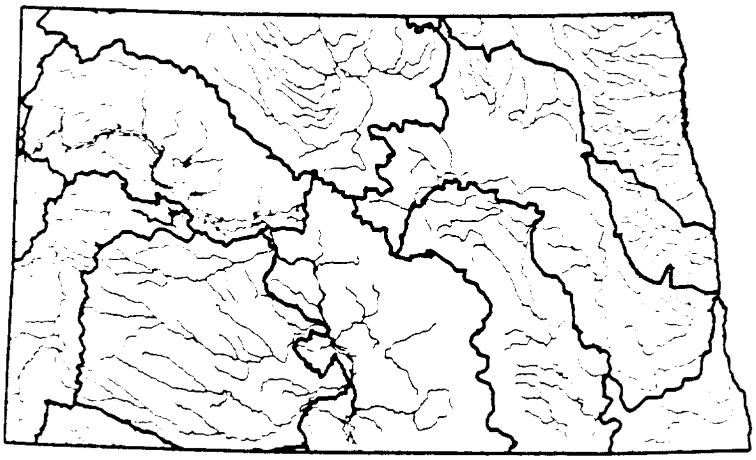
North Dakota



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the North Dakota 1994 305(b) report, contact:

Michael Ell
North Dakota Department of Health
Division of Water Quality
P.O. Box 5520
Bismark, ND 58502
(701) 328-5210

Surface Water Quality

North Dakota reports that 78% of its surveyed rivers and streams have good water quality that fully supports aquatic life uses now, but good conditions are threatened in most of these streams. Eighty-nine percent of the surveyed streams fully support swimming. Elevated siltation, nutrients, ammonia, pathogens, oxygen-depleting wastes, and habitat alterations impair aquatic life use support in 22% of the surveyed rivers and impair swimming in 11% of the surveyed rivers. The leading sources of contamination are agriculture, removal of streamside vegetation, municipal sewage treatment plants, and other habitat alterations. Natural conditions, such as low flows, also contribute to violations of standards.

In lakes, 95% of the surveyed acres have good water quality that fully supports aquatic life uses, and 98% of the surveyed acres fully support swimming. Siltation, nutrients, oxygen-depleting substances, and suspended solids are the most widespread pollutants in North Dakota's lakes. The leading sources of pollution in lakes are agricultural activities (including nonirrigated crop production, pasture land, irrigated crop production, and feedlots), municipal sewage treatment plants, and urban runoff/storm sewers. Natural conditions also prevent some waters from fully supporting designated uses.

Ground Water Quality

North Dakota has not identified widespread ground water contamination, although some naturally occurring compounds may make the quality of ground water undesirable in a few aquifers. Where human-induced ground water contamination has occurred, the impacts have been attributed primarily to petroleum storage facilities, agricultural storage facilities, feedlots, poorly designed wells, abandoned wells, wastewater treatment lagoons, landfills, septic systems, and the underground injection of waste. Assessment and protection of ground water continue through ambient ground water quality monitoring activities, the implementation of wellhead protection projects, the Comprehensive Ground Water Protection Program, and the development of a State Management Plan for Pesticides.

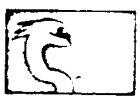
Programs to Restore Water Quality

North Dakota's Nonpoint Source Pollution Management Program has provided financial support to 26 projects over the past 4 years. Although the size, type, and target audience of these projects vary, the projects share the same basic goals: (1) increase public awareness of nonpoint source pollution, (2) reduce or prevent the delivery of NPS pollutants to waters of the State, and (3) disseminate information on effective solutions to NPS pollution.

Programs to Assess Water Quality

The North Dakota Department of Health monitors physical and chemical parameters (such as dissolved oxygen, pH, total dissolved solids, and nutrients), toxic contaminants in fish, whole effluent toxicity, and fish community structure. North Dakota's ambient water quality monitoring network consists of 61 sampling sites on 31 rivers and streams.

Individual Use Support in North Dakota

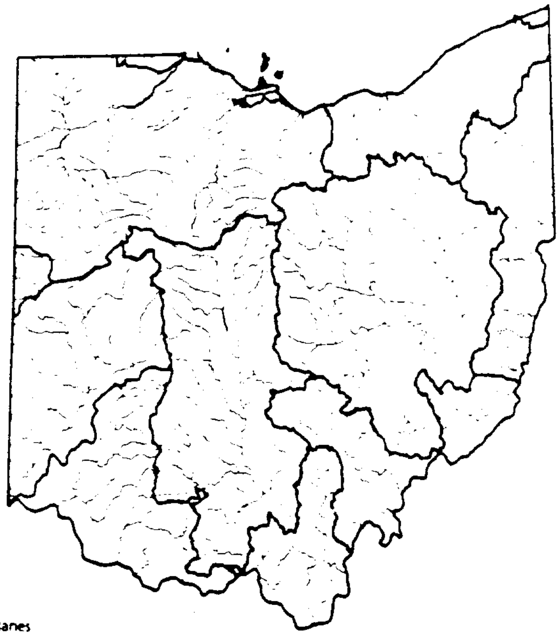
Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 11,868)[b]	Total Miles Surveyed					
	7,120	3	75	22	0	0
	510	0	0	100	0	0
	4,690	4	85	11	0	0
Lakes (Total Acres = 632,016)	Total Acres Surveyed					
	619,369	80	15	5	<1	<1
	590,606	31	<1	69	0	<1
	618,576	96	2	1	1	<1

[a] A subset of North Dakota's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

VOL 12

5671

Ohio



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Ohio 1994 305(b) report, contact:

Ed Rankin
Ohio Environmental Protection Agency
Division of Surface Water
1685 Westbelt Drive
Columbus, OH 43228
(614) 728-3385

Surface Water Quality

Ohio based their 1994 assessments on data collected between 1988 and 1994. Ohio's assessment methods compare observed ecological characteristics (including data on aquatic insects, fish species, habitat, and streamside vegetation) with background conditions found at least-impacted reference sites for a given ecoregion and stream type.

Ohio identified ecological impacts from organic enrichment and low dissolved oxygen concentrations, siltation, habitat modification, metals, ammonia, and flow alterations. Fecal coliform bacteria indicate impaired swimming conditions in 9% of the surveyed river miles. These impacts stem from municipal discharges, runoff from agriculture, hydromodification, industrial discharges, mining, urban runoff, and combined sewer overflows.

Ohio estimates that wastewater treatment plant construction and upgrades have restored aquatic life to about 1,000 river miles since the 1970s. Since 1988, the percentage of surveyed river miles fully fit for swimming also grew from 49% to 60%. However, increasing threats from nonpoint sources could erode gains made with point source controls and slow the rate of restoration.

The most common impacts on Ohio lakes include nutrients, volume loss due to sedimentation, organic enrichment, and habitat alterations. Nonpoint sources, including agriculture, urban runoff, and septic systems, generate most of these impacts. However, municipal point sources still affect 63% of the surveyed lake acres.

Most of the Lake Erie shoreline is fit for recreational use, but a fish consumption advisory for channel catfish and carp remains in effect along the entire shoreline. Ohio also issued fish consumption advisories for all species of fish caught on 137 river miles and documented elevated levels of PCBs in fish caught at two small lakes.

Ground Water Quality

About 4.5 million Ohio residents depend upon wells for domestic water. Waste disposal activities, underground storage tank leaks, and spills are the dominant sources of ground water contamination in Ohio.

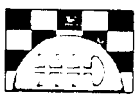
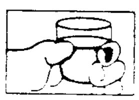
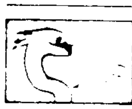
Programs to Restore Water Quality

To fully restore water quality, Ohio EPA advocates an ecosystem approach that confronts degradation on shore as well as in the water. Ohio's programs aim to correct nonchemical impacts, such as channel modification and the destruction of shoreline vegetation.

Programs to Assess Water Quality

Ohio pioneered the integration of biosurvey data, physical habitat data, and bioassays with water chemistry data to measure the overall integrity of water resources. Biological monitoring provides the foundation of Ohio's water programs because traditional chemical monitoring alone may not detect episodic pollution events or nonchemical impacts. Ohio EPA found that biosurvey data can increase the detection of aquatic life use impairment by about 35% to 50%.

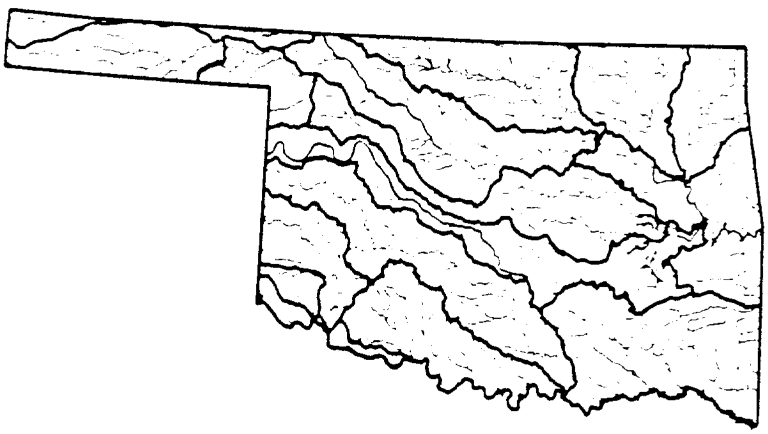
Individual Use Support in Ohio

Designated Use[a]	Total Surveyed	Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
		Percent				
Rivers and Streams (Total Miles = 55,059)[b]	Total Miles Surveyed					
	8,337	34	7	22	37	0
	•	•	•	•	•	•
	5,513	56	0	7	37	0
Lakes (Total Acres = 240,378)	Total Acres Surveyed					
	54,905	<1	20	75	5	0
	23,679	99	0	1	0	0
	55,127	3	1	44	52	0
	55,126	1	14	76	9	0
Great Lakes (Total Miles = 236)	Total Miles Surveyed					
	236	0	0	100	0	0
	236	0	0	100	0	0
	236	98	0	2	0	0

[a] A subset of Ohio's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Oklahoma



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Oklahoma 1994 305(b) report, contact:

John Dyer
Oklahoma Department of Environmental Quality
Water Quality Division
1000 NE 10th Street
Oklahoma City, OK 73117-1212
(405) 271-5205

Surface Water Quality

Fifty-eight percent of the surveyed river miles have good water quality that fully supports aquatic life uses and 65% fully support swimming. The most common pollutants found in Oklahoma rivers are siltation, pesticides, nutrients, and suspended solids. Agriculture is the leading source of pollution in the State's rivers and streams, followed by petroleum extraction and hydrologic/habitat modifications.

Fifty-seven percent of the surveyed lake acres fully support aquatic life uses and 60% fully support swimming. The most widespread pollutants in Oklahoma's lakes are siltation, nutrients, suspended solids, and oxygen-depleting substances. Agriculture is also the most common source of pollution in lakes, followed by contaminated sediments and flow regulation. Several lakes are impacted by acid mine drainage, including the Gaines Creek arm of Lake Eufaula and the Lake O' the Cherokees.

Ground Water Quality

Ambient ground water monitoring has detected elevated nitrate concentrations in monitoring wells scattered across the State. Monitoring has also detected isolated cases of hydrocarbon contamination, elevated selenium and fluoride concentrations (probably due to natural sources), chloride contamination from discontinued oil field activities, metals from past mining operations, and gross alpha activity above maximum allowable limits. Industrial solvents contaminate a few sites near landfills, storage pits, and Tinker Air Force Base. The State rates agriculture, injection wells, septic tanks, surface impoundments, and industrial spills as the highest priority sources of ground water contamination.

Programs to Restore Water Quality

Oklahoma's nonpoint source control program is a cooperative effort of State, Federal, and local agencies that sponsors demonstration projects. The demonstration projects feature implementation of agricultural best management practices, water quality monitoring before and after BMP implementation, technical assistance, education, and development of comprehensive watershed management plans. Currently, Oklahoma is conducting five NPS projects in Comanche County, Greer and Beckham Counties, Custer County, Tillman County, and the Illinois River Basin.

Programs to Assess Water Quality

Oklahoma's Conservation Commission is conducting five large watershed studies in the Illinois River Basin, the Little River Basin, the Neosho (Grand) River Basin, the Southeast Oklahoma Multiple Basin, and the Poteau River/Wister Lake Project (a cooperative effort with the LeFlore Conservation District, the Water Board, and the USGS). All together, 385 sites will be sampled for chemical parameters and one-third of these sites will also be sampled for biological integrity.

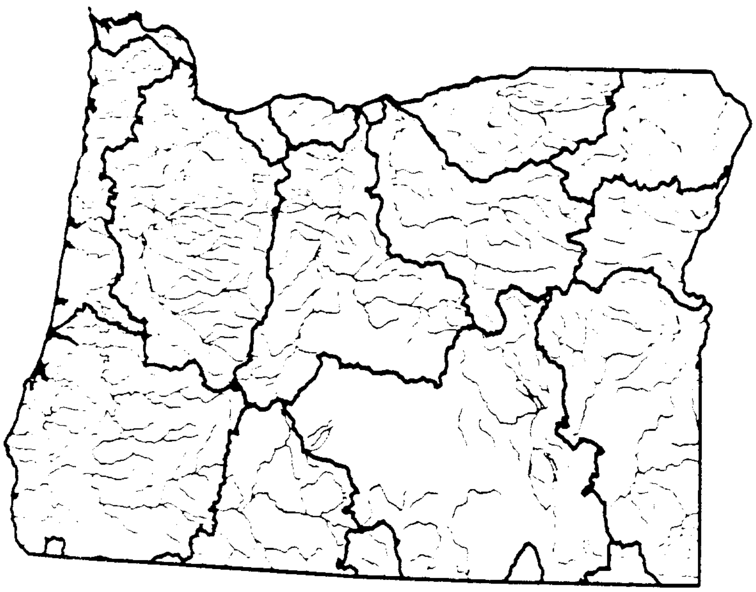
Individual Use Support in Oklahoma

Designated Use[a]	Total Surveyed	Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 78,778)[b]	Total Miles Surveyed					
	6,718	9	49	32	10	0
	-	-	-	-	-	-
	5,087	19	46	22	13	0
Lakes (Total Acres = 1,041,884)	Total Acres Surveyed					
	619,834	21	36	38	5	0
	-	-	-	-	-	-
	559,554	9	51	34	6	0

Percent values shown for use support categories.

- Not reported.
[a] A subset of Oklahoma's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Oregon



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Oregon 1994 305(b) report, contact:

Robert Baumgartner
Oregon Department of
Environmental Quality
Water Quality Division
811 SW Sixth Avenue
Portland, OR 97204
(503) 229-6962

Surface Water Quality

Forty-three percent of Oregon's surveyed rivers have good water quality that fully supports designated uses, 30% have fair water quality that partially supports uses, and 27% have poor water quality that does not support uses. The most widespread problems in Oregon's streams are habitat alterations, high temperatures, and siltation from grazing, other agricultural activities, forestry, and recreation.

In lakes, 74% of the surveyed acres fully support uses, 12% partially support uses, and 14% do not support uses. The most common problems in Oregon's lakes are excess nutrients, pH (acidity), and low dissolved oxygen. DEQ suspects that agriculture and natural conditions (including shallow depth and high evaporation rates) are the most significant sources of lake problems.

Six percent of Oregon's estuarine waters have good quality and 94% have fair water quality due to periodic violations of bacteria standards. High concentrations of fecal bacteria usually result from bypasses at municipal wastewater treatment plants during rainfall events or improper management of animal wastes.

Ground Water Quality

Monitoring has detected nitrates, benzene, other volatile organic compounds, bacteria, herbicides, and pesticides in ground water. Suspected sources include septic systems, agriculture, highway maintenance, industry, and commerce. During 1992 and 1993, DEQ conducted statewide ground water monitoring, developed a ground water data management system, and issued 16 grants for research and education projects designed to protect ground water from nonpoint sources of pollution.

Programs to Restore Water Quality

Oregon recently initiated a Watershed Health Program to encourage public/private partnerships for managing water quality and ecosystem enhancement. Under the Watershed Health Program, field-based technical teams work closely with watershed councils composed of local residents and stakeholders to set priorities and fund projects. DEQ and other State agencies targeted the Grand Ronde Basin and the combined South Coast and Rogue Basins to begin implementing the Watershed Health Program with $10 million in State funds for 1994 and 1995. These basins were selected because of existing Total Maximum Daily Load programs.

Programs to Assess Water Quality

DEQ routinely monitors about 3,500 miles of streams in its ambient river monitoring program. These streams receive about 90% of the wastewater discharged by point sources throughout the State. During 1992 and 1993, DEQ increased the number of ambient river monitoring stations and expanded other monitoring programs, including ground water studies, continuous monitoring, mixing zone studies, and bioassessments. Recently, Oregon also initiated the Coos Bay toxics study, the Tillamook Bay National Estuary Program, and the Lower Columbia River Bi-State Program to provide more information on estuarine water quality.

Overall[a] Use Support in Oregon

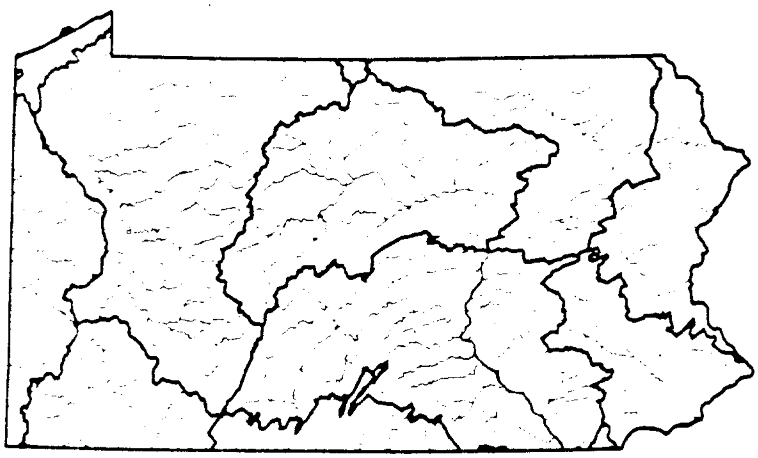
	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 114,823)[b] — Total Miles Surveyed 29,109	43	-	30	27	-
Lakes (Total Acres = 618,934) — Total Acres Surveyed 504,928	74	-	12	14	-
Estuaries (Total Square Miles = 206) — Total Square Miles Surveyed 60	6	-	94	0	-

- Not reported

[a] Overall use support is presented in this figure because Oregon did not report individual use support in their 1994 Section 305(b) report.

[b] Includes nonperennial streams that dry up and do not flow all year.

Pennsylvania



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Pennsylvania 1994 305(b) report, contact:

Robert Frey
Pennsylvania Department of Environmental Resources
Bureau of Water Quality Management
Division of Assessment and Standards
P.O Box 8465
Harrisburg, PA 17105-8465
(717) 783-3638

Surface Water Quality

Over 81% of the surveyed river miles have good water quality that fully supports aquatic life uses and swimming. About 8% have fair water quality that partially supports these uses, and 11% have poor water quality that does not support aquatic life uses and swimming. The most widespread pollutants are metals, which impact over 2,092 miles. Pollutants identified less frequently include suspended solids (impacting 603 miles), nutrients (impacting 586 miles), and pH (impacting 273 miles).

Abandoned mine drainage is the most significant source of surface water quality degradation in Pennsylvania. Drainage from mining sites pollutes at least 2,404 miles of streams representing 52% of all degraded streams in the Commonwealth. Other sources of degradation include agriculture (impacting 694 miles), municipal sewage treatment plants (impacting 241 miles), and industrial point sources (impacting 206 miles).

Pennsylvania has issued fish consumption advisories on 23 waterbodies. Most of the advisories are due to elevated concentrations of PCBs and chlordane in fish tissue, but a few advisories have been issued for mirex and mercury. In 1994, the State deactivated two advisories for dioxins on Codurus Creek and the South Branch of Codurus Creek as well as one advisory for chlordane on the Delaware River.

Ground Water Quality

Major sources of ground water contamination in Pennsylvania include leaking underground storage tanks, containers from hazardous materials facilities, and improper handling or overuse of fertilizer. Petroleum and petroleum byproducts are the most common pollutants in ground water. Coal mining and oil and gas production have also elevated concentrations of several elements (including chlorides, iron, barium, and strontium) in some regions of the Commonwealth. A Ground Water Quality Protection Strategy was adopted and released to the public in February 1992, and an Implementation Task Force was formed in August 1992. The Task Force reviewed all program regulations and scheduled revisions that will advance the Strategy goal of nondegradation of ground water quality.

Programs to Restore Water Quality

Eliminating acid mine drainage from abandoned mines will require up to $5 billion. The cost, difficulty, magnitude, and extent of the problem have hampered progress. To date, the Commonwealth has funded studies to determine the effectiveness of alternative techniques for treating mine drainage and preventing contamination. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service's Rural Abandoned Mines Program also reconstructs abandoned mine sites in Pennsylvania.

Programs to Assess Water Quality

The Water Quality Network monitors chemical and physical parameters almost monthly and biological parameters annually at 168 fixed stations on rivers, streams, and Lake Erie. In 1991, Pennsylvania began annual sampling at 15 to 20 lakes for 5 years. After 5 years, another set of lakes will be sampled annually for 5 years until 90 lakes have been monitored. The Commonwealth also conducts ambient ground water monitoring at 537 monitoring sites.

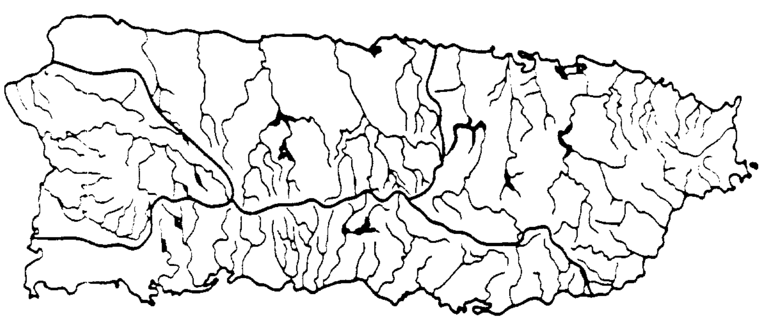
Individual Use Support in Pennsylvania

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 53,962)[b]	Total Miles Surveyed					
	24,948	81	0	8	11	0
	24,948	81	0	8	11	0
	24,948	81	0	8	11	0
Lakes (Total Acres = 161,445)	Total Acres Surveyed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

- Not reported.
[a] A subset of Pennsylvania's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

VOL 12

Puerto Rico



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Puerto Rico 1994 305(b) report, contact:

Eric H. Morales
Puerto Rico Environmental Quality Board
Water Quality Area
Box 11488
Santurce, PR 00910
(809) 751-5548

Surface Water Quality

In rivers and streams, 17% of the surveyed miles have good water quality that fully supports aquatic life uses, 32% partially support aquatic life uses, and 51% do not support aquatic life uses. Swimming is impaired in 79% of the surveyed rivers and streams. Low dissolved oxygen, pesticides, flow alteration, bacteria, and nutrients are the most widespread problems in rivers and streams. In lakes, 30% of the surveyed acres fully support aquatic life uses, 19% partially support these uses, and 51% do not support aquatic life uses. Swimming is impaired in 55% of the surveyed lake acres. Uses are impaired by inorganic chemicals, low dissolved oxygen concentrations, bacteria, priority organic chemicals, metals, and pesticides.

Only 16% of the assessed estuarine waters fully support aquatic life uses and only 17% fully support swimming due to oxygen-depleting organic substances, bacteria, and habitat alterations. Land disposal of wastes, urban runoff, agriculture, municipal sewage treatment plants, and natural conditions are the most common sources of water quality degradation in rivers, lakes, and estuaries. Industrial and municipal discharges also pollute beaches.

Ground Water Quality

Organic compounds, including dichloromethane, 1,1,2-trichloroethane, and toluene were detected below maximum contaminant levels in several wells. Four wells were closed due to bacterial contamination and high turbidity and two wells were shut down due to contamination from volatile organic compounds. The major sources of ground water contamination are septic tanks, livestock operations, agriculture, storage tanks, and landfills. Puerto Rico adopted ground water use classifications and water quality standards in 1990. In 1993, the Environmental Quality Board completed the ground water priority list that ranks critical areas for remediation and protection activities.

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Programs to Restore Water Quality

Puerto Rico requires permits or certificates for ground water and surface water discharges, underground storage tanks, and livestock operations. Certificates require livestock operations to implement animal waste management systems and other best management practices. During the 1992-1993 reporting period, Puerto Rico issued 194 certificates for livestock operations; inspected 427 livestock operations; implemented 77 BMPs in priority watersheds; offered 15 conferences to educate the public about nonpoint source pollution and controls, and monitored the effectiveness of BMPs implemented at poultry, dairy, and hog farms.

Programs to Assess Water Quality

Under a cooperative agreement with the government of Puerto Rico, the USGS collects bimonthly samples at 57 fixed surface water monitoring stations. The samples are analyzed for dissolved oxygen, nutrients, bacteria, and conventional parameters. Twice a year, the samples are analyzed for metals and several toxic substances. Puerto Rico also maintains a Permanent Coastal Water Quality Network of 88 stations and the San Juan Beachfront Special Monitoring Network of 22 stations sampled monthly for bacterial contamination.

Individual Use Support in Puerto Rico

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 5,385)[b]	Total Miles Surveyed					
	5,384	8	9	32	51	0
	-	-	-	-	-	-
	5,381	14	7	28	51	0
Lakes (Total Acres = 10,887)	Total Acres Surveyed					
	10,887	10	20	19	51	0
	-	-	-	-	-	-
	10,887	33	12	30	25	0
Estuaries (Total Miles = 175)	Total Miles Surveyed					
	175	3	13	24	60	0
	-	-	-	-	-	-
	-	-	-	-	-	-
	175	4	13	28	55	0

- Not reported

[a] A subset of Puerto Rico's designated uses appear in this figure. Refer to the Commonwealth's 305(b) report for a full description of the Commonwealth's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Rhode Island

For a copy of the Rhode Island 1994 305(b) report, contact:

Connie Carey
Rhode Island Department of
Environmental Management
Division of Water Resources
291 Promenade St.
Providence, RI 02908-5767
(401) 277-6519

Surface Water Quality

Eighty-four percent of Rhode Island's rivers, 81% of lakes, and 96% of estuarine waters support aquatic life uses. However, many of these waters are considered threatened. About 80% of rivers, 94% of lakes, and 93% of estuaries fully support swimming. The most significant pollutants in Rhode Island's waters are heavy metals (especially copper and lead), priority organic chemicals (PCBs), bacteria, low dissolved oxygen, excess nutrients, and low pH/low buffering capacity. Recurring algae blooms, high nutrients, and high turbidity threaten the use of several surface waters for drinking water supplies.

Rivers and estuaries are impacted by industrial and municipal discharges, combined sewer overflows, urban runoff, highway runoff, failed septic systems, and contaminated sediments. Lakes are primarily impacted by nonpoint sources, including septic systems, atmospheric deposition, and land and road runoff.

Ground Water Quality

About 24% of the State's population is supplied with drinking water from public and private wells. Overall, Rhode Island's ground water has good to excellent quality, but over 100 contaminants have been detected in localized areas. Twenty-one community and eight noncommunity wells have been closed and 400 private wells have required treatment due to contamination. The most common pollutants are petroleum products, certain organic solvents, and nitrates. Significant pollution sources include leaking underground storage tanks, hazardous and industrial waste disposal sites, illegal or improper waste disposal, chemical and oil spills, landfills, septic systems, road salt storage and application, and fertilizer application.

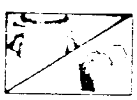
Programs to Restore Water Quality

Rhode Island's Nonpoint Source Management Program sponsored the following activities during 1992-1993: (1) preparation of NPS management plans for 10 surface water supply watersheds; (2) development of a Community NPS Management Guide; (3) development of a Stormwater Design and Installation Manual; (4) preparation of a manual for selecting best management practices for marinas; (5) development of a *Community Wastewater Management Guidance Manual*; (6) mitigation projects at Greenwich Bay, including septic system inspections and replacements; (7) technical assistance to communities developing zoning or NPS control ordinances; and (8) revising and updating the Rhode Island NPS Management Plan.

Programs to Assess Water Quality

Rhode Island's monitoring program consists of: (1) discharge effluent monitoring, (2) the Beach Monitoring Program, (3) the Shellfish Growing Area Monitoring Program, (4) USGS Water Quality Trend Monitoring Fixed Stations, (5) supplemental monitoring stations sampled by the Rhode Island Department of Environmental Management, (6) biological monitoring, and (7) limited expansion of ambient water quality stream biological and chemical monitoring. During the 1992-1993 reporting cycle, Rhode Island added 25 toxics monitoring stations to previously unmonitored streams.

Individual Use Support in Rhode Island

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 1,106)[b]	Total Miles Surveyed					
	667	47	37	7	9	0
	-	-	-	-	-	-
	667	55	25	1	5	14
Lakes (Total Acres = 17,328)	Total Acres Surveyed					
	17,328	65	16	16	3	0
	-	-	-	-	-	-
	17,328	86	6	2	2	2
Estuaries (Total Square Miles = 139)	Total Square Miles Surveyed[c]					
	193	92	4	0	4	0
	-	-	-	-	-	-
	-	-	-	-	-	-
	193	85	8	1	2	4

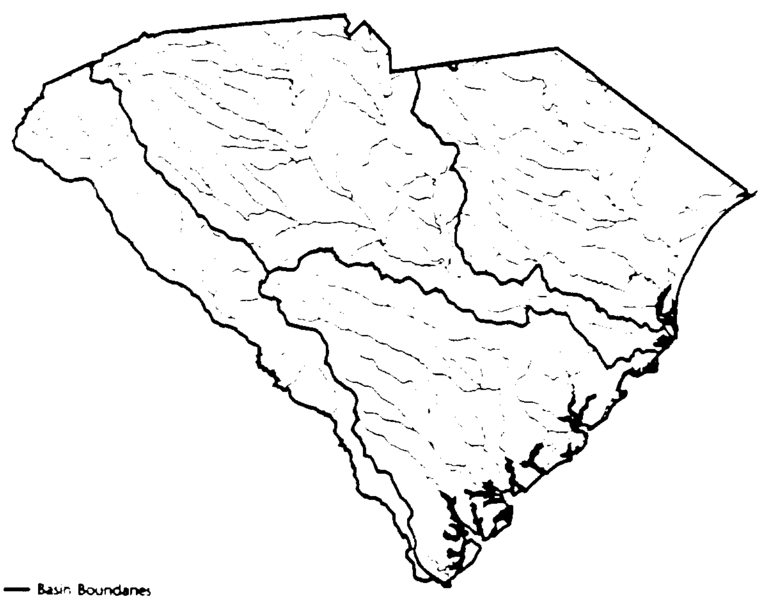
\- Not reported

[a] A subset of Rhode Island's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

[c] Includes ocean waters.

South Carolina



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the South Carolina 1994 305(b) report, contact:

Gina Lowman
South Carolina Department of Health and Environmental Control
Bureau of Water Pollution Control
2600 Bull Street
Columbia SC 29201
(803) 734-5153

Surface Water Quality

Ninety-one percent of surveyed rivers, 99% of surveyed lakes, and 75% of estuaries have good water quality that fully supports aquatic life uses. Sixty-three percent of rivers, 99% of lakes, and 86% of estuaries fully support swimming. Unsuitable water quality is responsible for shellfish harvesting prohibitions in only 2% of the State's coastal shellfish waters. Another 11% of shellfish waters are closed as a precaution due to potential pollution from nearby marinas or point source discharges.

Bacteria are the most frequent cause of impairment (i.e., partial or nonsupport of designated uses) in rivers and streams; metals are the most frequent cause of impairment in lakes, but only 1% of lakes do not fully support uses; and low dissolved oxygen is the most frequent cause of impairment in estuaries. Toxic contaminants do not appear to be a widespread problem in South Carolina surface waters. Of all waters assessed, only 5% had elevated levels of metals and only 3% had concentrations of PCBs, pesticides, and organics above the assessment criteria.

Ground Water Quality

Overall ground water quality remains excellent, although the number of reported ground water contamination cases rose from 60 cases in 1980 to 2,207 cases in 1993. The increase in the number of contaminated sites is primarily due to expanded monitoring at underground storage tank sites. Leaking underground storage tanks are the most common source of contamination, impacting 1,741 sites, followed by leaking pits, ponds, and lagoons.

Programs to Restore Water Quality

The South Carolina Department of Health and Environmental Control (DHEC) initiated a Watershed

Water Quality Management Strategy (WWQMS) to integrate monitoring, assessment, problem identification and prioritization, water quality modeling, planning, permitting, and other management activities by river drainage basins. DHEC has delineated five major drainage basins encompassing 280 minor watersheds. Every year, DHEC will develop or revise a management plan and implementation strategy for one basin. It will take 5 years to assess all basins in the State. The basin strategies will refocus water quality protection and restoration priorities for allocation of limited resources.

Programs to Assess Water Quality

Year round, DHEC samples chemical and physical parameters monthly at fixed primary stations located in or near high-use waters. DHEC samples secondary stations (near discharges and areas with a history of water quality problems) monthly from May through October for fewer parameters. Each year, DHEC adds new watershed stations within the specific basin under investigation. Watershed stations are sampled monthly for 1 year corresponding with the WWQMS schedule.

Individual Use Support in South Carolina

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 35,461)[b]	Total Miles Surveyed					
	26,314	91	0	4	5	0
	-	-	-	-	-	-
	26,314	63	0	16	21	0
Lakes (Total Acres = 525,000)	Total Acres Surveyed					
	211,244	99	0	0	1	0
	-	-	-	-	-	-
	211,245	99	0	<1	<1	0
Estuaries (Total Square Miles = 945)	Total Square Miles Surveyed					
	343	75	0	12	13	0
	-	-	-	-	-	-
	-	-	-	-	-	-
	343	86	0	6	8	0

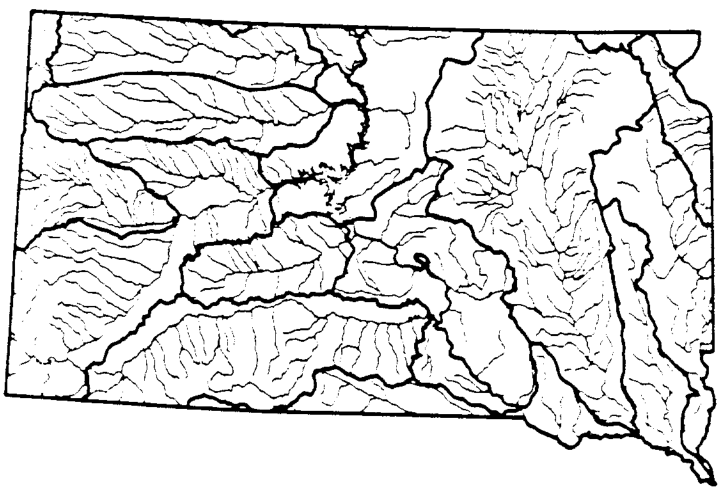
- Not reported

[a] A subset of South Carolina's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

R0038993

South Dakota



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit modified by South Dakota)

For a copy of the South Dakota 1994 305(b) report, contact:

Andrew Repsys
South Dakota Department of Environment and Natural Resources
Division of Water Resources Management
523 East Capitol, Joe Foss Building
Pierre, SD 57501-3181
(605) 773-3882

Surface Water Quality

Seventeen percent of South Dakota's surveyed rivers and streams fully support aquatic life uses and 83% do not fully support aquatic life uses. Thirty-five percent of the surveyed rivers also support swimming, and 65% of the surveyed rivers do not fully support swimming. The most common pollutants impacting South Dakota streams are suspended solids due to water erosion from croplands, gully erosion from rangelands, streambank erosion, and other natural forms of erosion. Ninety-eight percent of South Dakota's surveyed lake acres fully support aquatic life uses now, but the quality of these lakes is threatened. Similarly, 100% of the surveyed lake acres fully support swimming, but these waters are threatened. The most common pollutants in lakes are nutrients and sediments from agricultural runoff.

The high water conditions that prevailed in South Dakota for most of this reporting period greatly increased watershed erosion and sedimentation in lakes and streams. Suspended solids criteria were severely violated in many rivers and streams, and there was an increase in the incidence of fecal coliform bacteria in swimming areas at lakes. However, water quality improved in some lakes that experienced low water levels during the late 1980s, and high flows diluted bacteria in rivers and streams.

Ground Water Quality

Nitrates exceed EPA Maximum Contaminant Levels in more wells than any other pollutant. About 15% of the samples collected at three eastern State aquifers during 1988-1993 had nitrate concentrations that exceeded the State criteria of 10 mg/L. More than 7% of the samples collected from the Big Sioux aquifer consistently exceeded the nitrate standard. Potential sources of nitrate include commercial fertilizer use and manure applications. There were no violations of drinking water standards for petroleum products reported during 1992-1993, but petroleum products were involved in 81% of the spills reported during the period.

Programs to Restore Water Quality

Compliance with municipal wastewater discharge permit requirements has steadily risen from 37% in 1979 to 75% statewide in 1993 following construction of 162 wastewater treatment facilities. Compliance is even higher (97%) among the plants completed with EPA Construction Grants. South Dakota relies primarily on voluntary implementation of best management practices to control pollution from nonpoint sources, such as agricultural activities, forestry operations, and mining. The State has initiated over 50 BMP development and implementation projects.

Programs to Assess Water Quality

South Dakota conducts ambient water quality monitoring at established stations, special intensive surveys, intensive fish surveys, wasteload allocation surveys, and individual nonpoint source projects. The USGS, Corps of Engineers, and U.S. Forest Service also conduct routine monitoring throughout the State. Water samples are analyzed for chemical, physical, biological, and bacteriological parameters.

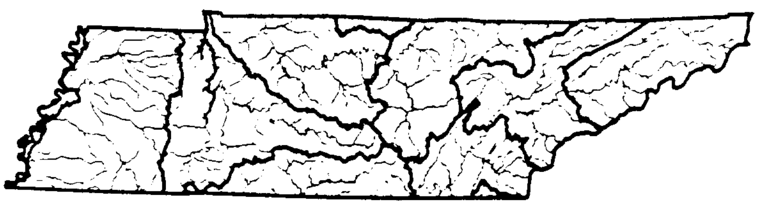
Individual Use Support in South Dakota

Designated Use*		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 9,937)	Total Miles Surveyed					
	2,352	17	0	14	69	-
	-	-	-	-	-	-
	839	35	0	53	12	-
Lakes (Total Acres = 750,000)	Total Acres Surveyed					
	685,071	0	98	2	0	-
	-	-	-	-	-	-
	685,071	0	100	0	0	-

- Not reported

*A subset of South Dakota's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

Tennessee



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Tennessee 1994 305(b) report, contact:

Greg Denton
Tennessee Department of
Environment and Conservation
Division of Water Pollution Control
401 Church Street, L&C Annex
Nashville, TN 37243-1534
(615) 532-0699

Surface Water Quality

Sixty-five percent of surveyed rivers and streams fully support aquatic life uses, 25% partially support these uses, and 10% are not supporting aquatic life uses due to severe pollution. Conventional pollutants (such as siltation, suspended solids, nutrients, and oxygen-depleting substances) affect the most river miles. Toxic materials, bacteria, and flow alterations impact rivers to a lesser extent. Major sources of pollutants include agriculture, hydromodification, and municipal point sources. Intense impacts from mining occur in the Cumberland Plateau region, and poor quality water discharged from dams impacts streams in east and middle Tennessee.

In lakes, 421,407 acres (78%) fully support aquatic life uses, 2,668 acres (less than 1%) are threatened, 27,987 acres (5%) partially support aquatic life uses, and 87,126 acres (16%) do not support these uses due to severe pollution. The most widespread problems in lakes include nutrients, low dissolved oxygen, siltation, and priority organics. Major sources of these pollutants are agriculture, municipal wastewater treatment plants, stream impoundments, hydrologic modification, mining, and nutrient addition.

Fish consumption advisories are posted on 142 miles of rivers and streams and over 84,000 acres of lakes due to elevated concentrations of chlordane, PCBs, dioxins, mercury, and other toxics in fish tissue samples. Swimming and wading are restricted in Chattanooga Creek and East Fork Poplar Creek due to toxic contamination from discontinued waste disposal practices.

Ground Water Quality

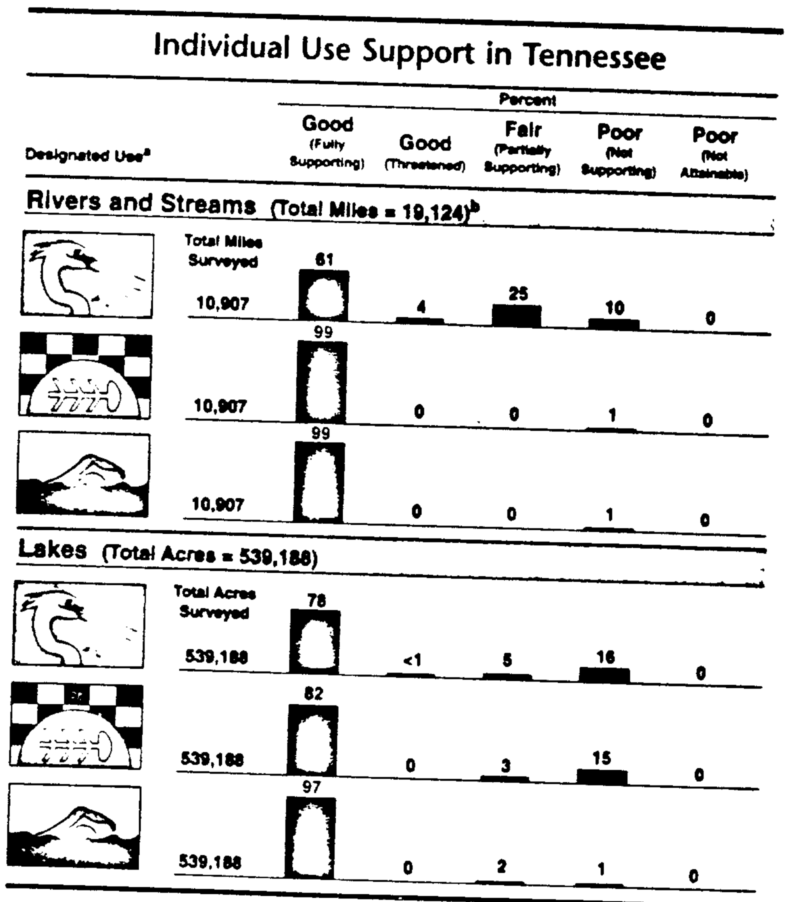
Ground water quality is generally good, but pollutants contaminate (or are thought to contaminate) the resource in localized areas. These pollutants include, but are not limited to, volatile and semivolatile organic chemicals, bacteria, metals, petroleum products, pesticides, and radioactive materials.

Programs to Restore Water Quality

Tennessee is considering issuing discharge permits on a rotating basis for each of the State's major river basins and is studying regionalized standards that take into account natural background conditions. The permits in each basin would be evaluated and reissued together on a 5-year cycle. Tennessee is also conducting several Total Maximum Daily Load studies that use a watershed approach to allocate maximum pollutant loading among all the point sources discharging into a stream or its tributaries.

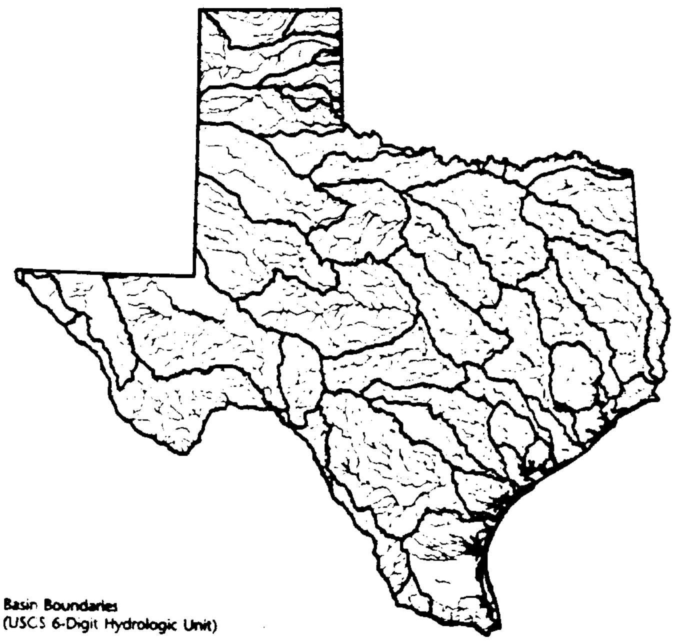
Programs to Assess Water Quality

Tennessee's ambient monitoring network consists of 156 active stations sampled quarterly for conventional pollutants (such as dissolved oxygen, bacteria, and suspended solids), nutrients, and selected metals. The State also performs intensive surveys at streams where State personnel suspect that human activities are degrading stream quality. Intensive surveys often include biological monitoring. The State samples toxic chemicals in fish and sediment at sites with suspected toxicity problems.



[a] A subset of Tennessee's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Texas



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Texas 1994 305(b) report, contact:

Steve Twidwell
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087
(512) 239-1000

Surface Water Quality

About 89% of the surveyed stream miles fully support aquatic life uses, 4% partially support these uses, and 6% do not support aquatic life uses. Swimming is impaired in 27% of the surveyed rivers and streams. The most common pollutants degrading rivers and streams are bacteria, metals, and oxygen-depleting substances. Major sources of pollution include municipal sewage treatment plants, unknown sources, pasture land runoff, and urban runoff.

In reservoirs, 98% of the surveyed surface acres fully support aquatic life uses and 2% partially support these uses. Less than 1% do not support aquatic life uses. Ninety-nine percent of the surveyed lake acres fully support swimming. The most common problems in reservoirs are low dissolved oxygen and elevated bacteria concentrations. Major sources that contributed to nonsupport of uses include unknown sources, natural sources (such as high temperature and shallow conditions), municipal sewage treatment plants, and industrial point sources.

The leading problem in estuaries is bacteria from unknown sources that contaminate shellfish beds. Fifty-nine percent of the surveyed estuarine waters fully support shellfishing use, 8% partially support this use, and 33% do not support shellfishing.

Ground Water Quality

About 44% of the municipal water is obtained from ground water in Texas. Natural contamination affects the quality of more ground water in the State than all other sources of contamination combined. Natural leaching from the aquifer matrix can elevate minerals, metals, and radioactive substances in ground water. The most common ground water contaminants from human activities are gasoline, diesel, and other petroleum products. Less common contaminants include volatile organic compounds and pesticides.

Programs to Restore Water Quality

The Texas Natural Resource Conservation Commission (TNRCC) launched a basin approach to water resource management with the Clean Rivers Program (CRP). The CRP is a first step in the development of a long-term, comprehensive and integrated geographic management approach aimed at improving coordination of natural resource functions in the agency. The basin approach will provide a framework for identifying problems, involving stakeholders, and integrating actions. The basin approach also allows for the use of risk-based targeting to prioritize issues and better allocate finite public resources.

Programs to Assess Water Quality

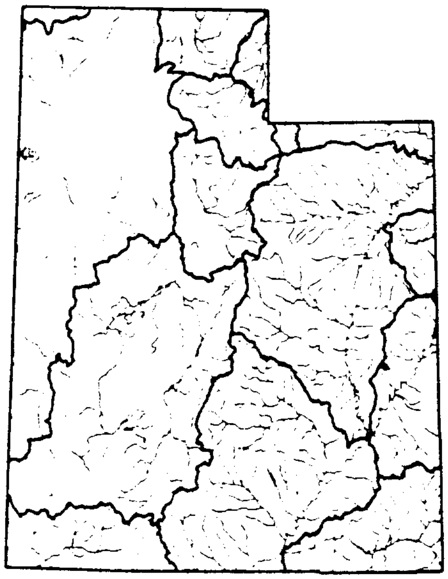
The TNRCC samples about 700 fixed stations as part of its Surface Water Quality Monitoring Program (SWQMP). The TNRCC samples different parameters and varies the frequency of sampling at each site to satisfy different needs. The TNRCC also conducts intensive surveys to evaluate potential impacts from point source dischargers during low flow conditions and special studies to investigate specific sources and pollutants. About 3,000 citizens also perform volunteer environmental monitoring in the Texas Watch Program.

Individual Use Support in Texas

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 191,228)[b]	Total Miles Surveyed					
	14,324	89	0	4	6	<1
	14,359	98	0	<1	1	0
	14,272	72	0	15	12	<1
Lakes (Total Acres = 3,065,600)	Total Acres Surveyed					
	1,505,059	98	0	2	<1	0
	1,505,059	99	0	<1	0	0
	1,505,059	99	0	<1	0	0
Estuaries (Total Square Miles = 1,991)	Total Square Miles Surveyed					
	1,991	98	0	2	<1	0
	1,991	96	0	0	4	0
	1,971	59	0	8	29	4
	1,987	99	0	<1	<1	-

[a] A subset of Texas' designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Utah



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Utah 1994 305(b) report, contact:

Thomas W. Toole
Utah Department of Environmental Quality
Division of Water Quality
P.O. Box 144870
Salt Lake City, UT 84114-4870
(801) 538-6859

Surface Water Quality

Of the 5,726 river miles surveyed, 75% fully support aquatic life uses, 20% partially support these uses, and 5% are not supporting aquatic life uses. The most common pollutants impacting rivers and streams are siltation and sediments, total dissolved solids, nutrients, and metals. Agricultural practices, such as grazing and irrigation, elevate nutrient and sediment loading into streams. Point sources also contribute to nutrient loads, while natural conditions introduce metals and sediments to streams in some areas. Resource extraction and associated activities, such as road construction, also impact Utah's rivers and streams.

About 61% of the surveyed lake acres fully support aquatic life uses, 32% partially support these uses, and 7% do not support aquatic life uses. The leading problems in lakes include nutrients, siltation, low dissolved oxygen, suspended solids, organic enrichment, noxious aquatic plants, and violations of pH criteria. The major sources of pollutants are grazing and irrigation, industrial and municipal point sources, drawdown of reservoirs, and natural conditions.

Fish and wildlife consumption advisories are posted on the lower portion of Ashley Creek drainage and Stewart Lake in Uintah County due to elevated levels of selenium found in fish, ducks, and American coots.

Ground Water Quality

In general, the quality of ground water in Utah has remained relatively good throughout the State, although some ground water degradation occurs in south central Utah in the metropolitan area of Salt Lake City and along the Wasatch Front area from Payson north to Brigham City. Sources of ground water degradation include irrigation, urbanization, landfills, mining and mine tailings, and drawdown. In 1994, new ground water regulations went into effect.

Programs to Restore Water Quality

The State's Nonpoint Source Task Force is responsible for coordinating nonpoint source programs in Utah. The Task Force is a broad-based group with representatives from Federal, State, and local agencies; local governments; agricultural groups; conservation organizations; and wildlife advocates. The Task Force helped State water quality and agricultural agencies prioritize watersheds in need of NPS pollution controls. As best management practices are implemented, the Task Force will update and revise the priority list.

Programs to Assess Water Quality

In 1993, Utah adopted a basinwide water quality monitoring approach. Utah initiated basinwide intensive studies in the Weber River Basin in 1993 and the Utah Lake-Jordan River Basin in 1994. A fixed-station network was also developed to evaluate general water quality across the State. Utah's surface water quality monitoring program consists of about 200 ambient stations, 7 salinity monitoring stations, and 30 biological monitoring sites. In addition, 135 industrial and municipal sites were monitored.

Individual Use Support in Utah

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 85,916)[b]	Total Miles Surveyed					
	5,726	75	0	20	5	0
	16	0	0	0	100	0
	285	86	0	0	14	0
Lakes (Total Acres = 481,838)	Total Acres Surveyed					
	450,078	61	0	32	7	0
	279	0	0	0	100	0
	1,000	0	0	0	100	0

[a] A subset of Utah's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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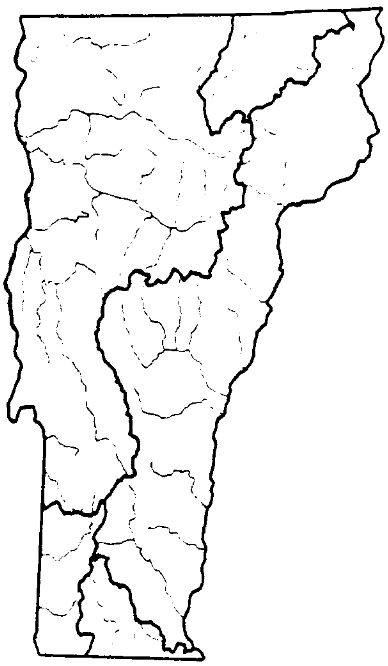
Vermont



— Basin Boundaries (USGS 6-Digit Hydrologic Unit)

For a copy of the Vermont 1994 305(b) report, contact:

Jerome J. McArdle
Vermont Agency of Natural Resources
Dept. of Environmental Conservation
Water Quality Division
103 South Main Street,
Building 10 North
Waterbury, VT 05671-0408
(802) 244-6951

Surface Water Quality

Of the 5,264 miles of surveyed rivers and streams, 81% fully support aquatic life uses, 15% partially support these uses, and 4% do not support aquatic life uses. Ten percent of the surveyed rivers and streams do not fully support swimming. The most widespread impacts include siltation, thermal modifications, organic enrichment and low dissolved oxygen, nutrients, pathogens, and other habitat alterations. The principal sources of impacts are agricultural runoff, streambank destabilization and erosion, removal of streamside vegetation, upstream impoundments, flow regulation, and land development.

Sixty-four percent of the surveyed lake acres (excluding Lake Champlain) fully support aquatic life uses, 27% partially support these uses, and 9% do not support aquatic life uses. The most common problems in lakes include fluctuating water levels, nutrient enrichment, algal blooms, organic enrichment and low dissolved oxygen, siltation, and aquatic weeds. Eurasian watermilfoil, an aquatic weed, infests 13% of the State's lakes that are 20 acres or larger. Runoff from agricultural lands, roads, and streambank erosion are the most frequently identified sources of lake problems.

In Lake Champlain, nutrients are the major cause of impairment, followed by fish consumption advisories posted for trout contaminated with PCBs and walleye contaminated with mercury. Discovery of the zebra mussel in 1993 threatens all uses.

Ground Water Quality

The quality of Vermont's ground waters is not well understood due to a lack of resources required to gather and assess ground water data. Ground water contamination has been detected at hazardous waste sites. Other sources of concern include failing septic systems, old solid waste disposal sites, agriculture, road salt, leaking underground storage tanks, and landfills. The State needs to implement a Comprehensive Ground Water Protection Program, but lacks the financial and technical resources to do so.

Programs to Restore Water Quality

During the reporting period, Vermont implemented dechlorination at 18 publicly owned sewage treatment plants, which improved water quality in about 47 miles of rivers and streams. The State also completed construction of the last two planned sewage treatment plants and upgraded four other plants. To prevent habitat modifications, the State used the Section 401 water quality certification process to require minimum stream flows at four hydroelectric facilities. The stream flow requirements should improve water quality on 11 miles of streams.

Programs to Assess Water Quality

Vermont's monitoring activities balance short-term intensive and long-term trend monitoring. Notable monitoring activities include fixed-station monitoring on lakes and ponds, citizen monitoring, long-term acid rain lake monitoring, compliance monitoring for permitted dischargers, toxic discharge monitoring, fish contamination monitoring, and ambient biomonitoring of aquatic insects and fish.

Individual Use Support in Vermont

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 5,264)[b] — Total Miles Surveyed						
Use 1	5,264	59	22	15	4	0
Use 2	5,063	98	2	<1	<1	0
Use 3	5,232	77	13	8	2	0
Lakes (Total Acres = 54,206)[c] — Total Acres Surveyed						
Use 1	52,770	32	32	27	9	0
Use 2	46,601	100	0	0	<1	0
Use 3	52,318	51	27	10	12	0
Lake Champlain (Total Acres = 174,175) — Total Acres Surveyed						
Use 1	174,175	16	68	13	3	0
Use 2	174,175	0	0	100	0	0
Use 3	174,175	0	7	83	10	0

[a] A subset of Vermont's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes perennial streams only.
[c] Excluding Lake Champlain.

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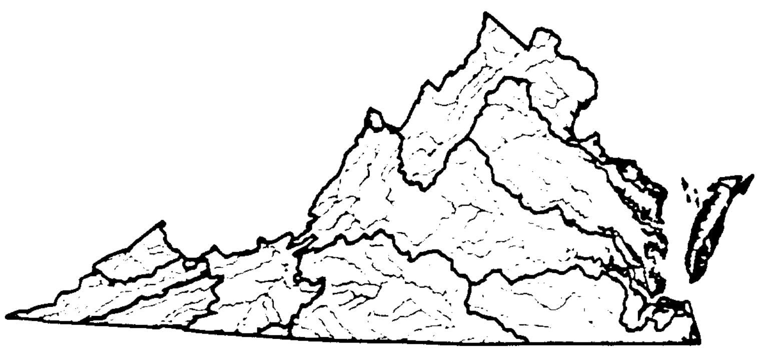
Virginia



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Virginia 1994 305(b) report, contact:

Carrie Gorsuch
Department of Environmental Quality
Water Division
Office of Water Resources Management
P.O. Box 10009
Richmond, VA 23240-0009
(804) 762-4290

Surface Water Quality

Of the 34,575 river miles surveyed, 90% fully support aquatic life use, another 5% fully support this use now but are threatened, and 5% do not fully support this use. As in past years, fecal coliform bacteria are the most widespread problem in rivers and streams. Agriculture and pasture land contribute much of the fecal coliform bacteria in Virginia's waters. Urban runoff also is a significant source of impacts in both rivers and estuaries.

Ninety-nine percent of Virginia's publicly owned lakes fully support their designated uses, and about 1% do not fully support uses. The most common problems in lakes include dissolved oxygen depletion, coliform bacteria, pH, and temperature, primarily from nonpoint sources.

In estuaries, 31% of the surveyed waters fully support aquatic life use, 64% support this use but are threatened, and 5% partially support this use. Nutrients are the most common problem in Virginia's estuarine waters, followed by organic enrichment and low dissolved oxygen concentrations. All of Virginia's Atlantic Ocean shoreline fully supports designated uses.

Six advisories limit fish consumption on 369 miles of Virginia's rivers and an undetermined number of miles of tidal tributaries to the James River. The Commonwealth lifted one advisory that had restricted fish consumption on the Jackson River and the Upper James River.

Ground Water Quality

Sampling by the Virginia Department of Health detected bacterial concentrations exceeding Maximum Contaminant Levels at 133 ground-water-based community public water systems in 1993. Nitrates and pesticides were also detected in a small percentage of the private wells sampled in a pilot study in Northampton County. Virginia revised ground water protection rules with the Ground Water Management Act of 1992.

Programs to Restore Water Quality

Virginia's Department of Environmental Quality recommends control measures for water quality problems identified in the 305(b) report in their Water Quality Management Plans (WQMPs). WQMPs establish a strategy for bringing impaired waters up to water quality standards and preventing the degradation of high-quality waters. Control measures are implemented through Virginia's point source permit program and application of best management practices for nonpoint sources.

Programs to Assess Water Quality

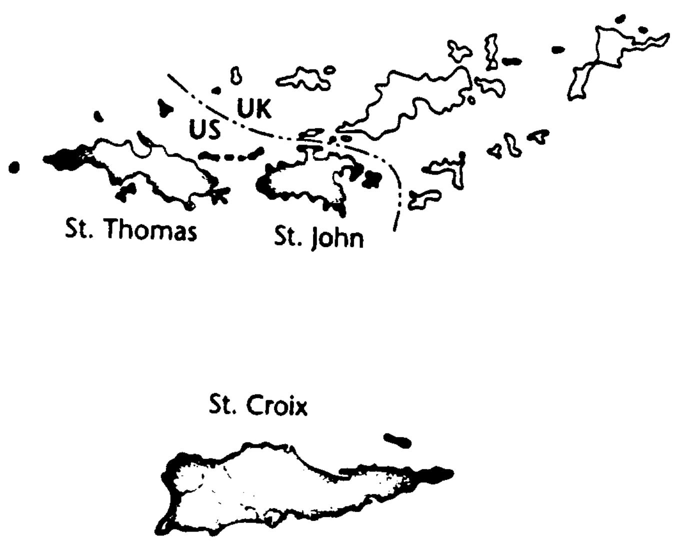
The Ambient Water Quality Monitoring Program grew to 896 monitoring stations, a 26% increase since the previous reporting period. These stations are sampled for chemical and physical parameters on a variable schedule. The Core Monitoring Program consists of a subset of 51 stations that are sampled for pesticides, metals, and organic chemicals in fish and sediment on a 3-year cycle. About 150 biological stations were also sampled during the 1992-1993 reporting cycle.

Individual Use Support in Virginia

Designated Use[a]	Total Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 44,852)[b]	Total Miles Surveyed					
	34,575	90	5	4	1	0
	34,644	96	3	1	<1	0
	34,462	98	0	2	<1	0
Lakes (Total Acres = 161,888)[c]	Total Acres Surveyed					
	151,071	99	0	1	0	0
	-	-	-	-	-	-
	161,364	99	0	1	<1	0
Estuaries (Total Square Miles = 2,500)	Total Square Miles Surveyed					
	2,470	31	64	5	0	0
	2,470	90	9	1	<1	0
	2,366	92	0	7	1	0
	2,470	100	0	0	0	0

- Not reported.
[a] A subset of Virginia's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.
[c] Size of significant publicly owned lakes, a subset of all lakes in Virginia.

Virgin Islands



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Virgin Islands 1994 305(b) report, contact:

Anne Hanley
U.S. Virgin Islands Department of Planning and Natural Resources
Division of Environmental Protection
P.O. Box 4340
St. Thomas, VI 00801
(809) 773-0565

Surface Water Quality

The U.S. Virgin Islands consist of three main islands (St. Croix, St. Thomas, and St. John) and over 50 smaller islands and cays located in the Caribbean Sea. The islands lack perennial streams or large freshwater lakes or ponds. Water quality in the U.S. Virgin Islands is generally good but declining due to an increase in point source discharges and nonpoint source pollution entering the marine environment.

The Virgin Islands municipal sewage treatment plants, operated by the Virgin Islands Department of Public Works, are the major source of water quality violations in the Territory. Neglect, combined with a lack of qualified operators and maintenance staff, results in frequent breakdowns of lift stations, pump stations, and pipelines. Clogged and collapsed lines frequently cause unpermitted discharges into surface waters. Stormwater also overwhelms sewage treatment facilities and results in bypasses of raw or undertreated sewage into bays and lagoons.

Other water quality problems result from unpermitted discharges, permit violations by private industrial dischargers, oil spills, and unpermitted filling activities in mangrove swamps. Nonpoint sources of concern include failing septic systems, erosion from development, urban runoff, waste disposal from vessels, and spills.

Ground Water Quality

The Virgin Islands' ground water is contaminated with bacteria, saltwater, and volatile organic compounds. Septic tanks, leaking municipal sewer lines, and sewage bypasses contaminate ground water with bacteria. Overpumping of aquifers causes saltwater intrusion. VOC contamination is due to underground storage tanks and indiscriminate discharges of waste oil.

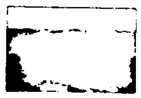
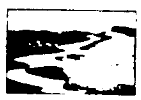
Programs to Restore Water Quality

The Territorial Pollution Discharge Elimination System (TPDES) requires permits for all point source discharges, but not all permitted facilities are in compliance with their permit requirements. During the 1992-1993 reporting period, the Division of Environmental Protection brought four major violators into compliance. The Virgin Islands is also developing new regulations for citing and constructing onsite sewage disposal systems and advocating best management practices in the *Revised Handbook for Homebuilders and Developers.*

Programs to Assess Water Quality

The Ambient Monitoring Program performs quarterly sampling at 64 fixed stations around St. Croix, 57 stations around St. Thomas, and 19 stations around St. John. Samples are analyzed for fecal coliforms, turbidity, dissolved oxygen, and temperature. Twenty stations on St. Croix were also sampled for phosphorus, nitrogen, and suspended solids. Intensive studies, which include biological sampling, are conducted at selected sites that may be affected by coastal development. The Virgin Islands does not monitor bacteria in shellfish waters or toxics in fish, water, or sediment.

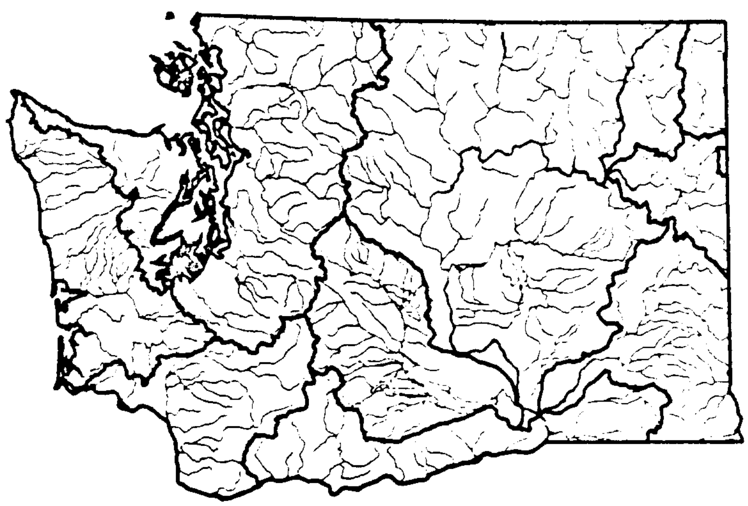
Overall[a] Use Support in Virgin Islands

		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Estuaries (Total Square Miles = 5.9)						
	Total Square Miles Surveyed 5.6	62	17	10	11	0
Ocean Shoreline (Total Miles = 173)						
	Total Miles Surveyed 13	77	15	0	8	0

[a] Overall use support is presented in this figure because the Virgin Islands did not report individual use support in their 1994 Section 305(b) report.

Note: The Virgin Islands report that there are no perennial streams or significant lakes under their jurisdiction.

Washington



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Washington 1994 305(b) report, contact:

Steve Butkus
Washington Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600
(360) 407-6482

Surface Water Quality

Washington reports that 18% of their surveyed river miles fully support aquatic life uses, 22% partially support these uses, and 60% do not support aquatic life uses. In lakes, 35% of the surveyed acres fully support aquatic life uses, and 65% do not support aquatic life uses.

Thirty-two percent of the surveyed estuarine waters fully support aquatic life uses, 24% partially support these uses, and 44% do not support aquatic life uses.

Low levels of dissolved oxygen, often naturally occurring, are the major cause of impairment of designated uses in estuaries. Bacterial contamination, primarily from agricultural runoff, onsite wastewater disposal, and municipal wastewater treatment plants also causes impairment in estuaries. Major causes of impairment in lakes include nutrients, pesticides, siltation, flow alteration, and low dissolved oxygen. Agricultural production is the predominant source of impairment in lakes. Other sources include urban runoff, land disposal, septic tanks, and natural sources. In rivers and streams, agriculture is the major source of water quality degradation, followed by industrial point sources and hydro-habitat modification. Causes of water quality impairment from these sources include thermal modification, pathogen indicators, and ammonia.

Ground Water Quality

The highest priority ground water issues in Washington are nitrates, pesticides, and other agricultural chemicals from fertilizer applications, pesticide applications, and septic tanks.

Programs to Restore Water Quality

Washington provides financial incentives to encourage compliance with permit requirements, the principal vehicle for regulating point source discharges. The State also has extensive experience developing, funding, and implementing nonpoint source pollution prevention and control programs since the early 1970s. The State has developed nonpoint source control plans with best management practices for forest practices, dairy waste, irrigated agriculture, dryland agriculture, and urban stormwater. The State is now focusing attention on watershed planning. Efforts are currently geared toward prioritizing watersheds and developing comprehensive plans for the priority watersheds.

Programs to Assess Water Quality

Washington implements an aggressive program to monitor the quality of lakes, estuaries, and rivers and streams. The program makes use of fixed-station monitoring to track spatial and temporal water quality changes so as to ascertain the effectiveness of various water quality programs and be able to identify desirable adjustments to the programs.

Individual Use Support in Washington

Designated Use[a]	Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 73,886)[b]	Total Miles Surveyed					
	7,021	18	0	22	60	0
	651	0	0	38	62	0
	4,467	29	0	11	60	0
Lakes (Total Acres = 466,296)	Total Acres Surveyed					
	63,337	35	0	<1	65	0
	18,472	0	0	0	100	0
	36,920	92	0	4	4	0
Estuaries (Total Square Miles = 2,943)	Total Square Miles Surveyed					
	143	32	0	24	44	0
	7	0	0	0	100	0
	568	47	0	14	39	0
	140	84	0	3	13	0

[a] A subset of Washington's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

West Virginia

— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For information about water quality in West Virginia, contact:

Mike Arcuri
West Virginia Division of
Environmental Protection
Office of Water Resources
1201 Greenbrier Street
Charleston, WV 25311
(304) 558-2108

Surface Water Quality

West Virginia reported that 42% of their surveyed river and stream miles have good water quality that fully supports aquatic life uses, and 75% fully support swimming. In lakes, 32% of the surveyed acres have good water quality that fully supports aquatic life uses and 100% fully support swimming.

Metals and siltation are the most common water quality problems in West Virginia's rivers and lakes. Fecal coliforms and acidity also impair a large number of river miles. In lakes, oxygen-depleting substances, acidity, nutrients, and algal blooms also impair a significant number of acres. Coal mining impaired the most stream miles, followed by municipal point sources and agriculture. Coal mining was also the leading source of degraded water quality in lakes, followed by forestry and agriculture.

West Virginia reported that fish consumption advisories are posted for the Kanawha River, Pocatalico River, Armour Creek, Ohio River, Shenandoah River, North Branch of the Potomac River, the Potomac River, and Flat Fork Creek. Five of the advisories were issued because of elevated dioxin concentrations in bottom feeders. The other advisories address PCBs and chlordane in suckers, carp, and channel catfish.

Ground Water Quality

West Virginia ranked mining and mine drainage as the highest priority source of ground water contamination in the State, followed by municipal landfills, surface water impoundments (including oil and gas brine pits), abandoned hazardous waste sites, and industrial landfills. West Virginia has documented or suspects that ground water has been contaminated by pesticides, petroleum compounds, other organic chemicals, bacteria, nitrates, brine/salinity, arsenic, and other metals.

Programs to Restore Water Quality

No information was available from the State.

Programs to Assess Water Quality

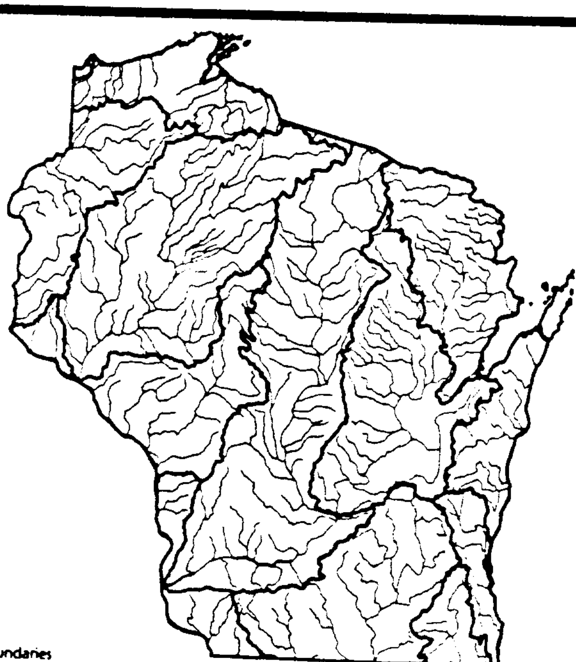
No information was available from the State.

Individual Use Support in West Virginia

Designated Use[a]	Total Surveyed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 32,278)	Total Miles Surveyed					
	6,334	35	7	49	9	0
	659	24	0	76	<1	0
	6,357	75	<1	16	8	0
Lakes (Total Acres = 21,523)	Total Acres Surveyed					
	21,523	11	21	60	8	0
	91	100	0	0	0	0
	21,523	87	13	0	0	0

[a] A subset of West Virginia's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Wisconsin



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Wisconsin 1994 305(b) report, contact:

Meg Turville-Heitz
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
(608) 266-0152

Surface Water Quality

The Wisconsin Department of Natural Resources (WDNR) found that 78% of the surveyed river miles fully support aquatic life uses, 2% support these uses now but are threatened, 14% partially support aquatic life uses, and 6% do not support aquatic life uses. WDNR believes that the survey process underestimated the number of threatened river miles. The most prevalent problems in rivers are habitat and flow alterations, siltation, excessive nutrients, and oxygen-depleting substances. The sources of these problems are often polluted runoff, especially in agricultural areas, and river modifications, such as ditching, straightening, and the loss of wetlands alongside streams. Wastewater discharges also moderately impair more than 1,000 miles of streams.

About 57% of the surveyed lake acres fully support aquatic life uses, 3% support these uses but are threatened, 15% partially support these uses, and 25% do not support aquatic life uses. The primary source of lake degradation is deposition of airborne pollutants, especially mercury, and polluted runoff. All of Wisconsin's Great Lakes' shoreline partially supports fish consumption use due to fish consumption advisories posted throughout the Great Lakes. Bacteria from urban runoff also impair swimming along 60 miles of shoreline.

Ground Water Quality

The primary sources of ground water contamination in Wisconsin are agricultural activities, municipal landfills, leaking underground storage tanks, abandoned hazardous waste sites, and spills. Other sources include septic tanks and land application of wastewater. Nitrate-nitrogen is the most common ground water contaminant. Nitrates come from fertilizers, animal waste storage sites and feedlots, municipal and industrial wastewater and sludge disposal, refuse disposal areas, and leaking septic systems.

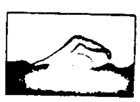
Programs to Restore Water Quality

WDNR is integrating multiple agencies, programs, interests, and jurisdictions in an "ecosystem approach" that looks at all parts of the ecosystem when addressing water quality—the land that drains to the waterbody, the air above it, the plants, animals, and people using it. Since the 1970s, WDNR has prepared water quality management plans for each of the State's river basins that summarize the condition of waters in each basin, identify improvements and needs, and make recommendations for cleanup or protection. WDNR updates the plans every 5 years and uses the plans to rank watersheds for priority projects under the Wisconsin Nonpoint Source Water Pollution Abatement Program and to address wastewater discharge concerns.

Programs to Assess Water Quality

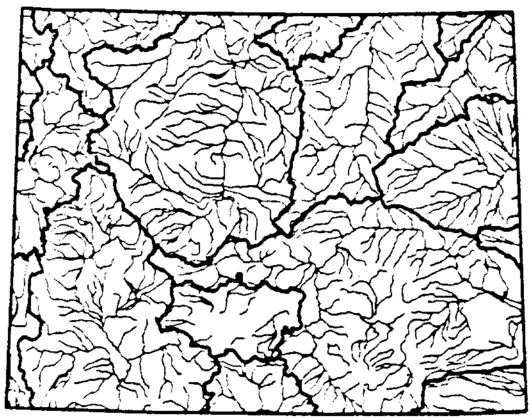
In 1992, Wisconsin implemented a surface water monitoring strategy to support river basin planning. The strategy integrates monitoring and management activities in each of the State's river basins on the 5-year basin planning schedule. In recent years, Wisconsin has placed more emphasis on monitoring polluted runoff and toxic substances in bottom sediments and tissues of fish and wildlife.

Individual Use Support in Wisconsin

Designated Use[a]	Total Surveyed	Good (Fully Supporting) %	Good (Threatened) %	Fair (Partially Supporting) %	Poor (Not Supporting) %	Poor (Not Attainable) %
Rivers and Streams (Total Miles = 57,698)[b]	Total Miles Surveyed					
	21,411	78	2	14	6	<1
	2,456	73	6	16	5	0
	NA	NA	NA	NA	NA	NA
Lakes (Total Acres = 982,163)[c]	Total Acres Surveyed					
	294,479	57	3	15	25	0
	158,630	58	0	28	14	0
	NA	NA	NA	NA	NA	NA
Great Lakes (Total Miles = 1,017)	Total Miles Surveyed					
	1,017	0	79	21	0	0
	1,017	0	0	100	0	0
	1,017	90	4	4	2	0

NA = Not applicable because use is not designated in State standards.
[a] A subset of Wisconsin's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Wyoming



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Wyoming 1994 305(b) report, contact:

Beth Pratt
Wyoming Department of
Environmental Quality
Water Quality Division
Herschler Building
122 West 25th Street
Cheyenne, WY 82002
(307) 777-7079

Surface Water Quality

Of the 6,091 river miles surveyed, 13% fully support aquatic life uses, 22% fully support these uses now but are threatened, 63% partially support aquatic life uses, and 2% do not support aquatic life uses. The most widespread problems in rivers and streams are siltation and sediment, nutrients, total dissolved solids and salinity, flow alterations, and habitat alterations. The most prevalent sources of water quality problems in rivers and streams are rangeland, natural sources, irrigated cropland, pasture land, and construction of highways, roads, and bridges.

In lakes, 31% of the surveyed acres fully support aquatic life uses, 47% partially support these uses, and 22% do not support aquatic life uses. The leading problems in lakes are low dissolved oxygen concentrations and organic enrichment, nutrients, sediment and siltation, other inorganic substances, and metals. The most prevalent sources of water quality problems in lakes are natural sources, rangeland, irrigated cropland, flow regulation, and municipal sewage treatment plants.

The State's water quality survey is designed to identify water quality problems, so it is reasonable to assume that most of the unassessed waters are not impacted. However, the State lacks definitive information to that effect.

Ground Water Quality

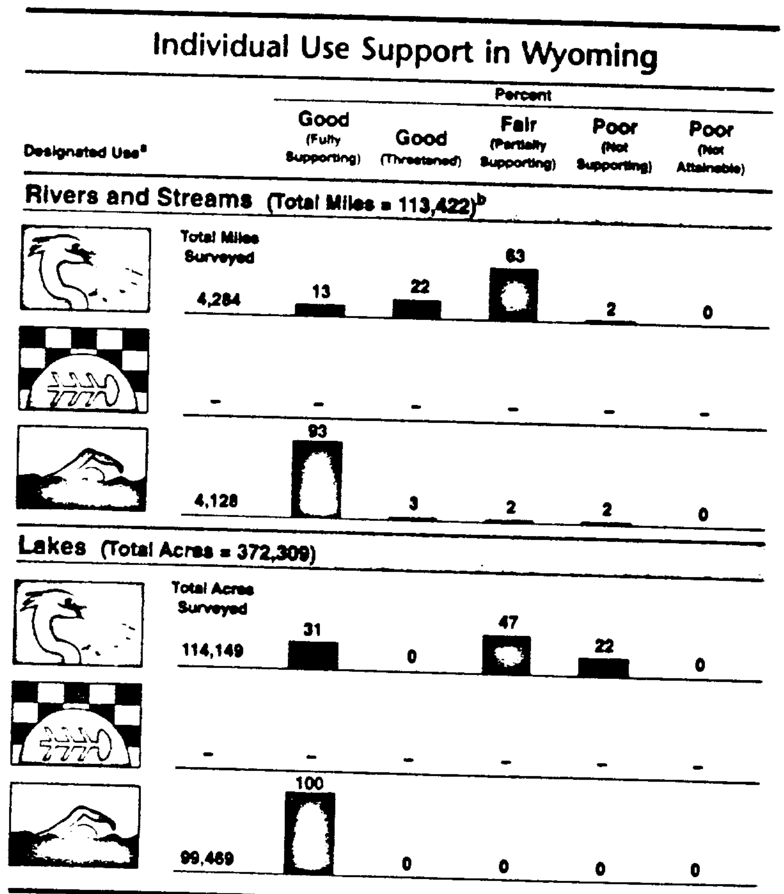
Some aquifers in Wyoming have naturally high levels of fluoride, selenium, and radionuclides. Petroleum products and nitrates are the most common pollutants in Wyoming's ground water, and leaking underground storage tanks are the most numerous source of contamination. Other sources include uranium and trona mineral mining, agricultural activities, mill tailings, spills, landfills, commercial and industrial sumps, septic tank leachfields, wastewater disposal ponds at coal-fired power plants and other industrial sites, and commercial oilfield disposal pits.

Programs to Restore Water Quality

Wyoming requires discharger permits and construction permits for all wastewater treatment facilities. The Department of Environmental Quality (DEQ) reviews proposed plans and specifications to ensure that plants meet minimum design criteria. Wyoming's nonpoint source program is a nonregulatory program that promotes better management practices for all land use activities, including grazing, timber harvesting, and hydrologic modifications.

Programs to Assess Water Quality

Wyoming is currently monitoring reference stream sites around the State in order to define characteristics of relatively undisturbed streams in each ecoregion. The State is sampling chemical and biological parameters, such as dissolved oxygen, nutrients, aquatic insect species composition, species abundance, and habitat conditions at the candidate reference stream sites. Once established, the reference site conditions will serve as the basis for assessing other streams in the same ecoregion or subecoregion. Wyoming will use the reference conditions to establish a volunteer biological monitoring program.



- Not reported

[a] A subset of Wyoming's designated uses appear in this figure. Refer to the State's 305(b) report for a full description of the State's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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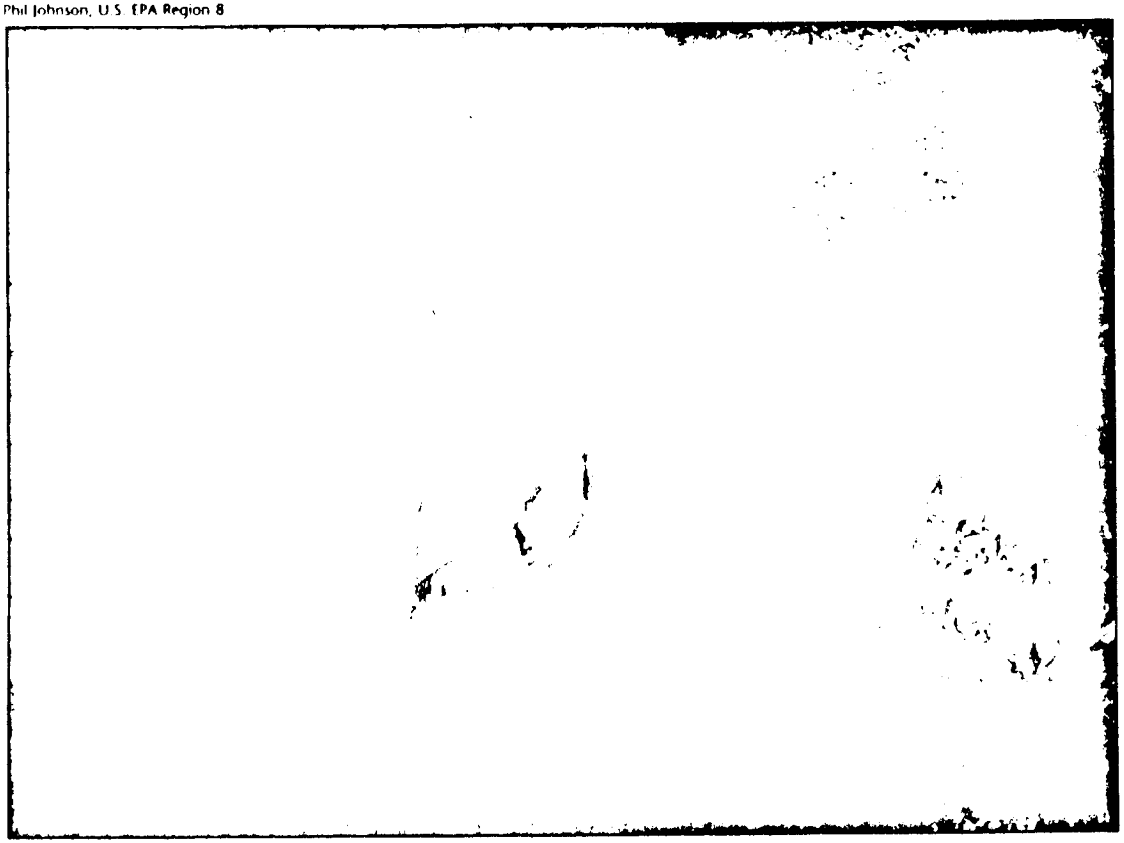
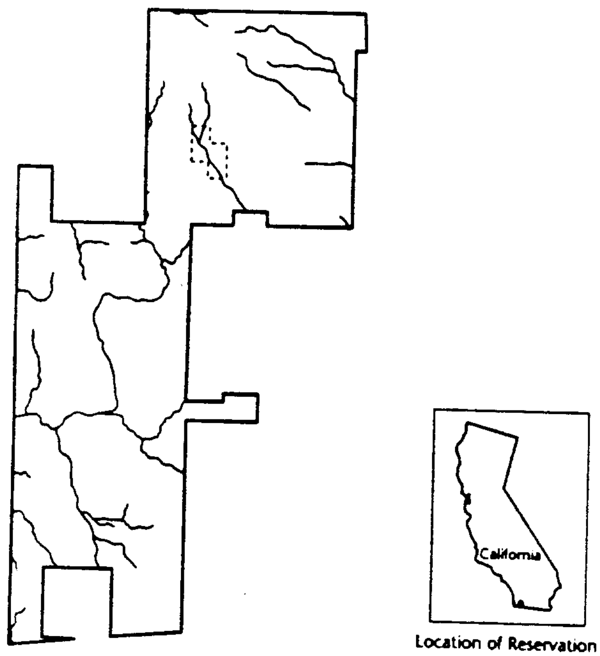
Phil Johnson, U.S. EPA Region 8



Tribal Summaries

This chapter provides individual summaries of the water quality survey data reported by six American Indian Tribes in their 1994 Section 305(b) reports. Tribal participation in the Section 305(b) process grew from two Tribes in 1992 to six Tribes during the 1994 reporting cycle, but Tribal water quality remains unrepresented in this report for the hundreds of other Tribes established throughout the country. Many of the other Tribes are in the process of developing water quality programs and standards but have not yet submitted a Section 305(b) report. As Tribal water quality programs become established, EPA expects Tribal participation in the Section 305(b) process to increase rapidly. To encourage Tribal participation, EPA has sponsored water quality monitoring and assessment training sessions at Tribal locations, prepared streamlined 305(b) reporting guidelines for Tribes that wish to participate in the process, and published a brochure, *Knowing Our Waters: Tribal Reporting Under Section 305(b)*. EPA hopes that subsequent reports to Congress will contain more information about water quality on Tribal lands.

Campo Indian Reservation



Location of Reservation

For a copy of the Campo Indian Reservation 1994 305(b) report, contact:

Stephen W. Johnson
Michael L. Connolly
Campo Environmental Protection Agency
36190 Church Road, Suite #4
Campo, CA 91906
(619) 478-9369

Surface Water Quality

The Campo Indian Reservation covers 24.2 square miles in southeastern San Diego County, California. The Campo Indian Reservation has 31 miles of intermittent streams, 80 acres of freshwater wetlands, and 10 lakes with a combined surface area of 3.5 acres.

The natural water quality of Tribal streams, lakes, and wetlands ranges from good to excellent. There are no point source discharges within or upstream of the Reservation, but grazing livestock have degraded streams, lakes, and wetlands with manure containing fecal coliform bacteria, nutrients, and organic wastes. Livestock also trample streambeds and riparian habitats. Septic tanks and construction also threaten water quality.

Ground Water Quality

Ground water supplies 100% of the domestic water consumed on the Campo Indian Reservation. Nitrate and bacteria from nonpoint sources occasionally exceed drinking water standards in some domestic wells. The proximity of individual septic systems to drinking water wells poses a human health risk because Reservation soils do not have good purification properties. Elevated iron and manganese levels may be due to natural weathering of geologic materials.

Programs to Restore Water Quality

The Campo Environmental Protection Agency (CEPA) has authority to administer three Clean Water Act programs. The Section 106 Water Pollution Control Program supports infrastructure, the 305(b) assessment process, and development of a Water Quality Management Plan. The Tribe is inventorying its wetlands with funding from the Section 104(b)(3) State Wetlands Protection Program. The Tribe has used funding from the Section 319 Nonpoint

Source Program to stabilize stream banks, construct sediment retention structures, and fence streams and riparian zones to exclude livestock. CEPA will promulgate water quality standards in 1995 that will establish beneficial uses, water quality criteria, and antidegradation provisions for all Tribal waters.

In 1994, the General Council passed a resolution to suspend cattle grazing on the Reservation for at least 2 years and to concurrently restore degraded recreational water resources by creating fishing and swimming ponds for Tribal use.

Programs to Assess Water Quality

Streams, wetlands, and lakes on Tribal lands were not monitored until CEPA initiated its Water Pollution Control Program in 1992. Following EPA approval of CEPA's Quality Assurance Project Plan in May 1993, CEPA conducted short-term intensive surveys to meet the information needs of the 305(b) assessment process. Based on the results of the 1994 305(b) assessment, CEPA will develop a long-term surface water monitoring program for implementation in 1995. CEPA will consider including biological monitoring, physical and chemical monitoring, monthly bacterial monitoring in lakes, toxicity testing, and fish tissue monitoring in its monitoring program.

Individual Use Support in Campo Indian Reservation

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 31)[b]	Total Miles Assessed					
	22	0	0	100	0	0
	<1	100	0	0	0	0
	16	0	0	100	0	0
Lakes (Total Acres = 3.5)	Total Acres Assessed					
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-

[a] A subset of Campo Indian Reservation's designated uses appear in this figure. Refer to the Tribe's 305(b) report for a full description of the Tribe's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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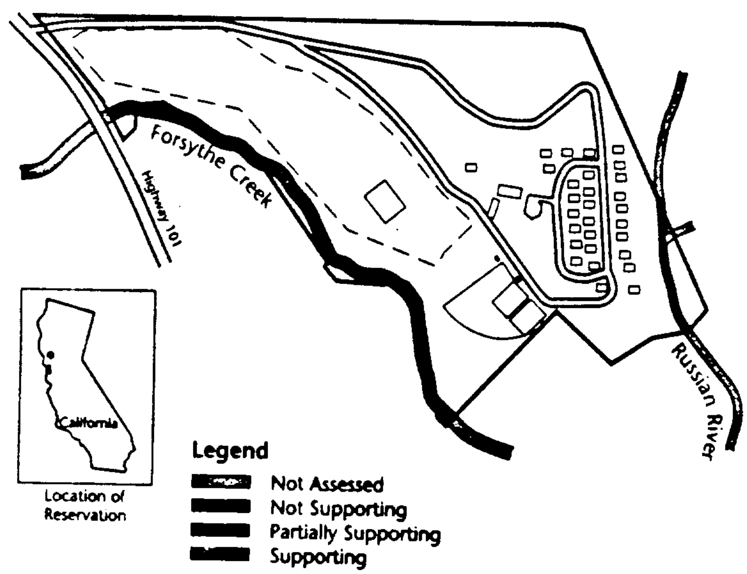
Coyote Valley Reservation



For a copy of the Coyote Valley Reservation 1994 305(b) report, contact:

Jean Hunt or Eddie Knight
The Coyote Valley Reservation
P.O. Box 39
Redwood Valley, CA 95470

Surface Water Quality

The Coyote Valley Band of the Pomo Indians is a federally recognized Indian Tribe, living on a 57-acre parcel of land in Mendocino County, California. Segments of the Russian River and Forsythe Creek flow past the Reservation, although flow diminishes in the summer and fall. Fishing, recreation, and religion are important uses for surface waters within the Reservation.

Currently, the Tribe is concerned about bacteria contamination in the Russian River, potential contamination of Forsythe Creek from a malfunctioning septic system leachfield, and habitat modifications in both streams that impact aquatic life. Past gravel mining operations removed gravel spawning beds, altered flow, and created very steep banks. In the past, upstream mining also elevated turbidity in Forsythe Creek. The Tribe is also concerned about a potential trend of increasing pH values and high water temperatures in Forsythe Creek during the summer.

Ground Water Quality

The Coyote Valley Reservation contains three known wells, but only two wells are operable, and only one well is in use. The old shallow irrigation well (Well A) was abandoned because it went dry after the gravel mining operation on Forsythe Creek lowered the water table. Well B, located adjacent to Forsythe Creek, is used to irrigate a walnut orchard. Well C, located on a ridge next to the Reservation's housing units, is not in use due to severe iron and taste problems. Sampling also detected high levels of barium, total dissolved solids, manganese, and conductivity in Wells B and C. However, samples from Well B did not contain organic chemicals, pesticides, or nitrate in detectable amounts. Human waste contamination from septic systems may pose the greatest threat to ground water quality.

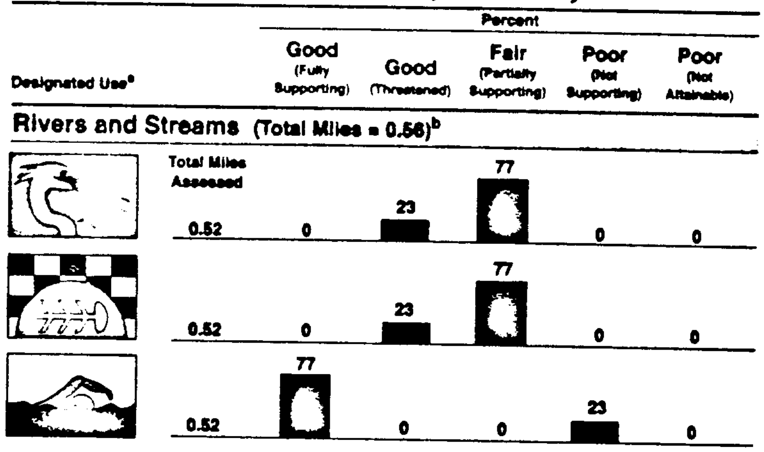
Programs to Restore Water Quality

Codes and ordinances for the Reservation will be established to create a Water Quality and Management Program for the Reservation. With codes in place, the Coyote Valley Tribal Council will gain the authority to restrain the discharge of pollutants that could endanger the Reservation water supply and affect the health and welfare of its people, as well as people in the adjacent communities.

Programs to Assess Water Quality

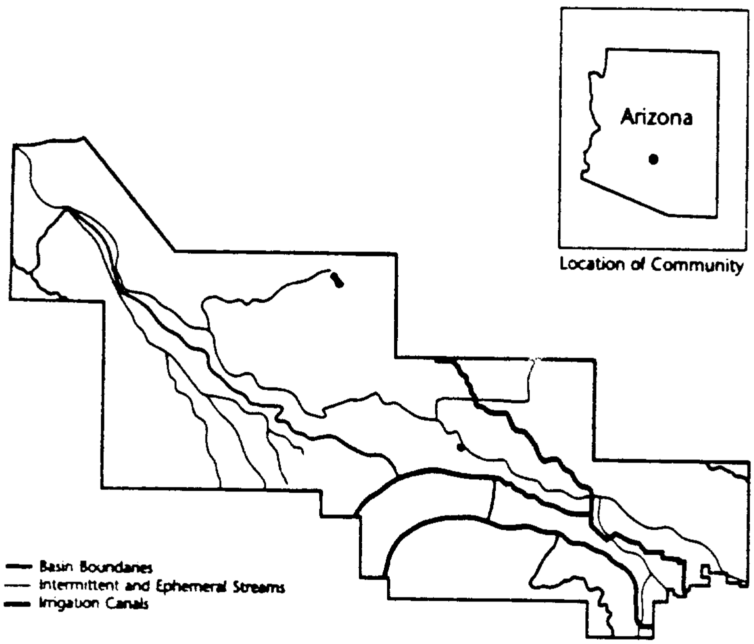
The Tribal Water Quality Manager will design a monitoring system with assistance from environmental consultants. The Water Quality Manager will sample a temporary monitoring station on Forsythe Creek and a proposed sampling station on the Russian River every month. A fisheries biologist will survey habitat on the rivers every other year, as funding permits.

Individual Use Support in Coyote Valley Reservation



[a] A subset of Coyote Valley Reservation's designated uses appear in this figure. Refer to the Tribe's 305(b) report for a full description of the Tribe's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Gila River Indian Community



For a copy of the Gila River Indian Community 1994 305(b) report, contact:

Errol Blackwater
Gila River Indian Community
Water Quality Planning Office
Corner of Pima and Main Streets
Sacaton, AZ 85247
(602) 562-3203

Surface Water Quality

The Gila River Indian Community occupies 580 square miles in Central Arizona adjacent to the metropolitan Phoenix area. About 8,500 members of the Pima and Maricopa Tribes live in 22 small villages inside the Community. The Gila River is the major surface water feature in the Community, but its flow is interrupted by upstream diversions outside of the Community. Arid conditions and little vegetative cover cause sudden runoff with high suspended sediment loads.

Surface water was evaluated with qualitative information due to the lack of monitoring data. Most of the Community's surface waters have fair water quality that partially supports designated uses because of turbidity, siltation, salinity, and metals loading from rangeland, agriculture, irrigation return flows, and upstream mining. Information was not available for assessing effects of toxic contaminants and acid rain. There is no information about water quality conditions in wetlands.

Ground Water Quality

Community ground water quality generally complies with EPA's Maximum Contaminant Levels, but concentrations of total dissolved solids often exceed recommended concentrations. However, members of the Community have either adjusted to the aesthetic problem of high dissolved solids or begun purchasing bottled water, as have other ground water users in the metropolitan Phoenix area. Occasionally, concentrations of coliform bacteria, nitrates, and fluoride exceed recommended criteria in isolated wells. Pathogens from onsite sewage disposal systems have been detected in ground water and pose the primary public health concern. Other concerns include salinity and pesticides from large-scale agriculture and potential fuel or solvent leaks.

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Programs to Restore Water Quality

The Gila River Indian Community needs a comprehensive water quality protection program, especially as nearby urban growth and agricultural expansion create additional pollution and place new demands on aquatic resources. As a first step, the Community's Water Quality Planning Office intends to address point sources of pollution through a Ground Water Protection Strategy. The Strategy will seek to eliminate all discharges that could reach ground water or require rapid mitigation if a discharge cannot be avoided. Principles of Arizona's Aquifer Protection Permit Program may serve as a basis for the Community's Strategy, but the Strategy will be streamlined and simple to implement. The Strategy may include technology-based or standards-based protocols for facilities and conditions for land use permits.

Programs to Assess Water Quality

The Community needs monitoring programs for ground water, surface water, and wetlands in order to assess use support and to support a water pollution control program.

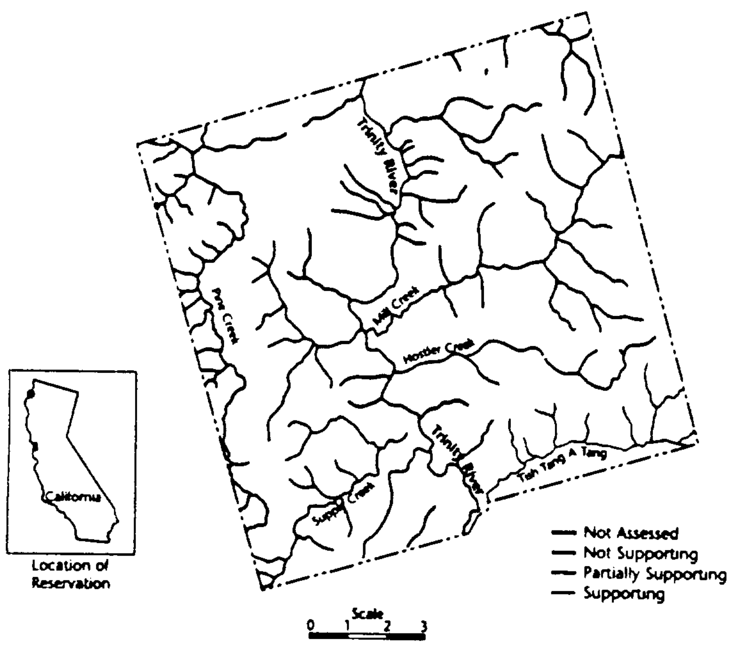
Individual Use Support in Gila River Indian Community

Designated Use[a]	Total Assessed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 196)[b]						
	Total Miles Assessed 196	0	0	31	69	0
	-	-	-	-	-	-
	196	0	0	31	69	0
Lakes (Total Acres = 153)						
	Total Acres Assessed 153	0	0	18	82	0
	153	0	0	0	100	0
	153	0	0	18	82	0

- Not reported.
[a] A subset of Gila River Indian Community's designated uses appear in this figure. Refer to the Community's 305(b) report for a full description of the Community's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

5715

Hoopa Valley Indian Reservation



For a copy of the Hoopa Valley Indian Reservation 1994 305(b) report, contact:

Colleen Goff
P.O. Box 1314
Hoopa, CA 95546
(916) 625-4275

Surface Water Quality

The Hoopa Valley Indian Reservation covers almost 139 square miles in Humboldt County in northern California. The Reservation contains 133 miles of rivers and streams, including a section of the Trinity River, and 3,200 acres of wetlands. The Reservation does not contain any lakes.

Surface waters on the Reservation appear to be free of toxic organic chemicals, but poor forest management practices and mining operations, both on and off the Reservation, have caused significant siltation that has destroyed gravel spawning beds. Water diversions, including the damming of the Trinity River above the Reservation, have also stressed the fishery by lowering stream volume and flow velocity. Low flows raise water temperatures and reduce flushing of accumulated silt in the gravel beds. Upstream dams also stop gravel from moving downstream to replace excavated gravel. Elevated fecal coliform concentrations also impair drinking water use on the Reservation.

Ground Water Quality

Ground water sampling revealed elevated concentrations of lead, cadmium, manganese, iron, and fecal coliforms in some wells. The Tribe is concerned about potential contamination of ground water from leaking underground storage tanks, septic system leachfields, and abandoned hazardous waste sites with documented soil contamination. These sites contain dioxins, herbicides, nitrates, PCBs, metals, and other toxic organic chemicals. The Tribe's environmental consultants are designing a ground water sampling program to monitor potential threats to ground water.

Programs to Restore Water Quality

In 1990, EPA approved the Hoopa Valley Tribe's application for treatment as a State under the Section 106 Water Pollution Control Program of the Clean Water Act. Following approval, the Tribe received Section 106 funding to conduct a Water Quality Planning and Management Program on the Reservation. The Tribal Water Quality Manager is developing water quality criteria for the Reservation, with the help of environmental consultants. The proposed criteria will be reviewed by the Hoopa Valley Planning Department and the Tribal Council.

Programs to Assess Water Quality

In June of 1992, the Tribal Planning Office and its hired consultants sampled eight surface water sites and six ground water sites. The Tribe measured different pollutants at each site, depending on the surrounding land use activities, including conventional pollutants, toxic organic pollutants, metals, and fecal coliforms. The Tribe plans to establish fixed monitoring sites in the near future, which will complement ongoing biological monitoring conducted by the Hoopa Valley Fisheries Department on the Trinity River.

Individual Use Support in Hoopa Valley Indian Reservation

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 133)[b]	Total Miles Assessed					
	77	0	12	88	0	0
	77	100	0	0	0	0
	77	100	0	0	0	0
	77	12	67	21	0	0
Wetlands (Total Acres = 3,200)	Total Acres Assessed					
	3,200	0	0	100	0	0
	-	-	-	-	-	-
	-	-	-	-	-	-
	3,200	0	0	100	0	0

- Not reported

[a] A subset of Hoopa Valley Indian Reservation's designated uses appear in this figure. Refer to the Tribe's 305(b) report for a full description of the Tribe's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

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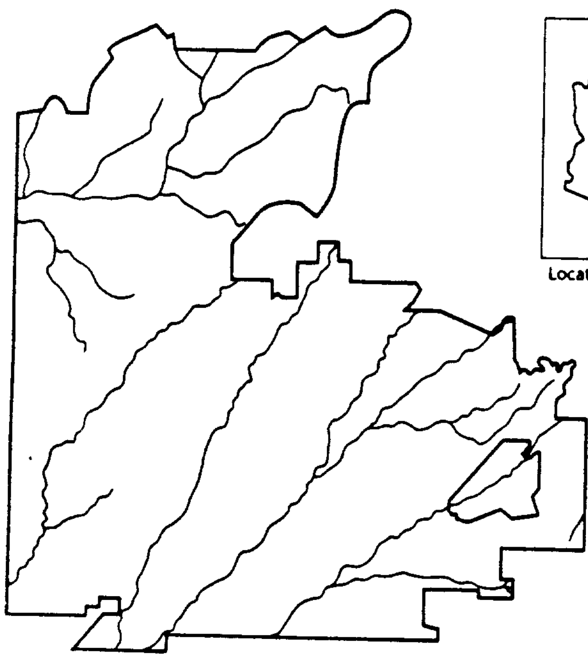
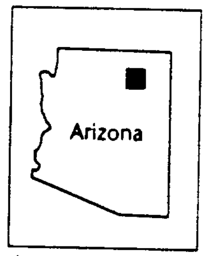
Hopi Tribe





Location of Hopi Tribe

For a copy of the Hopi Tribe's 1994 305(b) report, contact:

Phillip Tuwaletstiwa
The Hopi Tribe
Water Resources Program
Box 123
Kykotsmobi, AZ 86039
(520) 734-9307

Surface Water Quality

The 2,439-square-mile Hopi Reservation, located in northeastern Arizona, is bounded on all sides by the Navajo Reservation. Surface water on the Hopi Reservation consists primarily of intermittent or ephemeral streams. Only limited data regarding stream quality are available. The limited data indicate that some stream reaches may be deficient in oxygen, although this conclusion has not been verified by repeat monitoring.

In addition to the intermittent and ephemeral washes and streams, surface water on the Hopi Reservation occurs as springs where ground water discharges as seeps along washes or through fractures and joints within sandstone formations. The Hopi Tribe assessed 18 springs in 1992 and 1993. The assessment revealed that several springs had one or more exceedances of nitrate, selenium, total coliform, or fecal coliform. The primary potential sources of surface water contamination on the Hopi Reservation include mining activities outside of the Reservation, livestock grazing, domestic refuse, and wastewater lagoons.

Ground Water Quality

In general, ground water quality on the Hopi Reservation is good. Ground water from the N-aquifer provides drinking water of excellent quality to most of the Hopi villages. The D-aquifer, sandstones of the Mesaverde Group, and alluvium also provide ground water to shallow stock and domestic wells, but the quality of the water from these sources is generally of poorer quality than the water supplied by the N-aquifer.

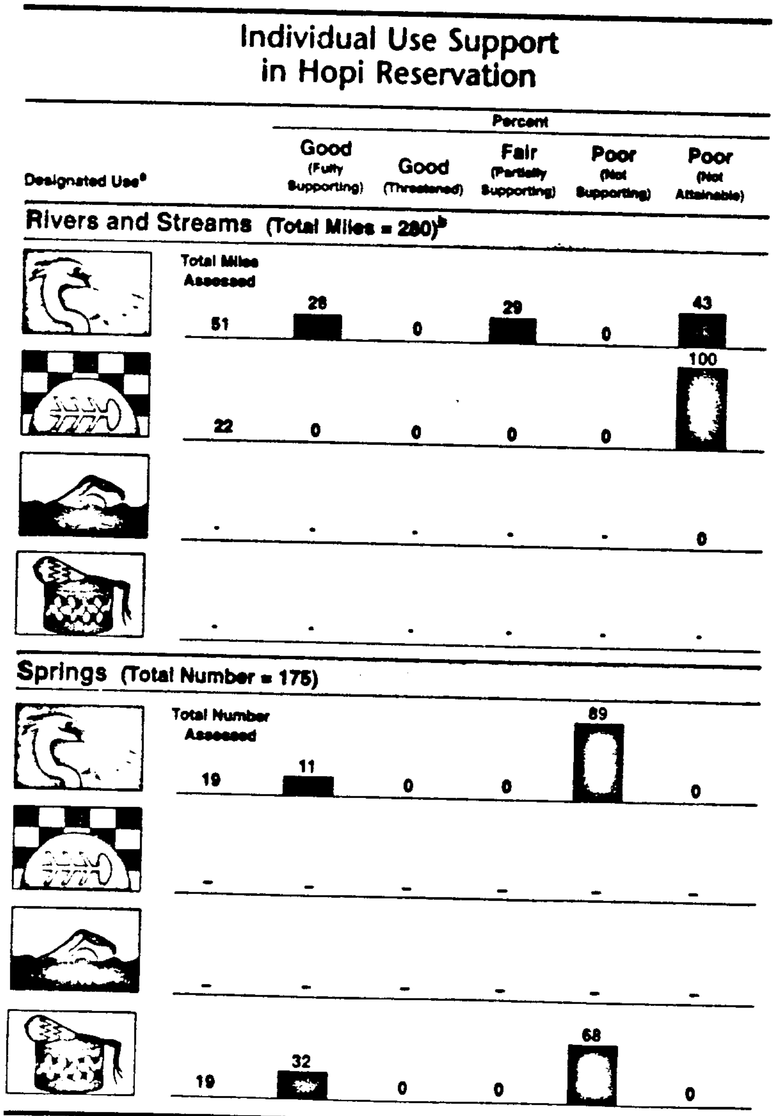
Mining activities outside of the Reservation are the most significant threat to the N-aquifer. Extensive pumping at the Peabody Coal Company Black Mesa mine may induce leakage of poorer quality D-aquifer water into the N-aquifer. This potential problem is being investigated under an ongoing monitoring program conducted by the U.S. Geological Survey. In addition, the U.S. Department of Energy is investigating ground water impacts from abandoned uranium tailings at Tuba City. Other potential sources of contamination in shallow wells include domestic refuse, underground storage tanks, livestock grazing, wastewater lagoons, and septic tanks.

Programs to Restore Water Quality

Draft water quality standards (including an antidegradation policy) were prepared for the Tribe in 1993. The Tribe is also reviewing a proposed general maintenance program to control sewage lagoons. The Tribe has repeatedly applied for EPA grants to investigate nonpoint source pollution on the Reservation, but the applications were denied.

Programs to Assess Water Quality

The Tribe focused on monitoring springs and ground water during the 1994 reporting cycle. Future surface water monitoring will assess aquatic life in springs, lakes, and streams; baseflow and storm flow in streams; and biological, sediment, and chemical content of streams and springs.

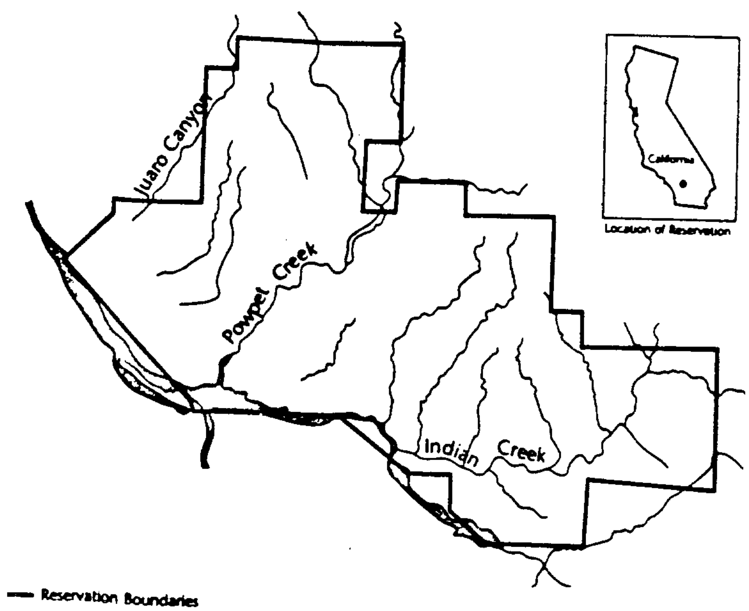


- Not reported

[a] A subset of the Hopi Tribe's designated uses appear in this figure. Refer to the Tribe's 305(b) report for a full description of the Tribe's uses.

[b] Includes nonperennial streams that dry up and do not flow all year.

Soboba Band of Mission Indians



For a copy of the Soboba Band of Mission Indians 1994 305(b) report, contact:

Jamie S. Megee
Soboba Band of Mission Indians
P.O. Box 487
San Jacinto, CA 92581
(909) 654-2765

Surface Water Quality

The Soboba Reservation encompasses about 9.2 square miles in southern California about 80 miles east of Los Angeles. The San Jacinto River is the major surface water feature on the Reservation. At one time, the San Jacinto River flowed year round, but upstream diversions and ground water withdrawals outside of the Reservation have reduced the flow to intermittent status for many years.

The chemical quality of surface water on the Soboba Reservation is excellent and remains unimpaired to date, based on very limited data. The quality of surface water, to the extent it is available, fully supports the existing uses of ground water recharge, wildlife habitat, and recreation. Overall, the greatest threat to water quality on the Soboba Reservation is the reduction of surface flows and ground water storage by off-Reservation diversions and pumping.

Ground Water Quality

Three major water supply wells extract water from two aquifers on the Soboba Reservation. Ground water overdraft outside the Reservation has seriously reduced the withdrawal capacity of the Reservation's wells and aquifers. The chemical quality of ground water on the Soboba Reservation is excellent and remains unimpaired to date. The single most critical threat to water quality is a proposal by the Eastern Municipal Water District to routinely recharge treated effluent at a site within 600 feet of an existing Soboba well.

Programs to Restore Water Quality

There are no formal water pollution control programs in place on the Reservation. However, the Band has achieved compliance with EPA monitoring and treatment requirements for its domestic ground water supply system and the Band is considering development of a wellhead protection program. In addition, the Band is seeking assistance from EPA under the Indian Environmental General Assistance Program to educate the Band about water quality issues, establish water resource protection ordinances, and undertake other water protection initiatives.

The Soboba Band is continuing its struggle to assert and defend its water rights. The Soboba Band has started negotiating with the major water users outside of the Reservation to fairly apportion the waters of the basin. Nondegradation of water quality will be a basic element of the Band's position in these negotiations.

Programs to Assess Water Quality

The Band advocates sharing and cooperative analysis of data on the hydrology and water quality of the San Jacinto watershed to facilitate water rights negotiations. This affirmative approach to water resource management should lead to a systematic, integrated water quality monitoring program for the basin that will benefit all users.

Individual Use Support in Soboba Band of Mission Indians

Designated Use[a]	Total Miles Assessed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 7.4)[b]						
	2.9	100	0	0	0	0
	2.9	100	0	0	0	0
	7.4	100	0	0	0	0

[a] A subset of Soboba Band of Mission Indians' designated uses appear in this figure. Refer to the Band's 305(b) report for a full description of the Band's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

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Barry Burgan, U.S. EPA

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Interstate Commission Summaries

Interstate Commissions provide a forum for joint administration of large waterbodies that flow through or border multiple States and other jurisdictions, such as the Ohio River and the Delaware River and Estuarine System. Each Commission has its own set of objectives and protocols, but the Commissions share a cooperative framework that embodies many of the principles advocated by EPA's watershed management approach. For example, Interstate Commissions can examine and address factors throughout the basin that contribute to water quality problems without facing obstacles imposed by political boundaries. The information presented here summarizes the data submitted by four Interstate Commissions in their 1994 Section 305(b) reports.

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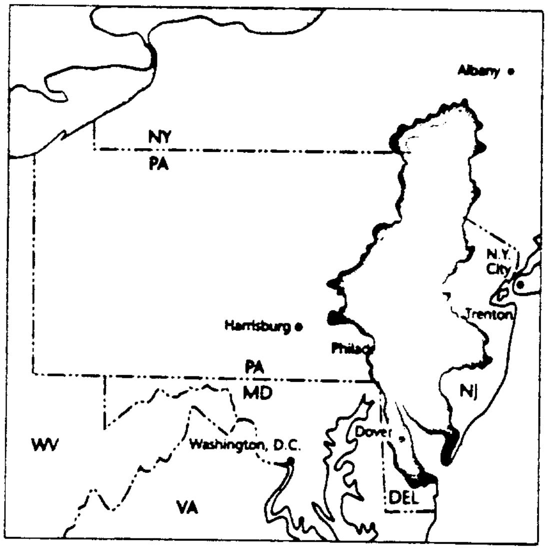
Delaware River Basin Commission



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Delaware River Basin Commission 1994 305(b) report, contact:

Robert Kausch
Delaware River Basin Commission
P.O. Box 7360
West Trenton, NJ 08628-0360
(609) 883-9500, ext. 252

Surface Water Quality

The Delaware River Basin covers portions of Delaware, New Jersey, New York, and Pennsylvania. The Delaware River system consists of a 207-mile freshwater segment, an 85-mile tidal reach, and the Delaware Bay. Nearly 8 million people reside in the Basin, which is also the home of numerous industrial facilities and the port facilities of Philadelphia, Camden, and Wilmington.

All of the riverine waters and 94% of the estuarine waters in the Basin have good water quality that fully supports aquatic life uses. Three percent of the riverine waters do not support fish consumption and 2% have fair quality that partially supports swimming. In estuarine waters, poor water quality impairs shellfishing in 29% of the surveyed waters. Low dissolved oxygen concentrations and toxic contaminants in sediment degrade portions of the lower tidal river and estuary. Fecal coliform bacteria and high pH values impair a few miles of the Delaware River. As of April 1994, fish consumption advisories were posted on about 6 miles of the Delaware River and 22 square miles of the tidal river, cautioning the public to restrict consumption of channel catfish, white perch, and american eels contaminated with PCBs and chlordane.

In general, water quality has improved since the 1992 305(b) assessment period. Tidal river oxygen levels were higher during the critical summer period, residues of toxic chemicals in fish and shellfish declined, and populations of important fish species (such as striped bass and American shad) increased during the 1994 assessment period.

Programs to Restore Water Quality

For many years, the Delaware River Basin Commission and the surrounding States have implemented an aggressive program to reduce point source discharges of oxygen-depleting wastes and other pollutants. These programs will continue, in addition to new efforts to determine the role of stormwater runoff. The Commission also adopted new Special Protection Waters regulations to protect existing high water quality in the upper reaches of the nontidal river from the effects of future population growth and development. The Commission also promotes a comprehensive watershed management approach to coordinate several layers of governmental regulatory programs impacting the Delaware River Basin.

Programs to Assess Water Quality

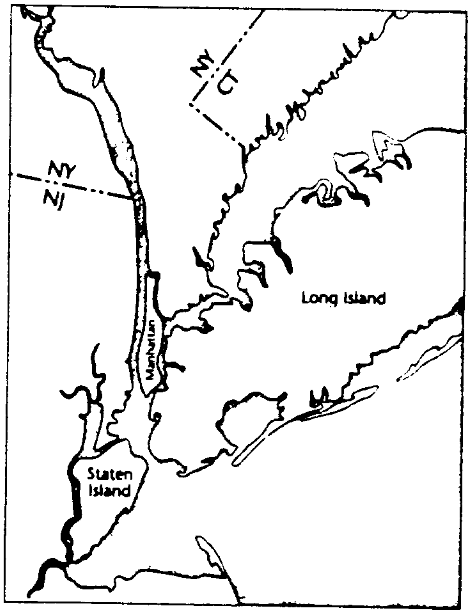
The Commission conducts an intensive monitoring program along the entire length of the Delaware River and Estuary. At least a dozen parameters are sampled at most stations, located about 7 miles apart. The new Special Protection Waters regulations require even more sophisticated monitoring and modeling, such as biological monitoring and continuous water quality monitoring. The Combined Sewer Overflow Study and the Toxics Study will both require additional specialized water quality analyses in order to understand how and why water quality is affected. New management programs will very likely require customized monitoring programs.

Individual Use Support in the Delaware River Basin

Designated Use[a]	Total Miles Assessed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 206)						
	207	86	14	0	0	0
	207	97	0	0	3	0
	207	98	0	2	0	0
Estuaries (Total Square Miles = 866)	Total Square Miles Assessed					
	216	86	8	6	0	0
	216	88	0	0	12	0
	132	71	0	0	29	0
	205	100	0	0	0	0

[a] A subset of the Delaware River Basin Commission's designated uses appear in this figure. Refer to the Commission's 305(b) report for a full description of the Commission's uses.

Interstate Sanitation Commission



— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the Interstate Sanitation Commission 1994 305(b) report, contact:

Howard Golub
Interstate Sanitation Commission
311 West 43rd Street
New York, NY 10036
(212) 582-0380

Surface Water Quality

Established in 1936 by Federal mandate, the Interstate Sanitation Commission (ISC) is a tristate environmental agency of the States of New Jersey, New York, and Connecticut. The Interstate Sanitation District encompasses approximately 797 square miles of estuarine waters in the Metropolitan Area shared by the States, including the Arthur Kill/ Kill Van Kuli, Lower Hudson River, Newark Bay, Raritan Bay, Sandy Hook Bay, and Upper New York Bay.

In general, water quality in the District waters improved during the 1992-1993 reporting cycle. Dissolved oxygen concentrations increased and bacteria densities decreased. The reduction in bacteria is due to the Commission's year-round disinfection regulations (which took effect in 1986), and the elimination of discharges receiving only primary treatment at Middlesex and Hudson Counties.

Topics of concern to the ISC include compliance with ISC regulations, toxic contamination in District waters, pollution from combined sewer overflows, closed shellfish waters, and wastewater treatment capacity to handle growing flows from major building projects.

Ground Water Quality

The ISC's primary focus is on surface waters shared by the States of New Jersey, New York, and Connecticut.

Programs to Restore Water Quality

The ISC actively participates in the Long Island Sound Study, the New York-New Jersey Harbor Estuary Program (HEP), the New York Bight Restoration Plan, and the Dredged Material Management Plan for the Port of New York and New Jersey. The ISC has representatives on the Management Committees and various workgroups for each program. For the HEP, the ISC organized a meeting entitled "Current Beach Closure Practices in New York, New Jersey, and Connecticut: Review and Recommendations" in

November 1993. Representatives of State, county, and municipal health departments and environmental agencies were invited to discuss bathing beach monitoring and closure policies. The public and environmental advocacy groups were also invited. The ISC reported the results to the HEP Pathogens Work Group.

During 1993, the ISC inspected 71 CSO outfalls in an effort to identify and eliminate all dry weather discharges. The ISC notified the States of dry weather discharges detected during field investigations and worked with the States to eliminate dry weather discharges.

Programs to Assess Water Quality

The ISC performs intensive ambient water quality surveys and samples effluent discharged by publicly owned and private wastewater treatment facilities and industrial facilities into District waterways. By agreement, the ISC's effluent requirements are incorporated into the individual discharge permits issued by the participating States.

Individual Use Support in Interstate Sanitation Commission Waters

Designated Use[a]		Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Estuaries (Total Square Miles = 72)	Total Miles Assessed					
	•	•	•	•	•	•
	•	•	•	•	•	•
	•	•	•	•	•	•

[a] A subset of the Interstate Sanitation Commission's designated uses appear in this figure. Refer to the Commission's 305(b) report for a full description of the Commission's uses.
Note: All waters under the jurisdiction of the Interstate Sanitation Commission are estuarine.

Ohio River Valley Water Sanitation Commission (ORSANCO)

— Basin Boundaries
(USGS 6-Digit Hydrologic Unit)

For a copy of the ORSANCO 1994 305(b) report, contact:

Jason Heath
ORSANCO
5735 Kellogg Avenue
Cincinnati, OH 45228-1112
(513) 231-7719

Surface Water Quality

The Ohio River Valley Water Sanitation Commission (ORSANCO) was established in 1948 by the signing of the Ohio River Valley Water Sanitation Compact by Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia. ORSANCO is an interstate agency with multiple responsibilities that include detecting interstate spills, developing waste treatment standards, and monitoring and assessing the Ohio River mainstem. The mainstem runs 981 miles from Pittsburgh, Pennsylvania, to Cairo, Illinois.

The most common problems in the Ohio River are PCB and chlordane contamination in fish and bacteria, pesticides, and metals in the water column. The States have issued fish consumption advisories along the entire length of the Ohio River based on ORSANCO data. ORSANCO also suspects that community combined sewer overflows along the entire length of the river elevate bacteria levels and impair swimming. ORSANCO detected bacteria contamination at all seven monitoring stations downstream of major urban areas with a large number of CSOs.

Copper, lead, and zinc exceeded criteria for protecting warm water aquatic life in waters near the Gallipolis-Huntington area, Cincinnati, Louisville, and the Paducah area. Acid mine drainage is a suspected source of some metals in the Ohio River.

Public water supply use of the Ohio River is impaired by 1,2-dichloroethane near Paducah and by atrazine near Louisville and the mouth of the River at Grand Chain, Illinois. The extent of atrazine contamination is unknown because few sites are monitored for atrazine.

NOTE: A more detailed account of water quality throughout the entire Ohio River Basin is presented in Chapter 12.

Ground Water Quality

ORSANCO does not have jurisdiction over ground water in the Ohio River Basin.

Programs to Restore Water Quality

In 1992, an interagency workgroup developed a CSO program for the Ohio River Basin with general recommendations to improve coordination of State CSO strategies. In 1993, ORSANCO added requirements for CSOs to the Pollution Control Standards for the Ohio River and the Commissioners adopted a strategy for monitoring CSO impacts on Ohio River quality. The Commission also established a Nonpoint Source Pollution Abatement Task Force composed of ORSANCO Commissioners, representatives from State NPS control agencies, and representatives from industries that generate NPS pollution.

Programs to Assess Water Quality

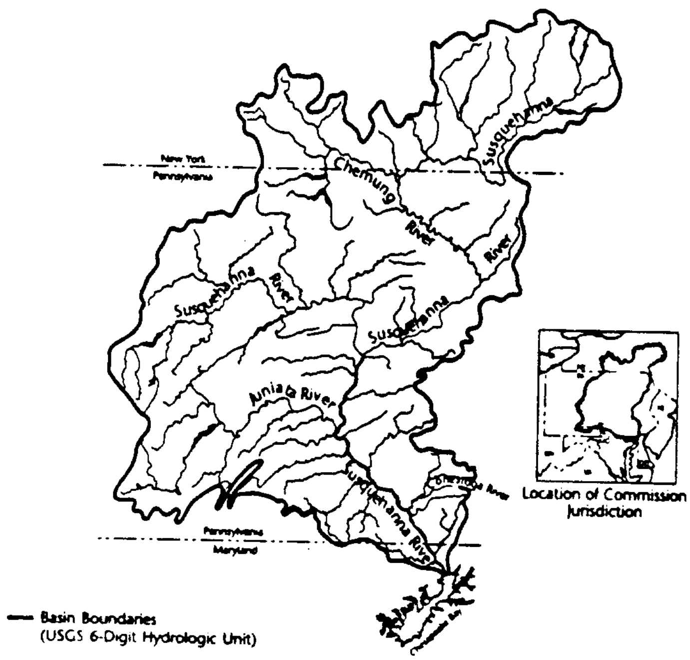
ORSANCO operates several monitoring programs on the Ohio River mainstem and several major tributaries, including fixed-station chemical sampling, daily sampling of volatile organic chemicals at water supply intakes, bacterial monitoring, fish tissue sampling, and fish community monitoring. ORSANCO uses the Modified Index of Well Being (MIwb) to assess fish community characteristics, such as total biomass and species diversity.

Individual Use Support in the Ohio River Valley Basin

Designated Use[a]	Total Miles Assessed	Percent: Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 37,600)[b]						
	981	38	0	62	0	0
	981	0	0	100	0	0
	981	0	0	82	18	0

[a] A subset of ORSANCO's designated uses appear in this figure. Refer to the Commission's 305(b) report for a full description of the Commission's uses.
[b] Includes nonperennial streams that dry up and do not flow all year.

Susquehanna River Basin Commission



For a copy of the Susquehanna River Basin Commission 1994 305(b) report, contact:

Robert E. Edwards
Susquehanna River Basin Commission
Resource Quality Management and Protection
1721 North Front Street
Harrisburg, PA 17102-0423
(717) 238-0423

Surface Water Quality

The Susquehanna River drains 27,510 square miles from parts of New York, Pennsylvania, and Maryland, and delivers over half of the fresh water entering the Chesapeake Bay. The Susquehanna River Basin Commission (SRBC) surveyed 17,464 miles of the 31,193 miles of rivers and streams in the Susquehanna River Basin. Over 90% of the surveyed river miles fully support designated uses, 4% partially support uses, and 6% do not support one or more designated uses. Metals, low pH, and nutrients are the primary causes of stream impacts in the Basin. Coal mine drainage is the source of most of the metals and pH problems degrading streams. Sources of nutrients include municipal and domestic wastewater discharges, agricultural runoff, and ground water inflow from agricultural areas.

During past reporting cycles, SRBC did not conduct any lake or reservoir assessments. However, a 2-year project funded by EPA and Pennsylvania should provide a foundation of lake data upon which SRBC can launch its lake assessment program.

Ground Water Quality

Ground water in the Basin is generally of adequate quality for most uses. Many of the ground water quality problems in the Basin are related to naturally dissolved constituents (such as iron, sulfate, and dissolved solids) from the geologic unit from which the water originates. The SRBC is concerned about ground water contamination from septic systems and agricultural activities.

Programs to Restore Water Quality

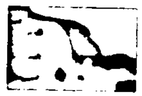
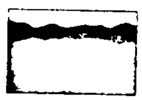
The Susquehanna River Basin Compact assigns primary responsibility for water quality management and control to the signatory States.

The SRBC's role is to provide a regional perspective for coordinating local, State, and Federal water quality management efforts. For example, the SRBC reviews proposed discharge permits (issued by the States) and evaluates potential interstate and regional impacts. The SRBC also recommends modifications to State water quality standards to improve consistency among the States.

Programs to Assess Water Quality

The SRBC's role in interstate and regional issues shaped the Commission's monitoring program. The SRBC's fixed-station monitoring network collects base flow data and seasonal-storm nutrient data on the Susquehanna mainstem and major tributaries to assist the Chesapeake Bay Program in evaluating nutrient reduction projects. The SRBC also established an interstate stream water quality network to evaluate streams crossing State boundaries for compliance with State water quality standards. Biological monitoring is conducted annually at 29 sites. The SRBC also conducts intensive subregional surveys to analyze regional water quality and biological conditions.

Overall[a] Use Support in the Susquehanna River Basin

		Percent				
		Good (Fully Supporting)	Good (Threatened)	Fair (Partially Supporting)	Poor (Not Supporting)	Poor (Not Attainable)
Rivers and Streams (Total Miles = 31,193)[b]						
	Total Miles Assessed 17,464	90	-	4	6	-
Lakes (Total Acres = 79,687)						
	Total Acres Assessed -	-	-	-	-	-

- Not reported.

[a] Overall use support is presented in this figure because the Commission did not report individual use support in their 1994 Section 305(b) report.

[b] Includes nonperennial streams that dry up and do not flow all year.

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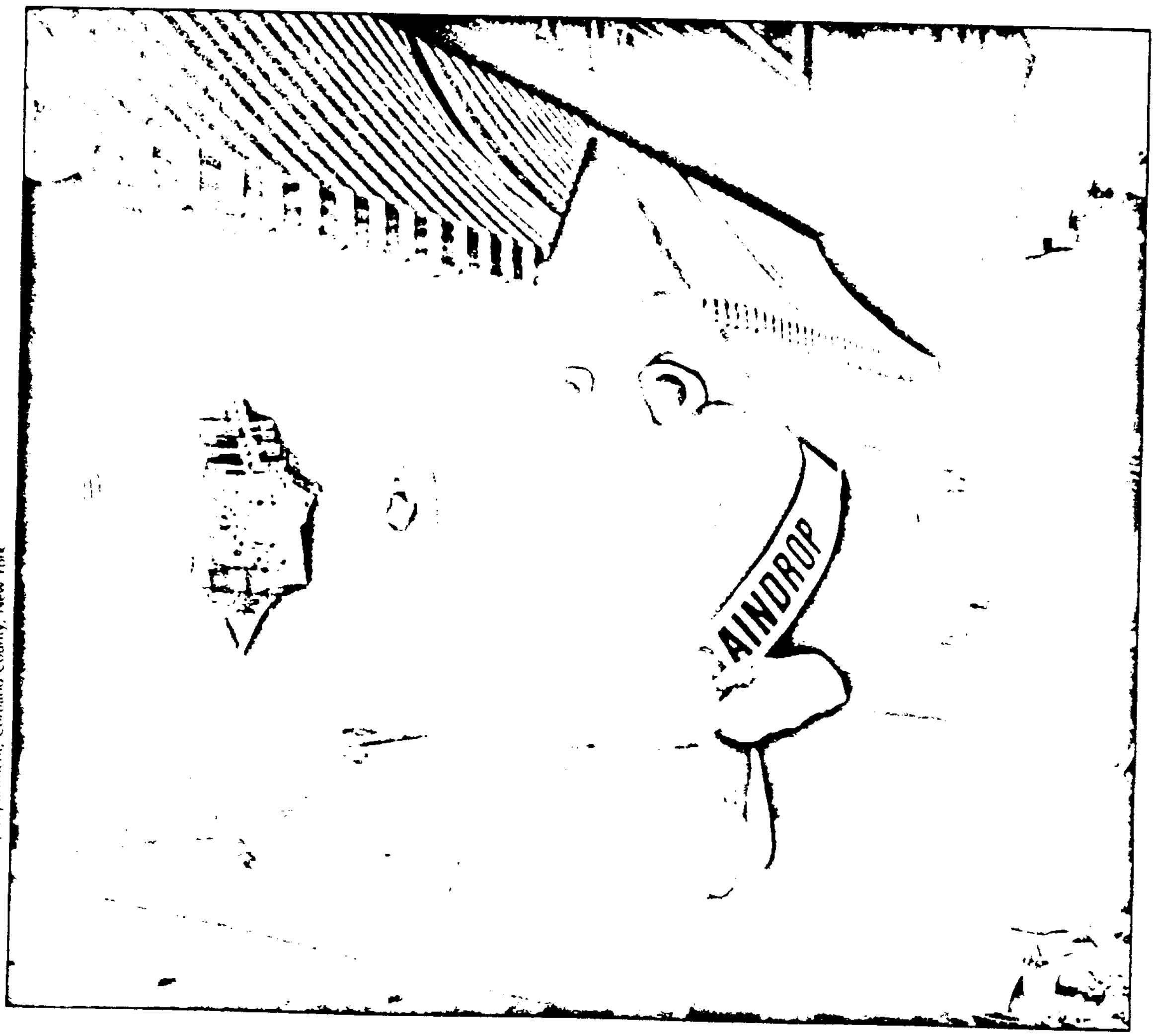

Nancy Mueller, Planning Department, Cortland County, New York

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12

The Watershed Protection Approach and Place-based Management Programs

Watershed Protection Approach

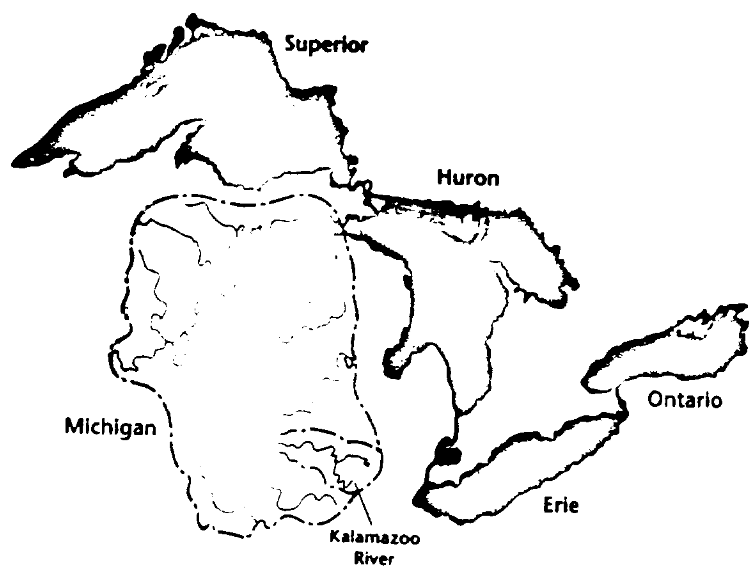
Introduction

The Nation's aquatic resources are among its most valuable assets. Although significant strides have been made in reducing the impacts of discrete pollutant sources, our aquatic resources remain at risk from a combination of point sources and complex nonpoint sources, including air pollution. Since 1991, the EPA has promoted the watershed protection approach as a holistic framework for addressing complex pollution problems.

The watershed protection approach is a place-based strategy that integrates water quality management activities within hydrologically defined drainage basins–watersheds–rather than areas defined by political boundaries. Thus, for a given watershed, the approach encompasses not only the water resource (such as a stream, lake, estuary, or ground water aquifer), but all the land from which water drains to the resource (Figure 12-1). To protect water resources, it is increasingly important to address the condition of land areas within the watershed because water carries the effects of human activities throughout the watershed as it drains off the land into surface waters or leaches into the ground water.

Figure 12-1

Watershed Management Units in the Great Lakes Basin



The watershed protection approach may be applied to watersheds of all sizes. Watershed size varies, depending on the objectives and scope of a watershed initiative. For example, partnerships are developing comprehensive management strategies for the entire Great Lakes Basin, the watershed draining into each Great Lake, and the watersheds draining into individual areas of concern on the Great Lakes, such as the Kalamazoo River watershed. Each level of detail provides additional insight about the factors contributing to complex water quality problems.

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Several key principles guide the watershed protection approach:

■ **Place-based focus** – Resource management activities are directed within specific geographical areas, usually defined by watershed boundaries, areas overlying or recharging ground water, or a combination of both.

■ **Stakeholder involvement and partnerships** – Watershed initiatives involve the people most likely to be affected by management decisions in the decision making process. Stakeholder participation ensures that the objectives of the watershed initiative will include economic stability and that the people who depend on the water resources in the watershed will participate in planning and implementation activities. Watershed initiatives also establish partnerships between Federal, State, and local agencies and nongovernmental organizations with interests in the watershed.

■ **Environmental objectives** – The stakeholders and partners identify environmental objectives (such as "populations of striped bass will stabilize or increase") rather than programmatic objectives (such as "the State will eliminate the backlog of discharge permit renewals") to measure success of the watershed initiative. The environmental objectives are based on the condition of the ecological resource and the needs of people in the watershed.

■ **Problem identification and prioritization** – The stakeholders and partners use sound scientific data and methods to identify and prioritize the primary threats to human and ecosystem health within the watershed. Consistent with the Agency's mission, EPA views ecosystems as the interactions of complex communities that include people; thus, healthy ecosystems provide for the health and welfare of humans as well as other living things.

■ **Integrated actions** – The stakeholders and partners take corrective actions in a comprehensive and integrated manner, evaluate success, and refine actions if necessary. The watershed protection approach coordinates activities conducted by numerous government agencies and nongovernmental organizations to maximize efficient use of limited resources.

EPA's Office of Water envisions the watershed protection approach as the primary mechanism for achieving clean water and healthy, sustainable ecosystems throughout the Nation. The watershed protection approach enables stakeholders to take a comprehensive look at ecosystem issues and tailor corrective actions to local concerns within the coordinated framework of a national water program. The emphasis on public participation also provides an opportunity to incorporate environmental justice issues into watershed restoration and protection solutions.

In May of 1994, the EPA Assistant Administrator for Water, Robert Perciasepe, created the Watershed Management Policy Committee to coordinate the EPA water program's support of the watershed protection approach. During 1995, EPA's water program managers, under the direction of the Watershed Policy Committee, evaluated their programs and identified additional activities needed to support the watershed protection approach in an action plan. The action plans address several broad directions:

- Enhance interagency coordination at the Federal, State, and local levels.

- Build State, Tribal, and Territorial watershed protection capabilities by encouraging States and Tribes to integrate existing programs (such as NPDES Permitting Programs, Section 319 Nonpoint Source Programs, Comprehensive State Ground Water Protection Programs, and State Wetlands Conservation Plans) using comprehensive State, Tribal, and Territorial watershed approaches.

- Develop tools (such as methods, models, criteria, indicators, data management, and monitoring techniques) for implementing the watershed protection approach.

- Provide training on watershed approach concepts and tools.

- Improve coordination within EPA, and streamline program requirements (such as allowing multipurpose planning, funding, and reporting for watershed efforts).

- Reach out to watershed stakeholders by publicizing accomplishments at meetings and conferences and in newsletters and publications.

EPA's Office of Water will continue to promote and support the watershed protection approach. This approach relies on active participation by local governments and citizens who have the most direct knowledge of local problems and opportunities in their watersheds. However, the Office of Water will look to the States, Tribes, and Territories to create the framework for supporting local efforts because most EPA programs are implemented by the States, Tribes, and Territories.

EPA's Office of Water has already taken steps to reorient and coordinate its programs to support the comprehensive watershed protection approach (see the highlight on the NPDES Watershed Strategy). In addition, EPA is supporting watershed management projects across the Nation that coordinate numerous agencies to simultaneously achieve multiple objectives. These projects are implemented by the States with EPA support channeled through various Office of Water programs, including the Section 319 Nonpoint Source Program, the Section 320 National Estuary Program, the Wetlands Grant Program, and the Comprehensive State Ground Water Protection Program (see highlight on the Bear River Project).

The Office of Water will continue to build upon its experience with established place-based programs, such as the Chesapeake Bay Program and the Great Lakes National Program, to eliminate barriers to the watershed protection approach. These integrated programs (described later in this chapter) laid the foundation for the Agency's shift toward comprehensive watershed management and continue to provide models for implementing the "place-based approach" to environmental problem solving.

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The National Pollutant Discharge Elimination System (NPDES) Watershed Strategy

On March 21, 1994, EPA issued the NPDES Watershed Strategy to fully integrate the NPDES permit program into the watershed protection approach. Over the past 20 years, the NPDES program has employed permitting requirements to achieve significant reductions in pollutant discharges to surface waters from industrial and municipal facilities (see Chapter 10 for a full description of the Point Source Control Program). In most cases, the States have assumed responsibility for implementing the NPDES permit program. In recent years, the NPDES program expanded to address remaining sources of pollutant discharges, including combined sewer overflows and storm water discharges. The NPDES Watershed Strategy provides a cost-effective mechanism for addressing the remaining point sources of environmental impacts while maintaining successful control of traditional discharges.

The NPDES Strategy outlines national objectives and implementation activities to (1) integrate NPDES program functions into the broader watershed protection approach, and (2) support development of statewide watershed or basin approaches. The Strategy identifies six essential items that EPA Headquarters and the Regions must support:

- Statewide coordination – promote development of watershed or basin management frameworks that identify the roles and responsibilities of participating programs, long-term programmatic and environmental goals, geographically delineated basins, and a schedule for periodically evaluating the environmental conditions in each basin.

- NPDES permits – encourage States to develop basin management plans that synchronize permit issuance within basins.

- Monitoring and assessment – encourage the States to develop statewide monitoring strategies that coordinate collection and analysis of data with NPDES permit issuance and other management activities within basins.

- Programmatic measures and environmental indicators – revise national accountability measures to facilitate implementation of watershed protection activities and establish new measures of success that reflect progress toward

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achieving watershed protection goals.

■ Public participation – promote long-term public support for basin management activities by providing opportunities for the public to participate in goal development, priority setting, strategy development, and implementation.

■ Enforcement – coordinate compliance and enforcement programs and activities at the Federal, State, Territorial, and Tribal levels to focus resources on priority point sources within identified basins.

The NPDES Watershed Strategy is intended to support ongoing State and Tribal initiatives and supplement the efforts of other environmental programs by identifying areas where the NPDES program can contribute. The Strategy recognizes that the NPDES program may play a central role in a number of watersheds, but point sources will not represent the primary stressors in many watersheds. In such cases, the NPDES program can support and facilitate activities for meeting environmental objectives, such as monitoring and public participation.

Several State and EPA Regions have taken significant steps toward integrating NPDES program activities into the broader watershed protection approach, but the NPDES Watershed Strategy remains largely untapped. To promote implementation at the national level, each EPA Regional Office completed the following action items during FY95:

■ Regional State-by-State Assessments and Action Plans – assess current watershed protection activities in each State and develop Regional action plans that identify how the Region will support and facilitate each State's movement toward the watershed protection approach.

■ State/EPA Workplan Agreements – include specific activities within workplans that will promote the central components of the NPDES Watershed Strategy.

■ Internal Coordination – develop Regional strategies that describe the Regional decision making processes, oversight role, and internal coordination efforts necessary to ensure support for the watershed protection approach.

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Implementing the Watershed Protection Approach on the Bear River, Utah

The Bear River has a 7,600-square mile watershed located in Wyoming, Utah, and Idaho. The Utah Division of Water Resources initiated the project in an effort to resolve major environmental problems:

- Soil erosion, increased sediment loadings, coliforms, and high nutrient loadings due to animal feeding operations, dairies, urban development, roads, oil and gas exploration, and silviculture
- Riparian vegetation removal
- Stream channelization
- Degraded stream channels and streambanks.

Interest in increasing the use of the river as a drinking water source for the growing urban population in the lower basin and along the Wasatch Front prompted the Utah Legislature to enact the Bear River Development Act and fund a Bear River water development and management plan. The effort is to address both water development and water quality issues, with a water quality plan that includes a broad-reaching analysis of pollutant loading to the river as well as chemical, biological, and physical habitat assessments. Because the Bear River encompasses Utah, Wyoming, and Idaho, a regional planning effort has been initiated. The purpose of the regional effort is to share information, coordinate planning efforts, and involve "grassroots" direction and participation. An array of water projects in the Bear River Basin initiated by different organizations and groups are being coordinated through the Bear River Watershed Water Quality Coordination Committee.

For example, the State of Utah, EPA, and the U.S. Department of Agriculture (USDA) initiated a watershed restoration project on the Little Bear River (one of the major tributaries in the basin) using funds from USDA and EPA. The project includes stream channel and riparian habitat restoration, land management, and animal waste treatment actions. Several additional nonpoint source projects are now under way in Wyoming that are aimed at restoring tributary streams that have been impacted by channelization, streambank modification, and riparian habitat loss.

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These "on-the-ground" demonstration projects are helping to generate enthusiasm for more cooperative efforts.

Stakeholders:

- Bear Lake Regional Commission
- Bear River Resource Conservation and Development Council
- Idaho Division of Environmental Quality
- Idaho Fish and Game Department
- Local citizen groups
- Soil Conservation Service
- U.S. Bureau of Land Management
- U.S. Bureau of Reclamation
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Utah Department of Agriculture
- Utah Department of Environmental Quality
- Utah Division of Water Resources
- Utah Division of Wildlife Resources
- Utah Power and Light
- Wyoming Department of Environmental Quality
- Wyoming Game and Fish Department

For further information, contact:

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Place-based Management Programs

Introduction

The programs described in this section (the Great Waterbodies Program, the Great Waters Program, and the National Estuary Program) embody a watershed protection approach at different scales. The Great Waterbodies Program and the Great Waters Program target entire drainage basins, such as the Gulf of Mexico, which drains two-thirds of the continental United States and a large portion of Mexico. The National Estuary Program (NEP) targets clusters of watersheds that drain into a specific estuary, such as Galveston Bay. NEP sites may be nested within a larger basin targeted by the Great Waterbodies or Great Waters Programs, such as the Gulf of Mexico.

Although scales differ, these programs share a common place-based ecosystem approach to solving water quality problems. The ecosystem approach recognizes that all components of the environment are interconnected and that pollution released in one area can cause problems in another. This concept requires all responsible parties to recognize and reduce impacts. Therefore, managing pollution on the ecosystem level requires building institutional frameworks that involve all affected parties, such as agricultural interests, environmental advocacy organizations, industry, government agencies, and private citizens. Consensus is a key to managing pollution on the ecosystem level.

The ecosystem approach also encourages pollution prevention and efforts to avoid actions that can even indirectly lead to contamination of the waterbody. Although such ecosystem perspectives are hardly new, they are more often applied to much smaller units such as watersheds.

The Great Waterbodies Program

Background

The Great Waterbodies Program manages water quality protection in the three largest watersheds targeted by EPA: the Gulf of Mexico, the Great Lakes, and the Chesapeake Bay.

The Gulf of Mexico

Background

The Gulf of Mexico is fed by rivers draining a vast area in five countries. The Gulf's watershed, which covers almost 2 million square miles, is far larger than any other in the Nation. It includes two-thirds of the continental United States, one-half of Mexico, and parts of Canada, Guatemala, and Cuba. Over 1.1 million square miles of the Gulf's watershed are in the Mississippi River drainage system, making the Mississippi the single largest freshwater riverine influence on the Gulf.

The Gulf of Mexico is enormously productive and diverse. Covering 600,000 square miles, the Gulf provides habitat for a majority

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of U.S. migratory waterfowl. Its commercial fisheries produced 1.7 billion pounds of fish, oysters, shrimp, and crabs in 1993, and almost 90% of U.S. offshore oil and gas comes from Gulf waters. Seven of our Nation's busiest ports border its shores, and many nations of the world fish its waters. As a recreational resource, the Gulf and adjacent estuaries provide a playground for sport fishing, diving, water skiing, sailing, swimming, sunbathing, beachcombing, or just plain relaxing.

However, the health and vitality of the Gulf have been declining in recent years, caused in part by increasing populations along its coast and upstream tributaries in the watershed and the growing demand upon its resources and in part by the accumulation of years of careless depletion, abuse, and neglect of its environment. These problems in the Gulf have reduced its ability to regenerate naturally. The result has been alarming damage and destruction of the Gulf's ecosystem and habitats, particularly wetlands and seagrasses. An estimated 50 square miles of Gulf wetlands were lost each year between the mid-1950s and the 1970s. These losses stem from: marine debris, toxic substances and pesticides, coastal and shoreline erosion, nutrient enrichment, alterations in freshwater inflow, nonpoint source runoff, and contaminants from inefficient or nonexistent septic systems. The effects are seen in decreasing populations of waterfowl and marine wildlife, increasing degradation and loss of wetlands and other habitat, and growing threats to human health from environmental pollution.

In response to signs of serious long-term environmental damage throughout the Gulf's coastal and marine ecosystem, the Gulf of Mexico Program (GMP) was established in August 1988 with EPA as the lead Federal agency. The Program Office is located at Stennis Space Center in Mississippi. Its main purpose is to develop and help implement a strategy to protect, restore, and maintain the health and productivity of the Gulf. The GMP is a grass roots program that serves as a catalyst to promote sharing of information, pooling of resources, and coordination of efforts to restore and reclaim wetlands and wildlife habitat, clean up existing pollution, and prevent future contamination and destruction of Gulf resources.

Because of the immense geographical expanse of the Gulf, as well as the numerous, and diverse nature of, environmental threats to it, no one agency has the expertise and authority needed to deal effectively with the vast array of problems that threaten the Gulf. In response to this, the GMP office at Stennis Space Center has evolved into a multiagency organization with staff from the Natural Resources Conservation Service, National Oceanic and Atmospheric Administration/National Marine Fisheries Service, Fish and Wildlife Service, Food and Drug Administration, National Aeronautics and Space Administration, Mississippi Cooperative Extension Service, and Mississippi Soil and Water Conservation Districts. This multi-agency staff assists in directing the organizational and operational strategy of the program on a day-to-day basis to more effectively deal with Gulf issues. In

COMMERCIAL FISHERIES on the Gulf of Mexico produced 1.7 billion pounds of fish and seafood in 1993.

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The goals of the Gulf of Mexico Program are to

- *Protect, restore, and enhance the coastal and marine waters of the Gulf and its natural coastal habitats*
- *Sustain living resources*
- *Protect human health and the food supply*
- *Ensure recreational use of Gulf shores, beaches, and waters in ways consistent with the economic well-being of the region.*

addition, advantages of this staff include a broad-based in-house expertise and a far-reaching networking capability.

The GMP mobilizes Federal, State, and local government; business and industry; academia; and the community at large through programs of public awareness, information dissemination, forum discussions, citizen committees, and technology application. A Policy Review Board and the Management Committee determine the scope and focus of GMP activities. The program also receives input from a Technical Advisory Committee and a Citizen's Advisory Committee. The GMP Office, eight technical issue committees, and the operations and support committees coordinate the collection, integration, and reporting of pertinent data and information.

The issue committees are responsible for documenting environmental problems and management goals, available government and private resources, and potential solutions relating to specific issue areas. The issue committees are composed of individuals from Federal, State, and local agencies and from industry, science, education, business, citizen groups, and private organizations. These committees cover a broad range of issues, including habitat degradation, public health, freshwater inflow, marine debris, coastal and shoreline erosion, nutrient enrichment, toxics and pesticides, and living aquatic resources. They develop and present their findings in GMP documents called Action Agendas, which describe strategies to build upon programs already under way and to develop new cooperative mechanisms with other public and private organizations. The Action Agendas also provide strategies to monitor and assess the effectiveness of ongoing efforts and to communicate information to individuals and agencies that can best use it. Two additional committees provide operational support for public education and outreach and data and information transfer activities for the entire GMP.

Partnership for Action

On December 10, 1992, EPA; the Governors of Alabama, Florida, Louisiana, Mississippi, and Texas; the Chair of the Citizens Advisory Committee; and representatives of 10 other Federal agencies signed a Gulf of Mexico Program Partnership for Action agreement for protecting, restoring, and enhancing the Gulf of Mexico and adjacent lands. The partnership document includes vision and goal statements and nine 5-year challenges for the GMP. The goals established for the Gulf of Mexico Program are to protect, restore, and enhance the coastal and marine waters of the Gulf of Mexico and its natural coastal habitats, to sustain living resources, to protect human health and the food supply, and to ensure the recreational use of Gulf shores, beaches, and waters in ways consistent with the economic well-being of the region.

The 10 environmental challenges commit the signatory agencies to pledge their efforts, over the next 5 years, to obtain the knowledge and resources to

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- Significantly reduce the rate of loss of coastal wetlands
- Achieve an increase in Gulf Coast seagrass beds
- Enhance the sustainability of Gulf commercial and recreational fisheries
- Protect human health and the food supply by reducing inputs of nutrients, toxic substances, and pathogens to the Gulf
- Increase Gulf shellfish beds available for safe harvesting by 10%
- Ensure that all Gulf beaches are safe for swimming and recreational uses
- Reduce by at least 10% the amount of trash on beaches
- Improve and expand coastal habitats that support migratory birds, fish, and other living resources
- Expand public education/outreach tailored for each Gulf Coast county or parish
- Reduce critical coastal and shoreline erosion.

The GMP structure has been streamlined to better meet the needs of the new 5-year environmental challenges. In addition, EPA has restructured its management scheme for the GMP to increase Regional involvement in the program as it moves to implement environmental protection and restoration activities.

The Gulf waters are impacted not only by the United States, but by Mexico and, to a lesser extent, by islands in the Caribbean Sea. The GMP has expanded its activities to provide support to this international community. By promoting Special Area Designation under MARPOL Annex V, the Program has advanced the emplacement of regulations to reduce the discharge of ship-generated waste in the Gulf and Caribbean; the discharge of any plastics is prohibited under Annex V. Additional assistance to Caribbean countries is provided through participation in the United Nations Environmental Programme via their Caribbean Environment Program (CEPPOL) and the Intergovernmental Oceanographic Commission, which focus on addressing land-based sources of pollution for the Caribbean.

The GMP is also advancing technology transfer with Mexico. The Program of Ecology, Fisheries and Oceanography of the Gulf of Mexico (EPOMEX) participates in the GMP's Living Aquatic Resources committee and in other Program activities. EPOMEX is an agency that coordinates the scientific research of institutions of higher education in the areas of the coastal zone and its biological resources and the conservation of the marine environment, coupling science with resource managers and policy makers in the Gulf of Mexico.

Take-Action Projects

During 1992, the GMP launched important environmental projects in each of the five Gulf States to demonstrate that GMP strategies and methods could achieve positive results quickly. Called "Take-Action Projects," they primarily address habitat protection and restoration and public health. They are designed for Gulf-wide application to help restore the environment.

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Water Quality

In Louisiana, Florida, and Alabama, several Take-Action Projects deal with pollution and contaminants from inadequate treatment of human waste—a main cause of damage to Gulf coastal ecosystems and a major concern to public health officials and to the tourism and seafood industries.

- An innovative wastewater treatment system is being monitored in a pilot project near the Port Fourchon/Bay Marchand area of Lafourche Parish, Louisiana. The upwelling injection system filters human wastewater through a sand/soil bed to remove fecal coliforms and enteric viruses—the primary pollutants and contaminants in human waste. The system uses inexpensive, easy to install equipment that has potential use throughout the Gulf's system of rivers and bayous. Monitoring and mathematical modeling will be used to evaluate the improvement of environmental conditions in nearby oyster beds.

- A Take-Action Project is under way in Florida's Suwannee Sound and Appalachicola National Estuarine Research Reserve to upgrade existing septic systems that pollute coastal waters. Contamination from fecal coliforms has required suspension of oyster harvesting and threatened to close beaches. Health officials are monitoring improvements to oyster habitat and recreational uses of coastal waters.

- The use of peat moss as a medium for filtration and biological treatment of household wastewater is being demonstrated in Weeks Bay, Alabama. Use of this raw material and renewable resource as a sewage treatment medium is intended to reduce fecal coliforms in nearby oyster-producing waters.

Pollution Prevention

The State of Mississippi has developed a common sense publication entitled *The Gulf of Mexico Citizens Pollution Prevention Handbook*. Written in nontechnical language, the handbook describes the Gulf of Mexico and explains why it is a valuable resource to our Nation's economy and quality of life. This take-action guide provides a detailed listing of contacts for more information, and it explains specific ways that everyone in the Gulf region can be actively involved in restoring and preserving the environmental quality of the Gulf.

Habitat Protection

Based on a Texas program called Coastal Preserves, a GMP Take-Action Project called Gulf Ecological Management Sites (GEMS), seeks innovative approaches to protect coastal tracts that have been identified as important to the Gulf ecosystem. In some cases, areas may be preserved as wilderness. In others, they would be conserved—that is, carefully monitored and managed to maintain their vitality as wildlife and marine life habitat while being used for hunting, fishing, resource extraction, recreation, or other development. Ideally, these tracts would be under the management and protection of a government agency or established environmental organization.

To promote the concept Gulf-wide, the GMP sponsored a GEMS Workshop in New Orleans to share

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information about the need to protect such areas; to discuss the resources available to help manage, preserve, or conserve them; and to develop a strategy for generating Gulf-wide support and funding for protecting the most valuable of these tracts.

■ Adopting this concept, Mississippi established a Coastal Preserves Program and set aside a donated portion of the Graveline Bayou Estuary. This area has been placed under the protection and management of the State's Department of Marine Resources.

■ Protection of oyster habitat is the goal of a Take-Action Project in Alabama. Oyster beds and reef systems in the shallow waters of Mobile Bay, often harmed unintentionally by boaters and fishermen, have been marked with buoys and signs to help boaters and fishermen avoid damaging them in the future.

Habitat Restoration

The degradation (and in many cases, complete disappearance) of wildlife and marine life habitats is one of the most serious environmental problems of the Gulf ecosystem. Restoration of these habitats is the focus of numerous GMP Take-Action Projects throughout the Gulf Region. Wetlands, reefs, seagrasses, and the quality of the water in these habitats are among the most significant concerns receiving immediate attention.

Seagrass Beds

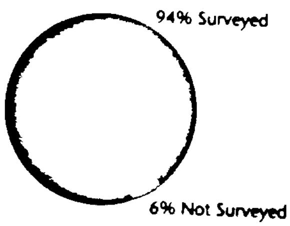
One of several Take-Action Projects in Alabama's Mobile Bay is an innovative program to restore damaged or destroyed seagrass beds—a major habitat for fish, shrimp, and crabs. A new approach being developed is less costly and labor intensive than current methods of transplanting from existing seagrass beds. Seagrasses are germinated from the seeds of wild plants, grown in the natural environment within protected mesh-covered trays, then planted in designated areas where seagrass beds are in decline or are known to have once existed. Low in cost and requiring very little equipment or technical knowledge, this program lends itself extremely well to hands-on participation by concerned citizens and can be easily implemented Gulf-wide.

Salt Marsh Wetlands

Another Take-Action Project in Alabama's Mobile Bay is the restoration of a salt marsh wetland on an abandoned site near the Dauphin Island Sea Lab. A wildlife habitat before the Civil War, this marsh wetland was filled in and used for a number of land uses including grave sites and large septic tank reservoirs. The objective of this project is to accelerate the natural reclamation process of tidal action and provide a model for future manmade marsh and wetlands areas. A team of scientists is carefully monitoring the marsh reconstruction (from initial sloping of the land and planting of marsh and wetlands flora, to rebuilding of the adjacent dune system) and will conduct a long-term evaluation of the habitat's health and development. This "living marsh" will also serve as an outdoor exhibit for the nearby *Estuarium*—a marine sciences museum intended to educate the

Great Lakes Shoreline Miles Surveyed by States and Tribes

1994 ■ 5,224 miles = 94% surveyed
■ Total shoreline miles: 5,559[a]



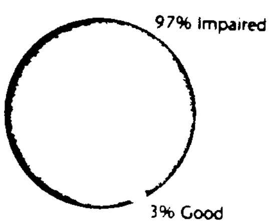
1992 ■ 5,319 miles: 99% surveyed
■ Total shoreline miles: 5,382[b]

1990 ■ 4,857 miles = 94% surveyed
■ Total shoreline miles: 5,169[c]

Of the surveyed Great Lakes shoreline waters:

- 82% were monitored
- 14% were evaluated
- 5% were not specified

Overall Surveyed Water Quality



[a] Source: 1994 State Section 305(b) reports.
[b] Source: 1992 State Section 305(b) reports.
[c] Source: 1990 State Section 305(b) reports.

public about the marine flora and fauna found in the surrounding area.

Oyster Beds

In Louisiana, Florida, and Alabama, the number of oyster reefs that have been closed to harvesting operations has steadily increased in recent years due to bacterial contamination from inadequately treated human waste. The solution is a series of Take-Action Projects to install upgraded septic systems or innovative sewage treatment systems in areas affecting the oyster beds. In a few short years, these low-cost, easy-to-install systems are expected to revitalize oyster habitats and help rebuild associated commercial operations.

■ In Louisiana, the Nation's number one producer of oysters, a take-action project in cooperation with the National Estuary Program targets 240,000 acres of the Barataria-Terrebonne Estuary that contain 68% of the State's private oyster leases—an area increasingly closed to harvesting. Likewise, the oyster-producing areas near Suwannee Sound and Appalachicola Bay (Florida) and Weeks Bay (Alabama) will benefit from similar projects to improve sewage treatment systems.

■ Another Take-Action Project in Alabama's Mobile Bay aims to restore and create oyster habitat with a certain type of Mexican coral taken from dead reef deposits found inland and used to form new living reefs for young oysters to grow on. This first-of-its-kind application of such coral will shorten the time it takes for oyster reefs to form. If successful, it could have far-reaching impacts in reef restoration Gulf-wide.

The Great Lakes Basin

Background: Water Quality in the Great Lakes

Great Lakes water quality is classically divided into two issues: nutrients and toxicants. Together with the Great Lakes States and the Province of Ontario, the United States and Canada have worked to implement a broad strategy to reduce loadings in both categories. In addition, the two countries have acted in acknowledgment of the interrelationship among water quality and many other elements of the ecosystem, including habitat and community structure, and the dynamics of exchange with the atmosphere and sediments.

During the past two decades, the United States and Canada have corrected many of the nutrient enrichment problems in the Great Lakes region that attracted national attention in the 1960s. Since 1970, phosphorus detergent restrictions, municipal sewage treatment plant construction and upgrades, and agricultural practices that reduce runoff have cut the annual phosphorus load into the Great Lakes in half.

The decline in phosphorus loadings is most evident in Lake Erie, which receives more effluent from sewage treatment plants and sediment from agricultural lands than the other Great Lakes. Lake Erie also experienced a concurrent decline in phytoplankton biomass, an indicator of trophic condition and nutrient enrichment. This decline in phytoplankton biomass, accompanied by dramatic improvements in water clarity and greatly reduced occurrences of anoxia in the Lake's eastern basin, provides evidence that the phosphorus controls implemented in the 1970s and 1980s have reversed Lake Erie's severe nutrient enrichment problems of the 1960s.

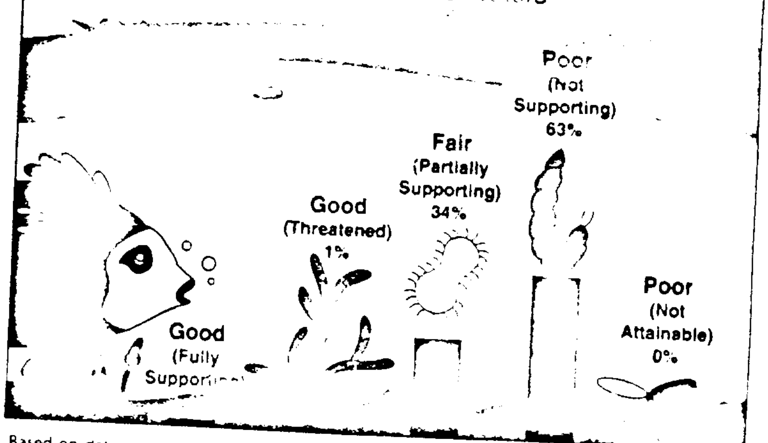
This picture is complicated by the recent invasion by, and profusion of, the zebra mussel, an exotic, or nonnative, species. Its impact is not yet well quantified but is believed to be substantial. The zebra mussel is a very effective filter feeder and is generally thought to have had a profound effect on plankton community structures in Lake Erie and elsewhere in the Great Lakes with concomitant changes in the food chain as energy is rerouted into the benthic (or bottom-dweller) community. Recent invasions of other exotic species, such as the spring water flea (*bythotrephes*) and two species of gobey, combined with introductions of Pacific salmon and the rusty crayfish, have dramatically altered the structure of the Great Lakes' communities.

Despite dramatic declines in the occurrence of algal blooms, fish kills, and localized "dead" zones depleted of oxygen, less visible problems continue to degrade water quality in the Great Lakes. The States report that toxic contamination is the most prevalent and persistent water pollution problem in the Great Lakes. The eight States bordering the Lakes have issued advisories to restrict consumption of fish caught along their entire shorelines. Depending upon location, mercury, PCBs, pesticides, or dioxins are variously found in fish tissues at levels that exceed standards set to protect human health. As a result, virtually all of the waters along the Great Lakes shoreline fail to fully support fish consumption and therefore fail to fully support overall designated uses (Figure 12-2). The levels of most organochlorine contaminants have declined dramatically since control measures began in the mid-1970s. As a result, although the trend seems to be leveling off, concentrations of these contaminants in fish tissue have declined. Toxaphene (or toxaphene-like compounds), however, appears to be running counter to this trend in Lakes Superior and Michigan, where fewer declines and even some increases have appeared. It is not clear, however, whether or not this increase can be attributed to historical use of the pesticide, toxaphene, or if the increase is due to the introduction of a similar compound from an unidentified source.

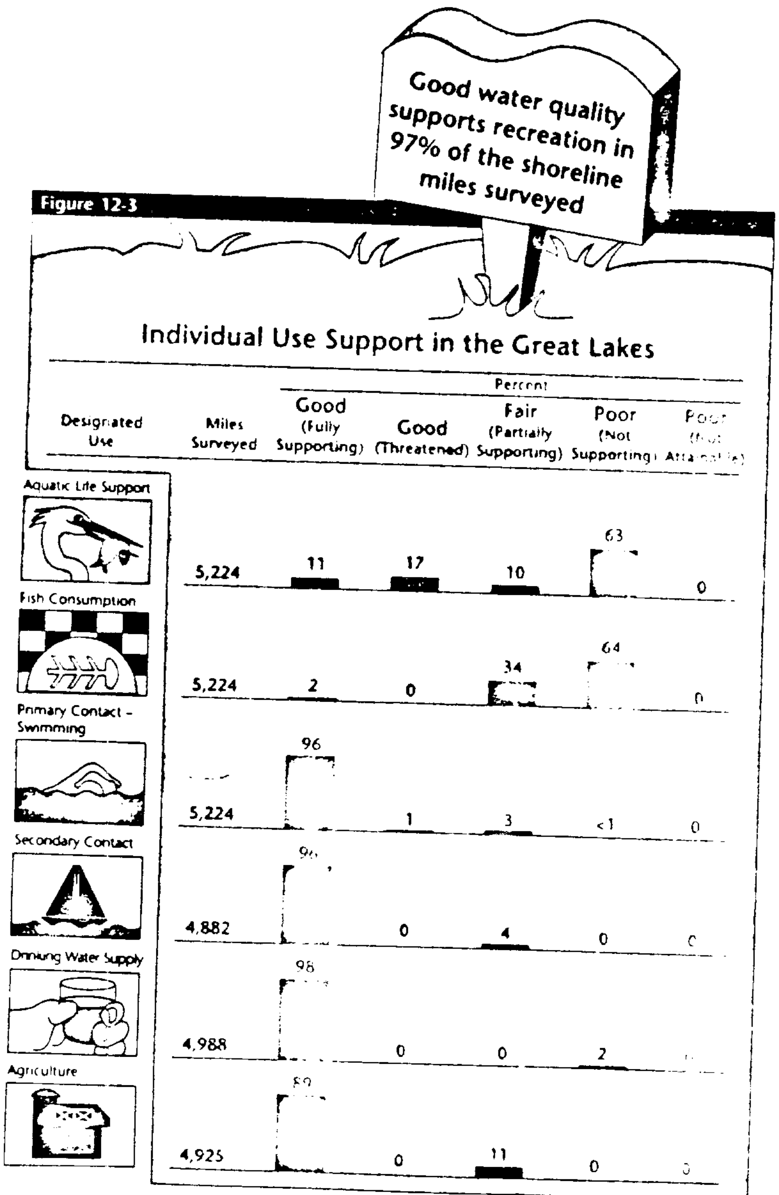
CONSIDERABLE SUCCESS has been had in controlling conventional pollutants and some toxic pollutants, but the Great Lakes are still subject to the effects of other toxic pollutants.

Figure 12-2

Overall Use Support
in Surveyed Great Lakes Shoreline Waters



Based on data contained in Appendix F, Table F-2.



Based on data contained in Appendix F, Table F-3

Efforts are under way by the U.S. EPA and Canada to determine the source of the toxaphene and toxaphene-like compounds. Fish consumption advisories have been issued for the Great Lakes due to apparent "toxaphene."

Although fish consumption use is impaired throughout the Lakes, more than 96% of the Great Lakes shoreline fully supports recreational uses and drinking water supply use (Figure 12-3). However, in the well-publicized outbreak of Cryptosporidiosis in 1993, storm flows carried pathogens from the Milwaukee River uplands well into Lake Michigan, where the pathogens entered the Milwaukee municipal drinking water intake, resulting in over 100 deaths and thousands of illnesses.

The individual use support data submitted by the States indicate that the remaining problems on the Lakes have the greatest impact on fishing activities and aquatic life. Aquatic life impacts include depleted fish populations and reproduction problems in pisciverous (fish-eating) birds (Table 12-1 and box). Aquatic life impacts result from persistent toxic pollutant burdens in birds, habitat degradation and destruction, and competition and predation by nonnative species, such as the zebra mussel and the sea lamprey.

The States reported that priority organic chemicals (primarily PCBs) are the most prevalent cause of impairment in their Great Lakes waters (Figure 12-4). These toxic chemicals persist in fish tissues, wildlife tissues, and sediment. The States reported much lower incidences of metal contamination, depressed

Trends in PCB Contamination in the Great Lakes

Research conducted by the United States and Canada in the Great Lakes indicates that PCB concentrations in wildlife have declined dramatically since the EPA banned most uses of PCBs in 1976. However, the PCB concentrations in fish persist well above concentrations set to protect public health, and the persistent PCB burdens in some fish, mammals, and birds still may impair reproductive success. For example, concentrations of PCBs in Lake Michigan lake trout declined by about 90% since 1970, but remain at about 180 times the target goal of 0.014 parts per million. Similarly, body burdens of PCBs in a colony of Forster's terns near Green Bay, Wisconsin, declined by 66% while hatching success tripled between 1983 and 1988. However, the terns' offspring continued to suffer "wasting" and other fatal health problems, which may have resulted from the contaminant burdens in the adult birds. For additional information, see D. De Vault, D.M. Whittle, and S. Rang, *Toxic Contaminants in the Great Lakes*, SOLEC Working Paper presented at State of the Lakes Ecosystem Conference, Chicago, IL (EPA 905-D-94-001a, October 1994).

Table 12. Effects of Toxic Contamination on Fish and Wildlife in the Great Lakes

Species	Population Decrease	Effects on Reproduction	Eggshell Thinning	Birth Defects	Behavioral Changes	Biochemical Changes	Mortality
Mink	X	X	NA	NE	NE	NE	X
Otter	X		NA	NE	NE	NE	?
Double-crested Cormorant	X	X	X	X		X	?
Black-crowned Night Heron	X	X	X	X		X	?
Bald Eagle	X	X	X	NE		NE	NE
Herring Gull		X	X	X	X	X	X
Ring-billed Gull				X		NE	X
Caspian Tern		X		X	NE	NE	
Common Tern		X	X	X		X	
Forster's Tern		X		X	X	X	
Snapping Turtle	NE	X	NA	X	NE	NE	NE
Lake Trout		X	NA			X	
Brown Bullhead			NA NA			X X	
White Sucker			NA	X		X	

X = Effects documented.
NA = Not applicable
NE = Not examined.
? = Suspected because population declined.

NOTE: Unpublished records of gross birth defects exist for the double-crested cormorant, great blue heron, and the Virginia rail.

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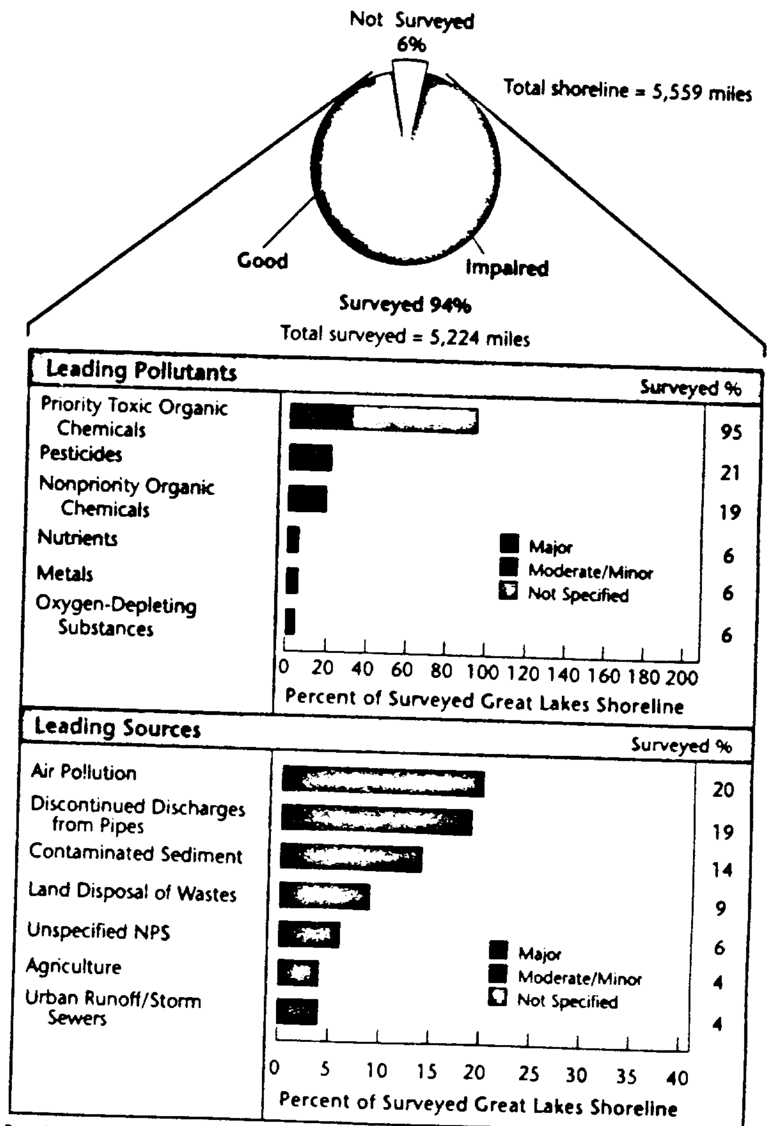
Figure 12-4

SURVEYED Great Lakes Shoreline: Pollutants and Sources



Based on data contained in Appendix F, Tables F-4 and F-5.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a segment of shoreline.

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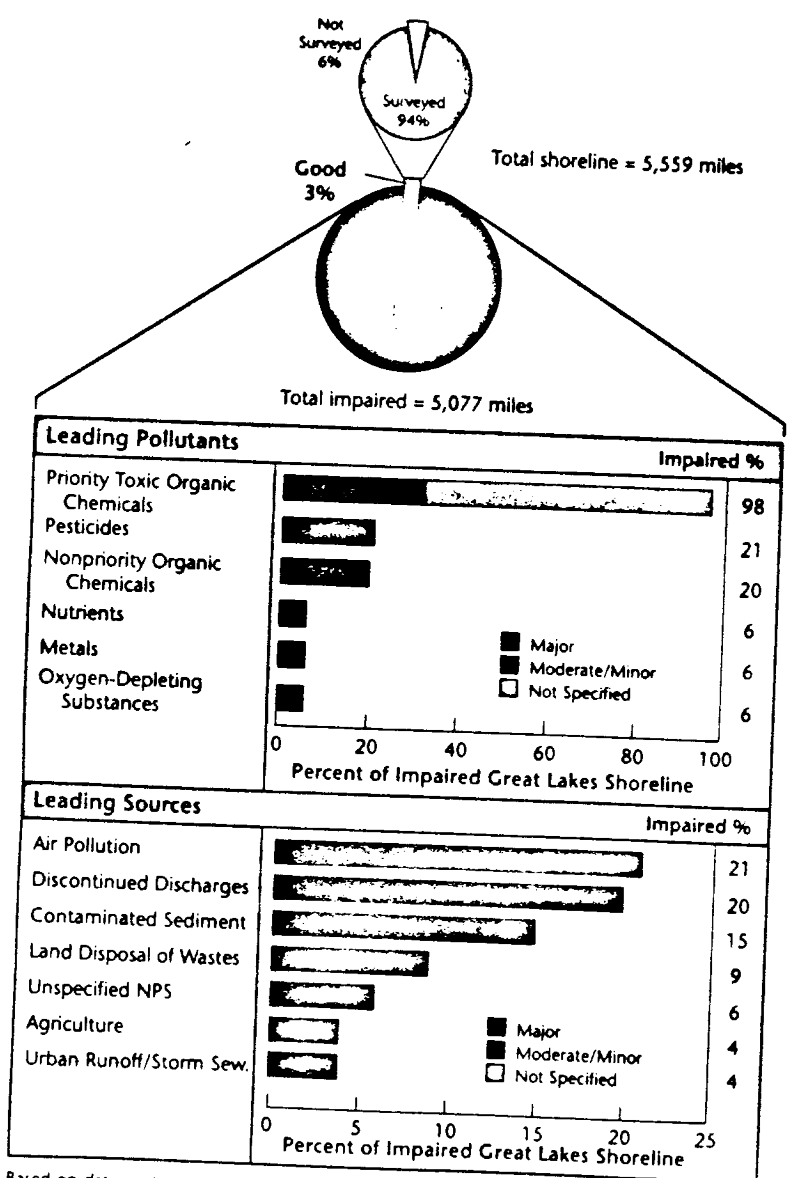
Figure 12-5

IMPAIRED Great Lakes Shoreline: Pollutants and Sources



Based on data contained in Appendix F, Tables F-4 and F-5.

PRIORITY TOXIC ORGANIC CHEMICALS are the most common pollutants affecting surveyed Great Lakes shoreline waters. Water quality problems from these toxic chemicals

- are found in 95% of all Great Lakes shoreline waters, and
- constitute 98% of all water quality problems.

Note: Percentages do not add up to 100% because more than one pollutant or source may impair a segment of shoreline.

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oxygen conditions, and nutrient pollution.

Only four of the eight Great Lakes States measured the size of their Great Lakes shoreline polluted by specific sources. These States have jurisdiction over one-third of the Great Lakes shoreline, so their findings do not necessarily reflect conditions throughout the Great Lakes Basin (Figure 12-5).

- Wisconsin identified air pollution and discontinued discharges as sources of pollutants contaminating all 1,017 of their surveyed shoreline miles. Wisconsin also identified smaller areas impacted by contaminated sediments, nonpoint sources, industrial and municipal discharges, agriculture, urban runoff and storm sewers, combined sewer overflows, and land disposal of waste.

- Indiana attributed all of the pollution along its entire 43-mile shoreline to air pollution, agriculture, and industrial and municipal discharges.

- Ohio reported that nonpoint sources pollute 86 miles of its 236 miles of shoreline, in-place contaminants impact 33 miles, and land disposal of waste impacts 24 miles of shoreline.

- New York identified many sources of pollutants in their Great Lakes waters, but the State attributes the most miles of degradation to contaminated sediments (439 miles) and land disposal of waste (374 miles).

Building Institutional Frameworks for the Great Lakes

Rehabilitating the Great Lakes requires cooperation from numerous organizations because pollutants originate in both Canada and the United States as well as other countries, and pollutants enter the Lakes via multiple media (i.e., air, ground water, and surface water). The International Joint Commission (IJC), established by the 1909 Boundary Waters Treaty, lays the foundation of the institutional framework for managing the Great Lakes. Under the auspices of that Treaty, the United States and Canada signed the Great Lakes Water Quality Agreement in 1978 (see further discussion on page 322). Representatives from the Governments of the United States and Canada, the Province of Ontario, and the eight States bordering the Lakes sit on the IJC's Water Quality Board.

The IJC Water Quality Board makes recommendations to the United States and Canada regarding actions needed to maintain the integrity of the Great Lakes ecosystem. It provides various platforms for addressing Great Lakes issues. The Board also monitors and reports upon the progress of the two nations in meeting their commitments under the Agreement and evaluates and comments upon their environmental policies and actions.

The EPA Great Lakes National Program Office (GLNPO) coordinates activities within the United States at all government levels, working with nongovernment organizations to protect and restore the Lakes. One vehicle for this coordination is the *Joint Federal/State*

5-Year Strategy (1992-97) for Protecting the Great Lakes. GLNPO provides additional leadership through its annual *Great Lakes Program Priorities and Funding Guidance.* It also serves as a liaison and provides information to the Canadian members of the IJC and the Canadian counterparts to the EPA. GLNPO is responsible for direct negotiations and cooperation with Canadian Federal agencies through the Binational Executive Committee.

The Great Lakes States and the Federal agencies work together to provide a broad range of routine monitoring of the Lakes and their basin. The States and U.S. Geological Survey perform most tributary monitoring, and State agencies and the U.S. Fish and Wildlife Service, together with the National Biological Service, collect tributary and open Lakes fish for contaminant monitoring. GLNPO conducts essentially all the United States' open Lakes water quality and sediment monitoring and carries out contaminant analyses on fish sampled by other agencies. It also carries out, and is the primary funding source for, major special studies, such as those for mass balance of Lake Michigan and Green Bay.

The Great Lakes governors have worked together on a number of common issues over the years. For example, the Great Lakes Protection Fund was formed by the Great Lakes Governors in 1989. The mission of the Fund is to identify, demonstrate, and promote regional action to enhance the health of the Great Lakes ecosystem. It is the Nation's first multistate environmental endowment. The Great Lakes States have pledged $100 million to its permanent endowment.

Public-private partnerships support the institutional framework for managing the Great Lakes water quality. Special boards, commissions, and committees composed of representatives from universities, environmental organizations, agricultural interests, industry, shipping interests, and government play vital roles in coordinating policy and management decisions. Some of these groups focus on local areas and issues, while others represent national organizations. To better coordinate their activities on the Great Lakes Basin, groups have begun to support umbrella organizations, such as Great Lakes United. Great Lakes United, started in 1982, represents more than 180 affiliated groups in the United States and Canada. One of its goals is to facilitate citizen involvement in decision making processes. Other Great Lakes environmental organizations have a specific geographic focus, such as the Lake Michigan Federation, or concentrate on a narrower topical area, such as the Tip of the Mitt Watershed Council, which primarily addresses land use issues (especially wetlands issues).

The Great Lakes Commission is a binationally chartered independent organization that integrates environmental concerns with economic development concerns. The Commission's members are appointed by the States, Canadian Provinces, and both Federal governments. The members issue reports on subjects such as the environmental impacts of transportation options in the Great Lakes Region. The reports provide data for decision-making by the government bodies with authority to manage the Lakes. The Commission is working under a

The 1978 Great Lakes Water Quality Agreement (GLWQA), as amended in 1987, established a commitment by the United States and Canada to restore and protect the Great Lakes.

cooperative agreement with GLNPO to operate the Great Lakes Information Network (GLIN), an Internet Server. The GLIN provides a major outlet and source for Great Lakes environmental information.

Private conservation groups are also working with government agencies to protect natural areas in the Great Lakes Basin. GLNPO is funding 69 restoration and protection projects based, in part, on findings of the Great Legacy Project. The Great Legacy Project, sponsored to a considerable extent by GLNPO, includes efforts by the Nature Conservancy of Canada and the United States and other conservation groups to pool natural heritage data from several public agencies and land trusts and to apply geographic targeting approaches to identify particularly high-quality resource areas. Since 1992, GLNPO has instituted and formalized a competitive process to select high-priority on-the-ground habitat protection, restoration, and remediation projects.

In 1994, GLNPO completed a statutory 6-year mandate, the Assessment and Remediation of Contaminated Sediments (ARCS) Program, working with academic, commercial, State, and local experts to develop and test new sediment remediation technologies. In both the habitat and sediment remediation arenas, it has organized significant training events and conferences to benefit both the public and private sectors.

In the fall of 1994, GLNPO and its Canadian counterpart in Environment Canada, together with the eight Great Lakes States, the Council of Great Lakes Industries, environmental groups, and the Province of Ontario, convened a partnered endeavor to provide all sectors of the Great Lakes community with a synopsis of the state of knowledge on the Great Lakes ecosystem. This effort took two forms: the State of the Lakes Ecosystem Conference, a major conference for senior environmental managers, and a set of six peer-reviewed draft topical papers and an integration paper. The papers were presented at the conference and designed to provide a comprehensive snapshot of the condition of the Lakes' ecosystems.

They provided a starting point for a series of topical and Lake-by-Lake discussions that became a framework for interaction and communication among disparate and sometimes traditionally opposed sectors.

The draft papers are posted on the Internet GLIN server for public access and comment. Comments from attendees and the Great Lakes community provided a final level of review prior to publication in mid-1995. The conveners of the State of the Lakes Ecosystem Conference worked with the authors to incorporate discussion and commentary into the final papers.

The Great Lakes Water Quality Agreement

The 1978 Great Lakes Water Quality Agreement (GLWQA), as amended in 1987, established a commitment by the United States and Canada to restore and protect the Great Lakes. The Amendments to the Agreement stress two central concepts: (1) the ecosystem approach, and (2) the virtual elimination of persistent toxic substances. The Agreement set a limited number of ecosystem-based objectives for water quality, biota, habitat, and beneficial uses of the Lakes. The Agreement also institutionalized the Areas of Concern concept as well as commitments to develop Remedial Action Plans and Lakewide Management Plans to address Great Lakes problems.

Although there has been considerable progress in addressing impacts from point and nonpoint loadings of conventional pollutants under the GLWQA, the Great Lakes are still highly vulnerable to toxic pollutants. The IJC released a set of recommendations identifying 11 "critical pollutants" for which management scrutiny is warranted throughout the Basin. These chemicals and possible sources are presented in Table 12-2.

The Great Lakes Water Quality Initiative

The Great Lakes Water Quality Initiative (GLWQI) is a key element of the environmental protection efforts undertaken by the United States in the Great Lakes Basin. The purpose of the Initiative is to provide a consistent level of protection in the Basin from the effects of toxic pollutants. This will further the national goal to restore, maintain, and protect the waters of this particularly valuable and sensitive ecosystem.

On March 23, 1995, EPA published *Water Quality Guidance for the Great Lakes System* in the *Federal Register* (60 CFR 15366). EPA issued the Guidance under the terms of the Great Lakes Critical Programs Act of 1990. Now that the Guidance is available, the next step is for the States and Tribes to incorporate provisions consistent with the Guidance into their laws and regulations within 2 years.

Foundations

The GLWQI was organized by EPA at the request of the Great Lakes States in 1989. State governors had signed an agreement in 1986 to promote consistency in their environmental programs for the Great Lakes Basin. At the same time, the governors had requested that EPA facilitate these efforts to promote consistency, and, in 1989, the Council of Great Lakes Governors unanimously reaffirmed their participation in the GLWQI, with U.S. EPA Region 5 (Chicago, IL) taking the lead role.

The Initiative provided a forum for a regional dialogue to establish minimum requirements that would reduce disparities between State water quality controls in the Great Lakes Basin. The scope of the Initiative included development of proposed Great Lakes water quality guidance for Great Lakes-specific water quality criteria and methodologies to protect aquatic life, wildlife, and human health; procedures to implement water quality criteria; and an antidegradation policy.

Organization and Process

The open dialogue used in the Initiative was exemplary and is a model for the future. Three committees were formed to carry out the Initiative:

- A Steering Committee (composed of directors of water programs in the Great Lakes States' environmental agencies and EPA's National and Regional Offices)

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Chemical	Production and Release	Source
2,3,7,8-TCDD (dioxin) and 2,3,7,8-TCDF (furan)	Unintentional	Contaminant in herbicides used in agriculture, range, and forest management. Also produced as a byproduct of combustion of fossil fuels and waste incineration and through production of pentachlorophenol (PCP) and pulp and paper production processes. 2,3,7,8-TCDD is the most toxic of 75 congeners (forms) of dioxin, and 2,3,7,8-TCDF is the most toxic of 135 congeners of furan.
Benzo[*a*]pyrene (b[*a*]p)	Unintentional	Product of incomplete combustion of fossil fuels and wood, including forest fires, grills (charcoal broiling), auto exhaust, and waste incineration. One of a large family of polynuclear aromatic hydrocarbons (PAHs).
DDT[a] and its breakdown products (including DDE)	Intentional[d]	Insecticide; used heavily for mosquito control in tropical areas. Banned for use in the U.S. and Canada with some exceptions for gypsy moth control. Once used extensively in North America and worldwide.
Dieldrin[a]	Intentional[d]	Insecticide used extensively at one time, especially on fruit.
Hexachlorobenzene (HCB)	Unintentional	Byproduct of combustion of fuels and waste incineration and of manufacturing processes using chlorine. Found as a contaminant in chlorinated pesticides.
Alkylated lead	Intentional	Used as a fuel additive and in solder, pipes, and paint.
	Unintentional	Released through combustion of fuel, waste, and cigarettes, and from pipes, cans, and paint chips.
Mirex[b]	Intentional[d]	Fire retardant; pesticide used to control fire ants. Breaks down to more toxic form, photomirex, in presence of sunlight.
	Unintentional	Present sources are residuals from manufacturing sites, spills, and land disposal.
Mercury	Intentional	Used in metallurgy, batteries, thermometers, electrical switches, and disinfectants.
	Unintentional	Byproduct of chlor-alkali, gold mining, paint, and electrical equipment manufacturing processes. Also occurs naturally in soils and sediments. Releases into the aquatic environment may be accelerated by sulfate deposition (i.e., acid rain) and leaching from landfills.
Polychlorinated biphenyls (PCB)[c]	Intentional[d]	Insulating fluids used in electrical capacitors and transformers and in the production of hydraulic fluids, lubricants, and inks. Was previously used as a vehicle for pesticide dispersal. PCBs comprise a family of 209 congeners of varying toxicity.
	Unintentional	Primarily released to the environment through leakage, spills, and waste storage and disposal. Leaches from soil and sediment deposits.
Toxaphene[a]	Intentional[d]	Insecticide used on cotton. Substitute for DDT. Use in Great Lakes Basin not documented, but the presence of toxaphene in the Great Lakes raised the issue of long-range transport, or atmospheric deposition. Efforts are under way by EPA and Canada to identify the sources of the increased levels of toxaphene and toxaphene-like compounds.

[a] Use restricted in the United States and Canada.

[b] Banned for use in the United States and Canada.

[c] Manufacture and new uses prohibited in the United States and Canada.

[d] The intentional production and release of the chemical occurred, for the most part, prior to the issuance of bans and restrictions that currently limit the use of the chemical in the United States and Canada.

discussed policy and scientific and technical issues, directed the work of the Technical Work Group, and ratified final proposals.

- The Technical Work Group (consisting of technical staff from the Great Lakes States' environmental agencies, EPA, the U.S. Fish and Wildlife Service, and the National Park Service) prepared proposals on elements of the Guidance for consideration by the Steering Committee.

- The Public Participation Group (consisting of representatives from environmental groups, municipalities, industry, and academia) observed the deliberations of the other two committees, advised them of the public's concerns, and kept its various constituencies apprised of ongoing activities and issues.

From the start, one of the Committees' goals was to develop the Guidance elements in an open public forum, drawing upon the extensive expertise and interest of individuals and groups within the Great Lakes community.

Great Lakes Critical Programs Act

The Initiative efforts were well under way when Congress enacted the Great Lakes Critical Programs Act of 1990 to amend the Clean Water Act. The general purpose of these amendments was to improve the effectiveness of EPA's existing programs in the Great Lakes. The Act required EPA to publish proposed and final water quality guidance that specifies minimum requirements for waters in the Great Lakes System in three areas: (1) water quality standards (including numerical limits on pollutants in ambient Great Lakes waters to protect human health, aquatic life, and wildlife; (2) antidegradation policies; and (3) implementation procedures.

The Act also requires the Great Lakes States to adopt provisions in their programs that are consistent with the final Guidance within 2 years of EPA's publication. In the absence of such action, EPA is required to promulgate any necessary requirements within that 2-year period. In addition, Indian Tribes authorized to administer an NPDES program or water quality standards program in the Great Lakes Basin will also need to adopt provisions consistent with the final Guidance into their water programs.

To carry out the Act, EPA proposed regulations for implementing the Guidance on April 16, 1993, and invited comment from the public. States and EPA conducted public meetings in all the Great Lakes States during the comment period, including two EPA public meetings. As a result, EPA received over 26,500 pages of comments from over 6,000 commenters. EPA reviewed all of this information in developing the final Guidance that was published in March of 1995.

Conclusion

The final Guidance represents a milestone in efforts by Great Lakes stakeholders to define and apply innovative and comprehensive environmental programs for protecting and restoring the Great Lakes. In particular, the publication of the final Guidance culminates 6 years of intensive cooperative effort that included participation by the eight Great Lakes States, the environmental community, academia, industry, municipalities, and EPA regional and national Offices.

The final Guidance will help establish consistent, enforceable, long-term protection with respect to all types of pollutants, but will place short-term emphasis on the types of long-lasting pollutants that accumulate in the food web and pose a threat to the Great Lakes System. The Initiative Committees devoted considerable effort to identifying such chemicals—persistent bioaccumulative pollutants termed "bioaccumulative chemicals of concern" (BCCs)—and developing the most appropriate criteria, methodologies, policies, and procedures to address them. The special provisions for BCCs, initially developed by the Initiative Committees and incorporated into the final Guidance, include antidegradation procedures to minimize future problems; general phaseout and elimination of mixing zones for BCCs (except in limited circumstances) to reduce their overall loadings to the Lakes; more extensive data generation requirements to ensure that BCCs are not underregulated for lack of data; and development of water quality criteria that will protect wildlife that feed on aquatic prey.

The GLWQI also supports more comprehensive management plans for the Great Lakes envisaged by the Great Lakes Water Quality Agreement of 1987 between the United States and Canada. Lakewide Management Plans (LaMPs) for each Great Lake and Remedial Action Plans (RAPs) for each of 42 Great Lakes "Areas of Concern" are under development by EPA, the States, local governments, and Canada. The GLWQI contributes to the implementation of all of these efforts because it defines levels of protection needed for any pollutant that might threaten the Great Lakes.

The GLWQI represents a partnership between the States and Federal government to protect this unique national resource. EPA is currently providing technical assistance to the States. Over the past 20 years great progress has been made to improve the quality of water in the Great Lakes, and the GLWQI represents a further step in ensuring the health and quality of the Great Lakes in the future.

Remedial Action Plans for Areas of Concern

Implementing control measures for pollutants usually begins in smaller drainages and waterbodies. At the smallest geographic scale, the IJC initially identified 42 Areas of Concern (AOCs) located primarily along river mouths or harbors where beneficial uses were impaired. Altogether, the IJC identified 14 types of use impairment ranging from limitations on use of water for commerce to fish consumption restrictions, reproductive problems among wildlife, and restrictions on disposal of dredged sediments.

The United States later designated Presque Isle Bay (in Pennsylvania) as the 43rd AOC, but Canada delisted Collingwood Harbor (in Ontario), returning the total number of AOCs to 42. The United States and Canada designated all 42 as AOCs, all of which face major toxics concerns. Thirty-five of the 42 AOCs report toxics concerns in ambient water, 41 of 42 report toxics in sediments, and 38 of 42 AOCs restrict consumption of fish harvested from local waters because of elevated toxic concentrations in fish tissues.

In 1985, the Great Lakes States and the Canadian Provinces agreed to develop and implement a Remedial Action Plan for each AOC. In 1987, the United States and Canadian Federal Governments incorporated the commitment to develop RAPs into the Great Lakes Water Quality Agreement. A complete RAP encompasses the following stages and has a planning document associated with each milestone:

STAGE 1 – Identifies the nature of the problem(s) and summarizes available information.

STAGE 2 – Specifies remedial and regulatory measures needed to restore beneficial uses.

STAGE 3 – Measures and summarizes results as progress is achieved in implementing management plans.

Of the 32 U.S. RAPs, 5 had been completed through Stage 2 and 19 others had been completed or nearly completed through Stage 1 by the end of 1994.

One of the RAPs, Fox River/ Green Bay, faced particular difficulties in identifying the comparative significance of various sources of certain contaminants, especially PCBs. In an unprecedented partnership, GLNPO joined with the Office of Research and Development, several State agencies in Wisconsin and Michigan, other Federal agencies, and several academic institutions, to sponsor the Fox River/ Green Bay Mass Balance Study from 1987 through 1994. This study demonstrated the feasibility of the mass balance approach for identifying the relative contributions to toxicant-induced environmental problems, and it provided the RAP committee and the State of Wisconsin with a unique tool to forecast the effects of proposed environmental management decisions.

Lakewide Management Plans

Lakewide Management Plans are the next level of geographic integration envisioned in the Great Lakes Water Quality Agreement. These plans are whole lake planning efforts. Under the Agreement, LaMPs are to employ an ecosystem approach founded on the same use impairments forming the basis of the RAP process. While focusing primarily on the effects of toxics, the LaMPs will also address habitat and nutrient concerns. Public involvement is a critical element in LaMP development.

The first effort at lakewide management was the Lake Ontario Toxics Management Plan (LOTMP), undertaken via a 1987 Declaration of Intent (known as the "Four-Party Agreement") among the U.S. EPA, Environment Canada, New York State Department of Environmental Conservation, and the Province of Ontario. This Agreement anticipated, in many respects, the LaMP concept expressed in the 1987 revisions to the GLWQA. The LOTMP effort is chaired by EPA Region 2. The Plan first developed a list of critical pollutants for Lake Ontario in

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1989. The "Four Parties" agreed at that time to undertake revisions that would permit the LOTMP to become the LaMP for Lake Ontario. Since then, there have been two major revisions of the LOTMP and, in August 1994, GLNPO and Region 2 cooperatively undertook an intensive month-long special study monitoring organic contaminants in the water and sediments of Lake Ontario. Public hearings on the first draft of the Plan as a Stage 1 LaMP are under way.

The United States has prepared the LaMP for the Lake Michigan Basin, which is contained entirely in this country. The effort is headed up by EPA Region 5 and involves all of the Lake Michigan States: Wisconsin, Illinois, Indiana, and Michigan. Although impacts from nutrients and un-ionized ammonia toxicity persist, most of the problems in Lake Michigan stem from toxic contaminants already in the Lake system and ongoing toxic loadings from point and nonpoint sources. Future iterations of the LaMP will address all 14 beneficial use impairments.

Building on work in progress at the various AOCs, the Lake Michigan LaMP will look at the lake ecosystem as a whole and identify a set of critical pollutants. In some cases, this is a subset of the range of pollutants being addressed at smaller geographic units such as the AOCs. In other cases, pollutants that are not of the highest concern in localized areas but are deemed critical to the entire Lake Michigan ecosystem may warrant scrutiny. The LaMP will propose a tiered concept for developing management actions.

Currently, there is a major effort under way on the part of GLNPO with the assistance of the Office of Research and Development Environmental Research Laboratory-Duluth, Region 5, and the Lake Michigan States (Wisconsin, Illinois, Indiana, and Michigan) to carry out a full-scale mass balance study of Lake Michigan. This Study, begun in the spring of 1994, is an effort to provide the LaMP with a more definitive understanding of loadings and fates of four toxic substances (PCB congeners, trans-nonachlor, atrazine, and mercury). It will project the effects of various management scenarios selected by the LaMP Management Committee. The Stage 1 Lake Michigan LaMP first draft was published in January 1992 and revised in September 1993. A final version is anticipated by the end of 1995.

The LaMPs for each Great Lake will also encourage pollution prevention approaches. Lake Superior provides perhaps the best opportunity to implement pollution prevention because it is the least impacted of the Great Lakes. Lake Superior has been spared much of the extreme ecological disruptions associated with industrial and municipal discharges, introduction of exotic species, and overharvesting of the fisheries that have had devastating impacts on the lower Great Lakes, especially Lakes Ontario and Erie.

In the Fall of 1991, the United States, Canada, and the States of Minnesota, Wisconsin, and Michigan and the Province of Ontario formally agreed on a new regional agreement to protect Lake Superior from toxic pollution. The Binational Program seeks to encourage

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pollution prevention and expand authorities (where appropriate) to implement a goal of zero pollutant discharge and emission of nine persistent bioaccumulative toxic substances. As a first step, both the U.S. and the Canadian governments will work to freeze loadings of toxic discharges. The United States and Canada issued a draft Stage 1 LaMP for Lake Superior in February 1994 and expect to transmit a Stage 1 version incorporating public comments to the IJC in the near future. A draft Stage 2 LaMP is expected to be made available to the public by the time of the IJC's biennial meeting in September 1995.

The LaMP for Lake Erie is now in the early stages of development with a binational Management Committee and Workgroup in place. The Workgroup, under the direction of the Management Committee, has begun developing ecosystem objectives and assessing the status of beneficial uses for Lake Erie. The Workgroup has also initiated a variety of public involvement activities, including developing a Lake Erie Forum and requesting comments on a concept paper outlining the LaMP framework.

Pollution Prevention Initiatives

The EPA GLNPO is working with EPA Regions 2, 3, and 5, the States, and their Canadian counterparts to promote pollution prevention as the most effective approach to achieve the GLWQA goal of virtually eliminating discharges of persistent toxic substances in the Great Lakes. In 1991, EPA and the States developed the Great Lakes Pollution Prevention Action Plan to highlight how EPA and the States will minimize the use, production, and release of toxic substances at the source. The Action Plan targets persistent bioaccumulative toxic substances for reduction or elimination.

The GLNPO has allocated significant funding and developed a formal process for funding numerous pollution prevention grants throughout the Great Lakes Basin for the past 3 years. The three Great Lakes Regions of EPA are using the pollution prevention approach to prioritize solutions. The Regions view pollution prevention as a voluntary program that falls back on regulation as needed. The 1992 program goal was surpassed by over 100 million pounds in reduced contaminant releases into the environment.

The EPA Regions and Great Lakes States are implementing the National 38/50 Program in the Great Lakes Basin. Under this program, EPA has received voluntary commitments from industry to reduce the emission of 17 priority pollutants by 50% by the end of 1995. This goal is expected to be achieved ahead of schedule. As part of the Binational Program to Protect Lake Superior, EPA and the States are also cooperating with Canada to undertake a virtual elimination initiative for Lake Superior that seeks first to eliminate new contributions of Great Lakes critical pollutants, with special emphasis on mercury. The EPA is also working with utilities located within the Great Lakes Basin to accelerate the phaseout of transformers containing PCBs.

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The Chesapeake Bay Program

Background

Now in its twelfth year, the EPA Chesapeake Bay Program is a regional partnership of Federal, State, and local participants that has directed and coordinated Chesapeake Bay restoration since 1983 when the historic Chesapeake Bay Agreement was signed. The partners in this agreement are the State of Maryland, the Commonwealths of Pennsylvania and Virginia, the District of Columbia, the Chesapeake Bay Commission, and the EPA, representing the Federal Government, as well as participating advisory groups.

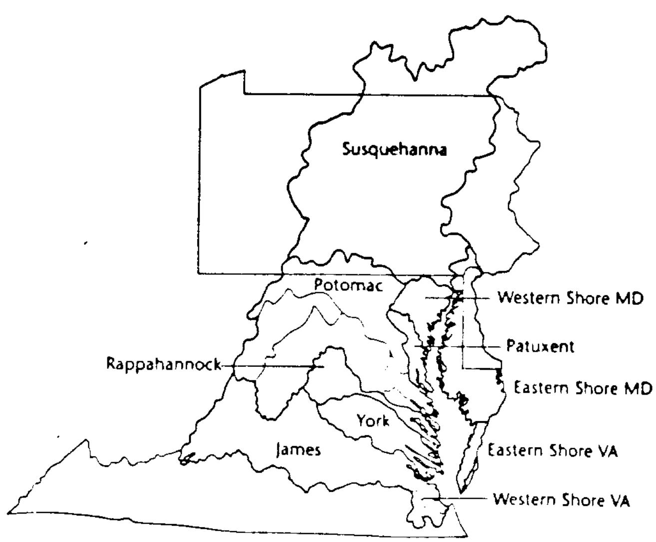
Considered a national and international model for estuarine restoration and protection, the Chesapeake Bay Program is still a "work in progress." Since 1983, milestones in the evolution of the program include the 1987 Chesapeake Bay Agreement, which set a goal of a 40% reduction of nutrients entering the Bay by the year 2000. In the 1992 amendments to the Agreement, the partners reaffirmed the 40% nutrient reduction goal, agreed to cap nutrient loadings beyond the year 2000, and agreed to attack nutrients at their source by applying the 40% goal to the 10 major tributaries of the Bay. The agreements have also stressed management of the Bay as a whole ecosystem, using the restoration of both habitat and living resources as measures of progress.

Federal agencies also play a significant role in the Chesapeake Bay Program. The Federal Government owns 1.6 million acres of land in the Bay watershed. In 1994, officials from 25 Federal agencies and departments signed the Agreement of Federal Agencies on Ecosystem Management in the Chesapeake Bay. This Agreement set out a number of specific goals and commitments for Federal agencies on their lands throughout the watershed, as well as new cooperative efforts by Federal agencies elsewhere.

The Chesapeake Bay is an enormously complex and dynamic system of fishes, waterfowl, and vegetation in an estuary where salt water from the Atlantic Ocean and fresh water from the many tributaries of the Bay come together (Figure 12-6). A host of complicated interactions having physical, chemical,

Figure 12-6

Chesapeake Bay Watershed with Its 10 Subwatersheds

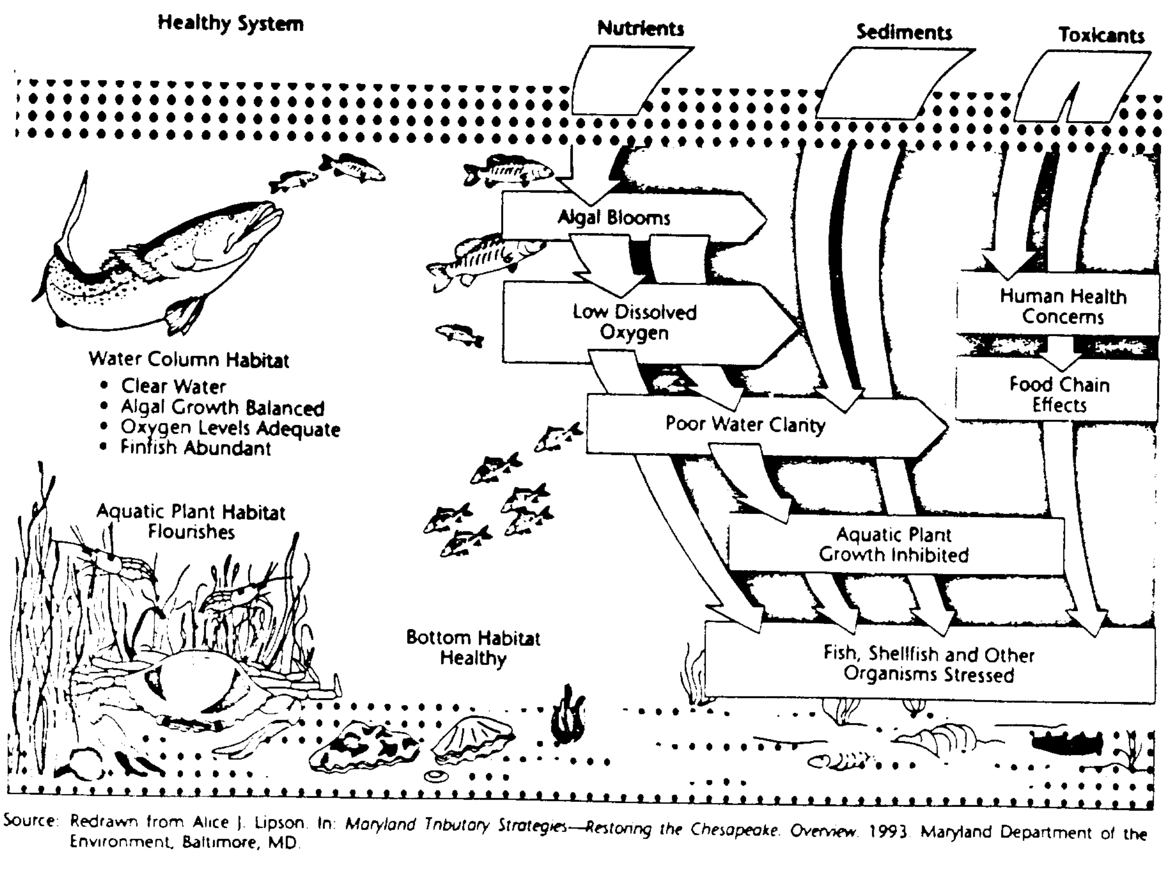


and biological dimensions present formidable challenges to the understanding and management of this great estuary (Figure 12-7).

If we liken the Chesapeake Bay to a patient in the hospital undergoing treatment for a life-threatening illness, we can now report that the patient's vital signs, such as living resources, habitat, and water quality are stabilized and the patient is out of intensive care. Some vital signs, such as striped bass and Bay grasses have improved dramatically, others, such as oysters, are still in danger, with still other vital signs mixed but stable. Nutrient levels continue on their downward slope, with phosphorus reduction outstripping that of nitrogen. Dissolved oxygen remains unchanged but has stopped declining. In the following sections, these findings are examined in more detail.

Figure 12-7

Effects of Pollutants in the Chesapeake Bay



Source: Redrawn from Alice J. Lipson. In: *Maryland Tributary Strategies—Restoring the Chesapeake. Overview.* 1993. Maryland Department of the Environment, Baltimore, MD.

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Stresses on the Ecosystem

Land Use

The Chesapeake Bay's watershed, radically changed by European settlement three centuries ago, continues to undergo changes that reflect how we use the land in this 64,000-square-mile expanse. Urban, suburban, and agricultural lands all leach more pollutants into the Bay than do natural forests and wetlands. About 40% of the land is no longer in its natural state and we are losing wetlands at a rate of 8 acres per day.

Data from 1990 show that forest is the dominant land use within the Bay watershed, constituting about 59% of the land, mostly in areas far removed from the Bay's shoreline. Agricultural land, including pasture and cropland, constitutes about 33% of the watershed. Urban and suburban lands are generally close to the Bay and its tidal tributaries and cover about 7% of the watershed. Wetlands, critical habitat environments, represent about 1%. Nutrient and sediment loads from forest land are low compared to urban and agricultural land uses.

Based on projections of a steadily increasing population, the largest change in land use will be from forest and agriculture to urban and suburban. In 1985, about 4.0 million acres of the watershed were urban or suburban. This number is projected to increase to about 5.4 million acres by the year 2000, an increase of 35% over the 1985 acreage. Between 1982 and 1989, 20,000 acres, about 2.5% of wetlands, were lost primarily through filling, draining, or conversion to open water. This represents a loss of about 8 acres per day.

Population

Population growth is the single most important factor underlying the various stresses on the Bay ecosystem. In 1950, the Bay's watershed contained 8.4 million residents. By 1990, this figure had grown to 14.2 million and, by 2020, there will be an estimated 17.4 million people living in the watershed. An expanding population relies on highways and automobiles, increasing both the number of cars on the road and the miles driven. The growing population also requires land for homes, transportation, shops, jobs, and recreation. Forests and other lands of environmental significance are often converted to meet these needs.

An ever-increasing population has resulted in higher wastewater flows to the Chesapeake Bay (Figure 12-8). As a result of improved wastewater treatment and bans on detergents containing phosphorus, point source loads of phosphorus have been reduced by 70% since a peak in the 1970s, despite a 40% increase in total flow. Nitrogen controls, just recently implemented, are already starting to reduce the levels of this pollutant entering the Bay from point sources such as industry and municipal sewage treatment plants.

Along with changes in land use, population growth also results in higher flows from wastewater treatment plants. This wastewater contains the nutrients phosphorus and nitrogen, excessive quantities of which are the primary pollution threats facing Bay waters. The Federal Construction Grants Program provided improved treatment at municipal plants to remove phosphorus, resulting in a sharp decline in phosphorus discharges between 1970 and 1980. These reductions have continued since 1980 with additional treatment plant upgrades and the implementation of phosphorus bans that prohibit the use of this nutrient in household detergents. Overall, phosphorus loads have declined by about 70% since the 1970s. Nitrogen discharges increased steadily between 1950 and 1985. Improved treatment at both industrial and municipal wastewater facilities is responsible for reductions in nitrogen discharges since 1985. Innovative technologies, such as biological nutrient removal (BNR) provide better management of the sewage treatment process, resulting in lower nitrogen and phosphorus levels.

The signatories of the Chesapeake Bay Agreement have committed to develop and implement nutrient reduction strategies—the Tributary Strategies—that will reduce the 1985 combined point and nonpoint source loads by 40% by the year 2000. Great strides have been made in reducing point source phosphorus loads. Continued reductions are needed, especially in nitrogen, however, to offset flow increases in areas of rapid population growth.

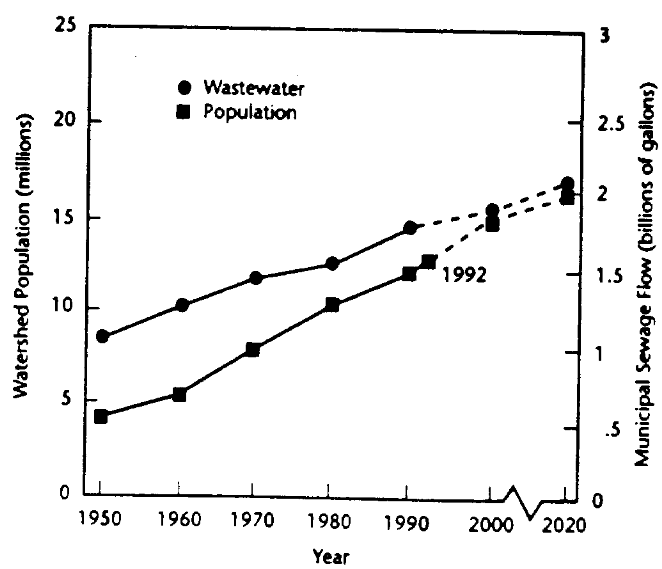
Impacts on the Ecosystem

Rivers – Nutrient and sediment pollution from the Susquehanna and Potomac Rivers, the two largest freshwater tributaries feeding the Bay, show encouraging signs. After many years of increasing nitrogen concentrations, most of the Bay's tributaries are showing a leveling off of this trend and some are actually showing a decline (Figure 12-9). Such results demonstrate that point and nonpoint source abatement programs instituted over the past 10 years are producing the desired results.

The quality of fresh water entering the Chesapeake Bay from the surrounding nontidal tributaries is an important factor in the water

Figure 12-8

Watershed Population and Wastewater Flow



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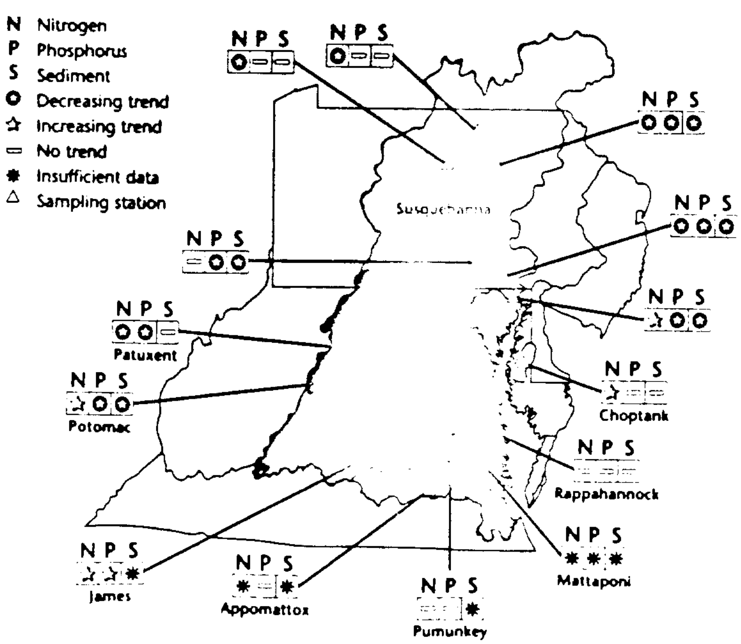
and habitat quality of the estuary. When taken as a whole, results from cooperative monitoring of input from the Bay's rivers generally show very encouraging signs.

Historical data from the 1970s and more recent data for 1984-1993 show that the concentrations of several important pollutants are either declining or leveling off after previously increasing trends. Point and nonpoint source controls appear to be having an impact on the total phosphorus concentrations for a number of the rivers. The phosphate detergent bans enacted in Maryland, Virginia, Pennsylvania, and the District of Columbia during the mid-1980s have clearly contributed to the lowering of phosphorus inputs from the rivers. Even nitrogen, which has only recently been targeted for load reductions is showing declines in parts of the Susquehanna and Patuxent Rivers.

Figure 12-9

Pollutant Trends in the Bay's Rivers



Estuaries – Nutrient levels in the tidal saline waters of the Chesapeake Bay and its tributaries are responding to the trends seen in the inputs of nutrients from the nontidal rivers (Figure 12-10). Many regions are showing declines in phosphorus levels. Nitrogen flowing into the Bay has stopped increasing in most areas. Despite these promising trends, dissolved oxygen levels are still low enough to cause severe impacts and stressful conditions in the mainstem of the Bay and several of the larger tributaries (Figure 12-11).

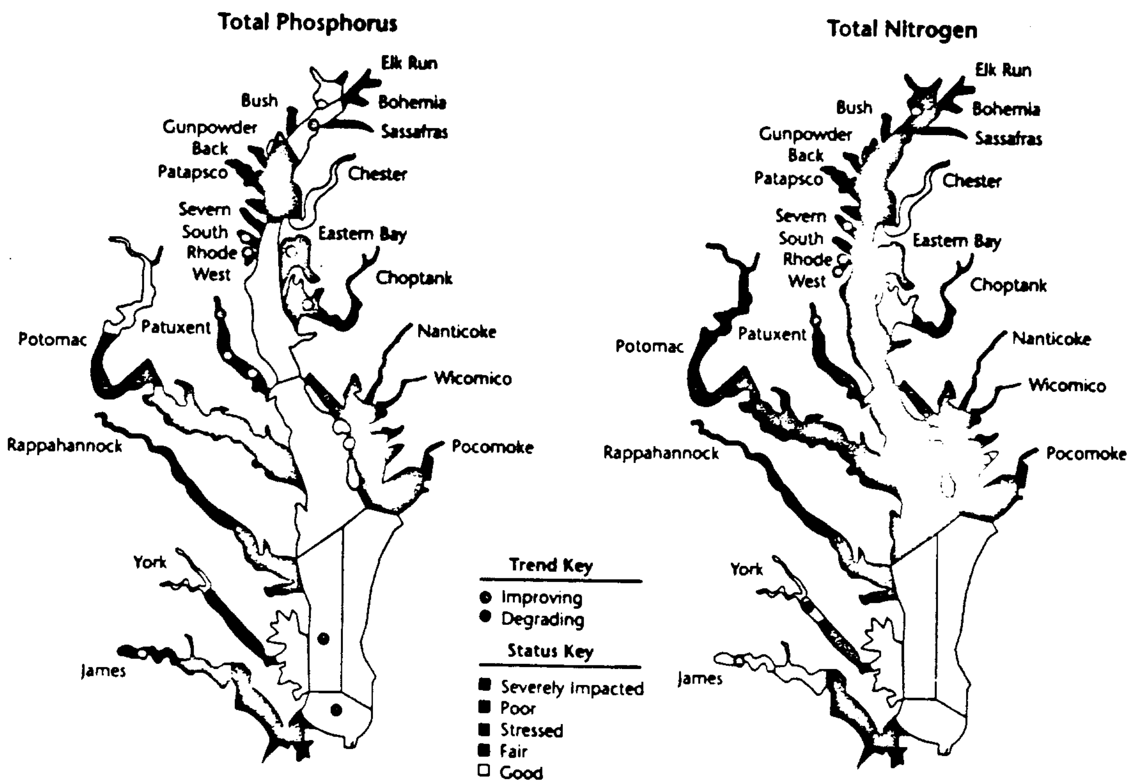
The main causes of the Bay's poor water quality and aquatic habitat loss are elevated levels of the nutrients nitrogen and phosphorus. Both are natural fertilizers found in animal waste, soil, and even the atmosphere. In excessive amounts, these nutrients cause an excessive growth of algae, which clouds the water and blocks the sunlight that is essential for submerged aquatic grasses. When the algae die, they sink and decompose, using up the dissolved oxygen in the water. Low oxygen conditions may cause the eggs and larvae of fish to die. The growth and reproduction of oysters, clams, and other bottom-dwelling animals are impaired. Adult fish find their habitat reduced and their feeding inhibited. Animals that cannot move may die.

Nitrogen concentrations in the water appear to be declining in some areas, especially Maryland's upper western shore, the Patuxent River, and the James River in Virginia. In all areas of the Bay and its tributaries, phosphorus concentrations are either declining or have remained stable since 1984. Changes in dissolved oxygen conditions are few and do not show any consistent pattern. The observed changes are primarily due to improved treatment at industrial and municipal point sources located in the major metropolitan areas that surround the upper tidal tributaries.

Sediment - Potentially toxic contaminants stored in the Bay's bottom sediments from years of

Figure 12-10

Nutrient Status and Trends



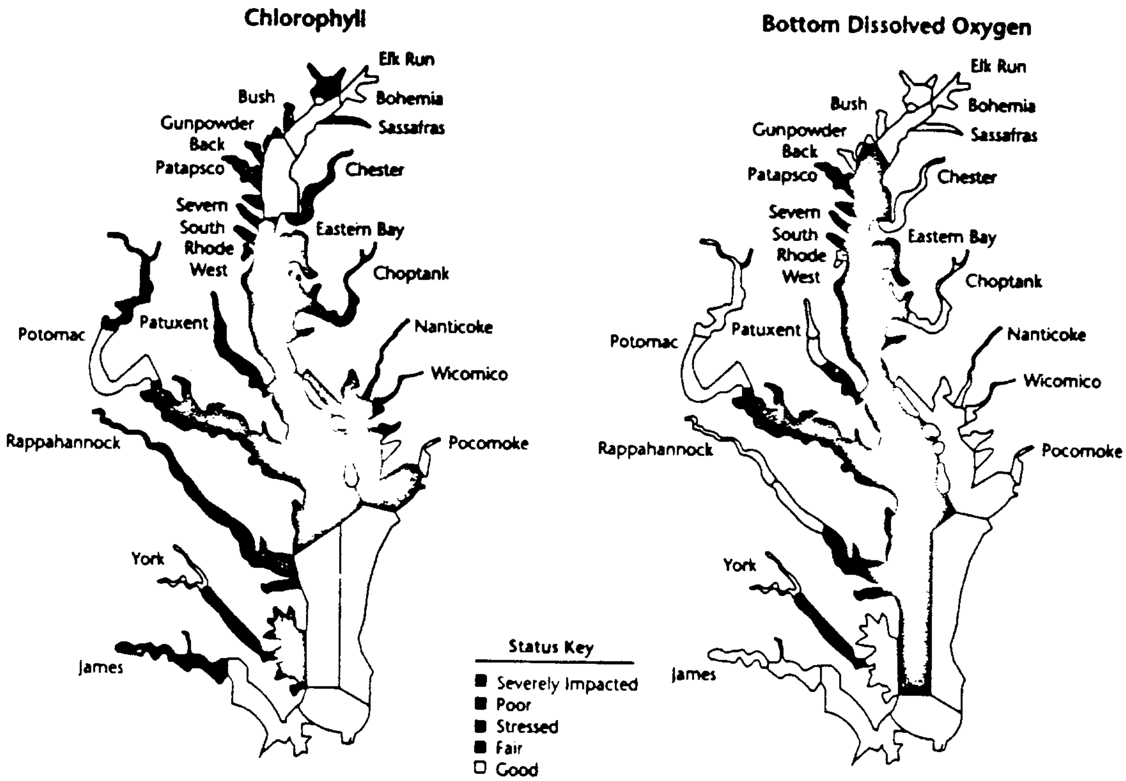
NOTE: Nutrient and chlorophyll status shadings are based on relative levels compared to similar salinity regions elsewhere in the Bay and its tributaries. If the nutrient levels were shown as absolute levels, the upper tributaries would have the highest nutrient levels.

pollution reach levels of concern only in a few localized areas that have intensive industrial activity and high population densities. The inputs of many of these pollutants have already been reduced but additional measures are being studied to mitigate any possible toxic impacts.

Many types of contaminants, including trace metals, organic compounds (such as PAHs and PCBs), and pesticides (such as DDT, chlordane, and atrazine), pose a threat to Bay waters. Most of these contaminants cling to particles suspended in the water and settle to the bottom; therefore, their concentrations in sediments are typically much higher than in the water. Monitoring toxic substances in the sediment is an efficient method of

Figure 12-11

Algae and Dissolved Oxygen Status



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determining contamination levels in the Bay and identifying areas that may require further evaluation of potential contaminant problems.

Living Resource Response

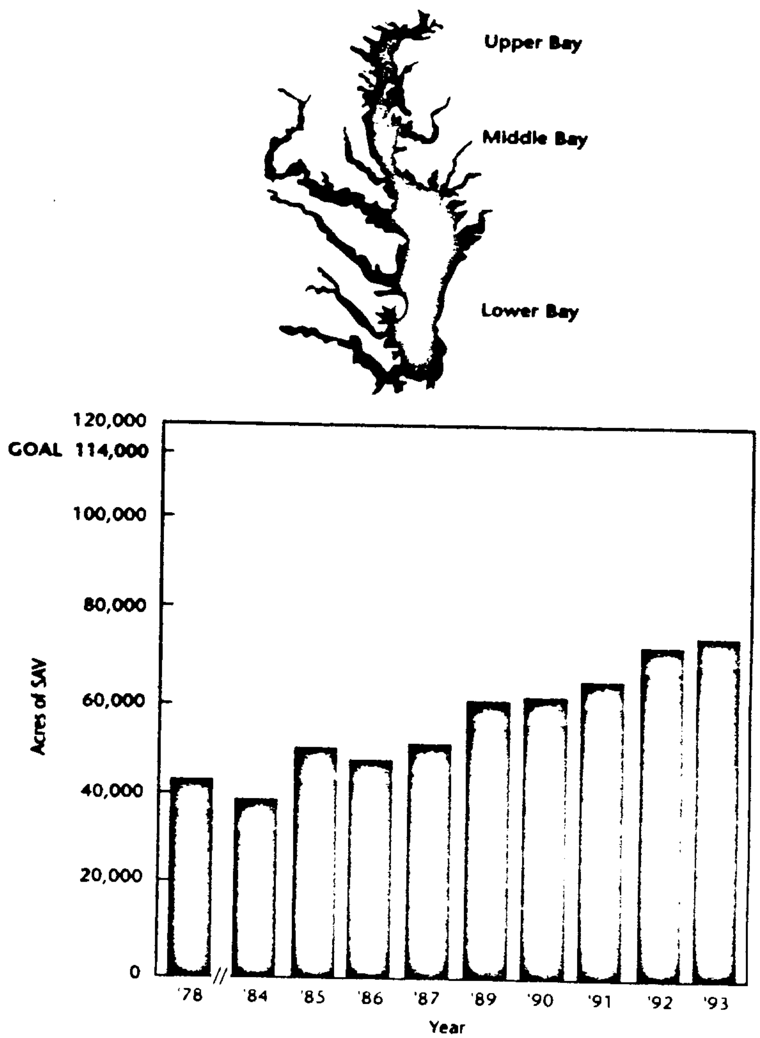
Submerged Aquatic Vegetation – Submerged aquatic vegetation (SAV), a critical habitat for fish, crabs, and waterfowl, has increased 75% since 1978 in response to improving water quality (Figure 12-12). These increases achieve about 64% of the initial restoration goal. Survey results for 1994 show a 10% decrease in the acreage of SAV due largely to record freshwater flows in spring that transported increased nutrient and sediment loads into the Bay. Additional improvements in water quality will be needed to sustain the resurgence in SAV.

The strong link between water quality and SAV distribution and abundance makes SAV plant communities good barometers of the Chesapeake Bay's health. SAV historically covered vast areas of the Bay's shallow waters and nurtured a rich variety of Bay life. During the late 1960s and early 1970s, however, Bay SAV populations experienced a dramatic decline due to increased nutrient and sediment pollution from development within the watershed.

Significant progress has been made in defining water quality requirements for SAV in the Bay. Those requirements emphasize good water clarity and low levels of suspended sediment, nutrients, and algae. The Chesapeake Executive Council used this new information about SAV in 1993 to establish an SAV restoration goal of 114,000 acres Bay-wide.

Figure 12-12

Trends in Submerged Aquatic Vegetation



NOTE: The Chesapeake Executive Council established an SAV restoration goal of 114,000 acres in 1993.

Recent changes in Chesapeake Bay SAV populations suggest that most of these populations can rebound rapidly if water quality conditions are improved and maintained. Some areas may not become revegetated even after the return of suitable water quality conditions, however, due to a lack of SAV propagules either within or close to these areas.

Biological Communities – Important biological communities in the Bay, such as plankton and benthos, reveal underlying concerns in the food web that sustain some of the more visible Bay species. Zooplankton describes the community of floating, often microscopic animals that inhabit aquatic environments. Zooplankton are the most plentiful animals in the Chesapeake Bay and its tributaries. The most common zooplankton are the crustacea, which include animals such as crab and barnacle larvae.

Zooplankton are proving to be good indicators of water quality conditions, habitat quality for living resources, and the effects of toxic contamination in the Bay. Several studies have indicated that sufficient numbers of zooplankton during the critical life stages of larval striped bass are vitally important to their growth and survival. Zooplankton act as a critical link between water quality and living resources, and zooplankton environmental indicators are currently under development for use in assessing the health of the Chesapeake Bay.

Phytoplankton refers to the community of floating, mostly microscopic plants or algae that inhabit aquatic environments. They are a critical component of the Chesapeake Bay ecosystem and represent the first biological response to the Bay's nutrient enrichment problem. Phytoplankton are particularly important to the Bay ecosystem because they are primary producers, converting energy from sunlight into food for animals such as zooplankton, oysters, and fish. Although phytoplankton form the foundation of the food chain in the Bay, problems can occur if this community grows out of control due to excess nutrients.

"Benthos" describes an invertebrate community of organisms that live on or in the bottom sediments. This community includes a wide variety of organisms such as clams, oysters, and small crustaceans, in addition to the blood and clam worms commonly used as bait.

Because most benthic invertebrates have limited mobility and cannot avoid changes in habitat quality, they are often used as reliable and sensitive environmental indicators. Some benthic organisms are commercially important and all have important functions in the Bay ecosystem. They act as nutrient recyclers and important links in the Bay's food chain, feeding on microscopic plankton and serving as food for the bottom-feeding blue crab and fish such as spot and croaker.

Most of the areas with severely or moderately degraded benthic communities are located in deeper tributary channels and the deep trench of the Bay and experience stress from low concentrations of dissolved oxygen. Sediment concentrations of toxic substances appear to have a secondary, but significant, influence on benthic community condition, primarily in industrialized

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areas such as the Elizabeth, Anacostia, and Patapsco Rivers.

Results indicate that implementation of the 1972 Clean Water Act resulted in large reductions in the quantity of contaminants discharged through industrial wastewater outfalls or sent to municipal wastewater plants and ultimately to Chesapeake Bay. Generally, contaminant concentrations in the sediment have been substantially reduced in the past two decades. Subsequent revisions of the Clean Water Act and the Clean Air Act required additional measures to reduce the discharge of trace metal and organic contaminants and prevent toxic impacts.

The Chesapeake Bay Program recently completed evaluating its toxic substances reduction strategy to better define the nature, extent, and magnitude of toxics problems in the Chesapeake Bay.

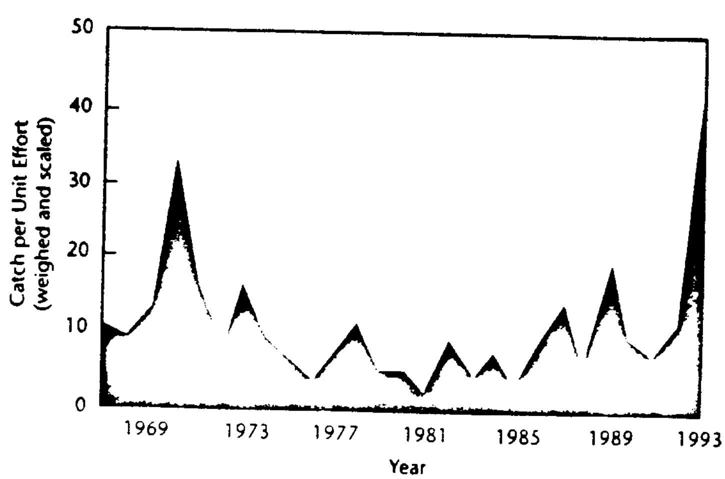
Striped Bass – Due to improved reproduction and better control of the harvest, striped bass, also known as rockfish, have made a remarkable recovery over the past decade. The increasing numbers of striped bass (*Morone saxatilis*) seen darting through Bay waters are a tribute to interagency cooperation in the management of an important Bay resource. Monitoring data show that significant progress has been made in rebuilding the population from the all-time lows of the 1980s (Figure 12-13). Striped bass spend most of their adult life in the ocean, returning each spring to spawn in tidal fresh or brackish waters found along the Atlantic coast, with the principal spawning and nursery areas found in the Chesapeake Bay. The increased abundance of striped bass is due largely to the implementation of coastwide fishing restrictions, including a fishing ban in Chesapeake Bay, allowing more fish to reach sexual maturity.

Shad - American shad, which spawn in the Bay's tributaries, have suffered population declines over the past century from overharvesting, dam construction that blocks migration routes, and habitat degradation. Once one of the most commercially valuable species in the Chesapeake Bay, American shad (*Alosa sapidissima*) populations have declined to a shadow of their former abundance. Historical overharvesting and habitat degradation, combined with stream impediments blocking miles of spawning and nursery grounds, have been cited as the main causes for this reduction.

Due to declining stocks, Maryland placed a moratorium on shad

Figure 12-13

Baywide Striped Bass Juvenile Index



in 1980, prohibiting the sale, capture, or possession of shad caught in Maryland waters of the Chesapeake Bay. The District of Columbia also placed a moratorium on American and hickory shad in 1989 and Virginia imposed a moratorium in 1994. None of these management decisions affect the coastal "intercept" fishery, which continues to harvest the species all along the Atlantic coast, although Maryland has proposed to end the coastal fishery in 1995.

In 1989, the Chesapeake Bay Program established an Alosid Fisheries Management Plan to protect, restore, and enhance Bay-wide stocks of American shad, hickory shad, blueback herring, and alewife. Efforts have focused on habitat restoration, restocking, reduction of fishing effort, and stock assessment survey improvement. Through these efforts, managers and researchers hope to restore a once valuable species to its former abundance in the Bay.

An integral component of the shad's long-term success is its ability to return to its upstream spawning habitat. The removal of blockages and construction of denil fishways and fish elevators to create fish passages has reopened 175 miles of river to anadromous fish throughout the Bay watershed. Many new projects are under way. The Bay Program has committed to reopening 582 miles of stream habitat by 1998 and 1,356 miles by 2003.

Blue Crab – The blue crab is currently the most important commercial and recreational fishery in the Bay. With increasing fishing pressures and relatively low harvests in recent years, there is growing concern for the health of the stocks. Both Maryland and Virginia have recently implemented new regulations on commercial and recreational crabbers to protect this important resource.

With the decline of other species in the Bay and the resultant increase in crab harvesting pressure, concern about the future of this great resource is mounting.

A priority for improving management of the blue crab fishery is to enhance our understanding of crab population dynamics. Knowledge of both environmental and anthropogenic factors contributing to annual fluctuations in reproductive success and population levels is essential for effective fishery management.

As with other Chesapeake Bay fisheries, a comprehensive approach to managing the blue crab is needed because biological, physical, economic, and social aspects of the fishery are shared among the Bay's jurisdictions. To provide such an approach, a Bay-wide blue crab fishery management plan was developed in 1989 to sustain the ecological and economic value of the blue crab stock. The plan has already resulted in the implementation of better fishery practices and more effective monitoring of the blue crab stock, as mentioned previously. A revised plan based on more accurate data and requiring further conservation measures will be completed in 1995.

Oysters – Prospects for the Bay's oyster population remain poor. Overharvesting, habitat loss, and disease have all conspired over the years to deplete the stocks severely.

New management efforts have been developed to improve this situation.

Oyster harvesting has been an integral part of the Bay region's economic development and cultural heritage. The filtering capabilities of the oyster enable it to remove large quantities of algae and sediment from the water column, while its shells provide habitat for a variety of benthic organisms and fish species. Some scientists feel that the restoration of this creature is an important key to improving water quality and the overall health of the Bay.

In 1989 the Chesapeake Bay Program established an oyster management plan with the goal of conserving oyster stocks while maintaining a viable fishery. In the latest effort to restore oyster stocks in Maryland, 40 representatives including watermen, academics, State officials, environmentalists, and aquaculturists joined in an Oyster Roundtable to address the oyster's dilemma. These discussions led to the signing of an "action plan" with several recommendations for aquaculture, research, and the designation of special "recovery areas." This management plan is the first of its kind to recognize the ecological importance of the oyster in addition to its commercial value.

Waterfowl – The Bay's waterfowl consist of several species, not all of which are indigenous. A long-term decline in the abundance of the native waterfowl is of great concern. The necessary corrective action to reverse this trend is habitat improvement and resurgence of SAV.

Historically, waterfowl were so abundant they seemed to blanket areas of the Bay. Today, their numbers are greatly reduced. Widespread deterioration of shallow water habitats and wetlands, coupled with increasing human disturbance, have reduced the ability of many Bay areas to support waterfowl. Overall, waterfowl are declining in the Bay, with the largest declines occurring in the Canada goose population. The black duck continues its gradual decline, as do scooters, oldsquaw, and goldeneye. Merganser, bufflehead, mallard, and the nonindigenous mute swan populations are increasing.

Conclusions

The connection between human activities on land and Chesapeake Bay degradation is clear. Overharvesting also contributes to declines in the Bay's living resources. While the findings in this report allow for much optimism, they also warn that we are far from declaring victory in our fight to save the Chesapeake Bay. The results show that the Chesapeake Bay is an interconnected system and that activities on the land and mismanagement of the resources can set off a chain of events that ultimately yields degraded conditions in the water and loss of living resources. The results also show that these conditions, which have resulted from almost 300 years of abuse, are reversible.

Overall, the Chesapeake Bay still shows symptoms related to stress from an expanding population and the changes such growth brings about in land use. However, the concentrated restoration and management effort begun 12 years ago has produced tangible results—a state of the Chesapeake Bay that is better today than it was when we

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> THE NEP currently supports 28 estuary projects.

started—and promises the future will be even brighter.

We cannot return the Chesapeake Bay to its pristine, or original, state, nor will we ever have the uninhabited expanses that our parents and grandparents knew. We will probably never go back to the days when we could harvest oysters by the tens of millions of bushels nor to the days when we could catch as many 40-pound rockfish as our boat could hold. Those days are gone forever. But, we can have relatively clean water and large, protected areas of marsh and shoreline. We can have viable fish and bird populations, although never the "limitless" stocks of fish for all to harvest. The lessons we learn from these experiences, and our willingness to act on them, will determine the state of the Chesapeake Bay that we leave to future generations.

The National Estuary Program

The National Estuary Program embodies the ecosystem approach by building coalitions, addressing multiple sources of contamination, pursuing habitat protection as a pollution control mechanism, and investigating cross-media transfer of pollutants from air and soil into estuarine waters.

Congress recognizes that estuaries are unique and endangered ecosystems and that traditional water pollution control programs alone cannot address the more complex issues associated with estuaries. These issues include protecting living resources and their habitats, controlling diffuse sources of pollutants, and managing estuaries as watershed ecosystems. Responding to the unmet needs of estuarine ecosystems, Congress established the National Estuary Program in 1987 under Section 320 of the Clean Water Act.

The NEP adopts a geographic, basinwide approach to environmental management. A State governor nominates an estuary in his or her State for participation in the program. The State must demonstrate a likelihood for success in protecting candidate estuaries and provide evidence of institutional, financial, and political commitment to solving estuarine problems.

If an estuary meets the NEP guidelines, the EPA Administrator convenes a management conference of representatives from interested Federal, Regional, State, and local governments; affected industries; scientific and academic institutions; and citizen organizations. The management conference defines program goals and objectives, identifies problems, and designs strategies to prevent and control pollution and manage natural resources in the estuarine basin. Each management conference develops and initiates implementation of a Comprehensive Conservation and Management Plan (CCMP) to restore and protect its estuary.

With the addition of seven estuary programs in July 1995, the NEP currently supports 28 estuary projects (Figure 12-14):

- Puget Sound in Washington State
- Columbia River in Oregon and Washington
- Tillamook Bay in Oregon
- San Francisco Bay Estuary in California
- Morro Bay in California

- Santa Monica Bay in California
- Corpus Christi Bay in Texas
- Galveston Bay in Texas
- Barataria-Terrebonne Estuarine Complex in Louisiana
- Mobile Bay in Alabama
- Tampa Bay in Florida
- Sarasota Bay in Florida
- Charlotte Bay in Florida
- Indian River Lagoon in Florida
- San Juan Bay in Puerto Rico
- Albemarle-Pamlico Sounds in North Carolina
- Maryland Coastal Bays in Maryland
- Delaware Inland Bays in Delaware
- Delaware Estuary in New Jersey, Pennsylvania, and Delaware
- Barnegat Bay in New Jersey
- New York-New Jersey Harbor in New York and New Jersey
- Long Island Sound in Connecticut and New York
- Peconic Bay in New York
- Narragansett Bay in Rhode Island
- Buzzards Bay in Massachusetts
- Massachusetts Bay in Massachusetts
- New Hampshire Estuaries in New Hampshire
- Casco Bay in Maine.

These 28 estuaries are nationally significant in their economic value as well as in their ability to support living resources. The project sites also represent a broad range of environmental conditions in estuaries throughout the United States and its Territories.

The NEP integrates science and decisionmaking for the protection, restoration, and maintenance of estuaries. Through a characterization process, scientists from Federal, State, and local government agencies, academic institutions, and the private sector analyze an estuary's problems and their causes and work with estuary managers to suggest remedies. Because the NEP is not a research program, it relies heavily on past and current research of other agencies and institutions to support its work.

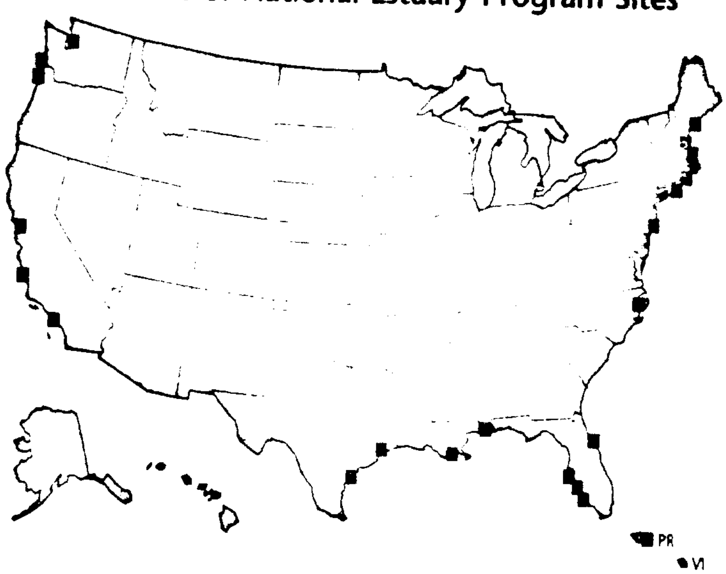
Appendix C, Table C-10, lists physical and economic characteristics of the NEP estuarine basins. The table also describes each estuary's susceptibility to pollution in terms of its ability to flush out and dilute pollutants. This information is being evaluated as part of a national survey of nutrient enrichment in estuaries, sponsored jointly by EPA and NOAA.

Estuarine Problems

Each of the 28 estuaries in the NEP is unique, yet the estuaries share common threats and stressors. Each estuary faces expanding human activity near its shores that

Figure 12-14

Locations of National Estuary Program Sites



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> NATIONAL ESTUARY programs are addressing eutrophication, toxic contamination, pathogen contamination, and habitat modification in their estuaries.

may degrade water quality and habitat. Eutrophication, toxic substances (including metals), pathogens, and changes to living resources and habitats top the list of problems being addressed by the NEP Management Conferences. Tables C-11, C-12, and C-13 in Appendix C list the problems stressing the NEP sites.

Eutrophication

Nutrients enter waterways through sewage treatment plant discharges, stormwater runoff from lawns and agricultural lands, faulty septic tanks, and even ground water discharges. (For example, nitrates are believed to leach into ground water and discharge into the Delaware Inland Bays.) Algae and bacteria respond to elevated inputs of nutrients by rapidly reproducing. Decomposition of the algae consumes oxygen and causes hypoxia–low concentrations of dissolved oxygen.

■ The Long Island Sound Study Management Conference (which includes representatives from NOAA, State and County agencies in Connecticut and New York, and New York City) is focusing on sources of hypoxia in the basin surrounding the Sound. During recent summers, poor water circulation exacerbated hypoxia problems in parts of the Sound. The Long Island Sound Study identified nitrogen as the primary nutrient linked to hypoxia in the Sound and concluded that discharges from sewage treatment plants and runoff are the leading controllable sources of nitrogen loadings to the estuary.

■ The Delaware Inland Bays Management Conference is focusing on the Inland Bays' capacity to assimilate nutrients. First, the study identified critical information gaps and planned research projects to fill the gaps. Ongoing research projects target four goals: (1) determine ground water contributions of nutrients, (2) develop a mass balance model of nutrient cycling between ground water and the Inland Bays, (3) define nutrient transport processes in the Inland Bays' basin, and (4) develop a strategy for using living resources as indicators of water quality. The project coordinates public input and research conducted by Federal, State, academic, and private scientists in an attempt to characterize the estuary and develop a Comprehensive Conservation and Management Plan.

Toxic Substances

■ Metals in Massachusetts Bay illustrate the impact from sewage treatment plants, atmospheric deposition, and polluted tributaries. The Bay receives high metal loading from the Merrimack River. The Comprehensive Conservation and Management Plan for the Bay will have to address sources of metals contaminating the Merrimack River as well as sources discharging metals directly into the Bay.

■ Sediment core samples collected at Narragansett Bay revealed that most metal concentrations peaked during the 1950s and have declined by an average of 60% since the 1950s. The study attributes declines in metal concentrations to improvements in sewage treatment.

■ The Casco Bay Estuary Project focuses on the extent of toxic contamination in Bay sediments. Heavy metal concentrations in Casco Bay sediments exceed concentrations in most NEP estuaries. The Casco Bay study detected heavy metals, PCBs, PAHs, pesticides, dioxins, and other organic compounds in the Casco Bay sediments. NOAA's flounder liver survey revealed heavy concentrations of lead, copper, zinc, silver, and PCBs in fish captured in Casco Bay.

Pathogens

Pathogens are bacteria and viruses that cause diseases. To protect public health, State agencies prohibit the harvest of shellfish in waters contaminated with pathogens or pathogen indicators, such as fecal coliforms. Waters contaminated with pathogens also pose a health risk to swimmers, surfers, and divers.

■ A growing network of shellfish farms on the Indian River Lagoon serves as a monitoring system to alert scientists and managers to water quality problems in the Lagoon, including the presence of pathogens.

■ Elevated counts of bacterial and viral indicators in two Santa Monica storm drains raised concern about the safety of swimming near storm drain outfalls. Additional sampling confirmed elevated bacterial indicator counts in the surf zone and in storm drain runoff. However, the data were inadequate to calculate health risks. The study recommended additional research to determine the source of fecal organisms and viruses in the storm drains and the dispersion of runoff along the shoreline.

Living Resources and Their Habitat

Overharvesting and loss of habitats have led to a decline of valuable species, an increase in populations of less desirable species, and a decrease in the diversity of living resources in estuaries. Land development in upland areas increases sedimentation in waterways; construction in wetlands destroys this valuable filter system and habitat for juvenile fish; bulkheading interferes with natural plant and animal shoreline interactions; and dredge and fill activities create turbid waters, destroy habitat, and interfere with circulation patterns. In Florida, ongoing estuary projects study the effects of habitat changes, rapid growth and development, and sewage treatment plant expansion on living resources.

■ The Florida Marine Research Institute is conducting cooperative studies of fish-habitat relationships in Tampa Bay with NOAA funding channeled through the Florida Department of Environmental Regulation. These studies examine fish community structure along the salinity gradient, fish density in seagrass beds and unvegetated habitats, and the use of microhabitats by economically valuable fish species. The State will enter the results of this research into a database for predicting the effects of future habitat modifications.

- In Sarasota Bay, water quality trends indicate that nutrient and salinity levels and the alkalinity/acidity ratio have decreased over time. The decrease reflects a shift from agrarian to urban land use. On the eastern shore, submerged aquatic vegetation has declined, particularly in an area within transport range of a seawater treatment plant outfall. Although the total concentration of suspended solids is elevated, researchers cannot link increased biomass to decreased light resulting from the sewage plant discharges. Further studies are investigating another possible cause of the vegetation losses: the formation of insoluble calcium carbonate from the soluble bicarbonate present in the sewage plant effluent.

- The Bay Study Group of the City of Tampa has conducted extensive monitoring in Tampa Bay. Monitoring at middle Tampa Bay and Hillsborough Bay indicate wastewater plant upgrades implemented in 1979 reduced nitrogen and chlorophyll concentrations and blue-green algae levels in Hillsborough Bay. Dissolved oxygen concentrations and water transparency also increased. At the same time, sea grasses colonized shallow areas around Hillsborough Bay, which had been barren of attached vegetation for several decades preceding the sewage plant upgrades. The Bay Study Group has documented a fourfold increase in the quantity of sea grasses since they began monitoring sea grass in 1986.

Although historical information and current investigations have expanded our understanding of estuarine problems, cooperative scientific studies must continue to evaluate management options for correcting estuarine impairments. Knowledge of estuarine systems lays the foundation for successful management plans.

Looking to the Future: Trends and Needs

Closer Integration with EPA Programs

There is growing concern about impacts on estuaries from air deposition, solid and hazardous waste sites, and contaminated ground water. Several NEP projects are investigating cross-media pollutant sources. The Long Island Sound Study is investigating the role that vehicle emissions play in polluting the Sound. Work at Superfund sites in Puget Sound and Buzzards Bay has been coordinated with NEP projects, but even closer ties between remediation activities at waste sites and estuary projects are needed. Although the New York-New Jersey Harbor estuarine program addresses the problems caused by solid waste, few projects deal directly with trash by encouraging household recycling and waste reduction. With cooperation from the Rhode Island business community, the Narragansett Bay Project is performing hazardous waste audits and encouraging source reduction, recycling, and safer chemical substitution.

Though much interaction among EPA's base programs is under way, more integration is needed at EPA Regional Offices and Headquarters.

A Scientific/Management/ Public Partnership

Using the scientific knowledge gathered and interpreted during the characterization phase ensures that the public, elected officials, and special interest groups–all part of the Management Conference–understand the problems of the estuary and are prepared to support the measures needed to correct the problems.

This process is simple in theory but complex in practice. Scientists do not always agree on the causes of a problem or the solutions. Furthermore, scientists and managers do not always communicate well with each other. In the NEP, managers operate on a 5-year plan; yet scientists rarely operate on a fixed 5-year plan. Under the auspices of the Management Conferences, however, scientists are focusing their research and applying their results to project managers' needs and time constraints. Managers are challenging scientists to direct their studies to meet Management Conference needs for short-term answers. The Management Conference enhances communication between scientists and managers and results in better solutions to management issues.

Members of the public often express concerns about highly visible problems, yet these issues may not be the most important problems for the Management Conference to consider. In fact, spending resources on a highly visible but relatively insignificant problem could divert attention from a crucial matter. It is imperative, therefore, that scientific findings be widely communicated and form the basis for public education efforts.

- Faced with diverse constituencies, each with a different idea of what constitutes a monitoring program appropriate for Santa Monica Bay, the Santa Monica Bay Restoration Program held a 2-day consensus-building conference for scientists, managers, dischargers, regulators, and public interest group representatives. The conference goal was to outline monitoring objectives that would guide the development of detailed hypotheses and sampling and analysis plans. Conference participants were led through a set of structured exercises that focused on the overall concerns driving the regulatory/monitoring system, agreement on a monitoring philosophy for the Bay, and determination of which Bay resources were the most highly valued. These exercises were followed by a decisionmaking process through which specific monitoring objectives were developed. The selected objectives reflected management goals, scientific knowledge, and public concerns.

Every estuary program in the NEP has a public participation and education component. Solutions to pollution problems are grounded in scientific information, but protection of habitats and commitment to action are dependent upon public education. Through education and participation, the public gains an understanding of the estuary and its problems, the will to act to solve immediate problems, and the desire to be stewards of the ecosystem for the future.

IT IS IMPERATIVE that scientific findings be widely communicated and form the basis for public education efforts.

ONE OF OUR MAJOR CHALLENGES is to control nonpoint sources resulting from population growth and their impacts on estuarine habitats.

Priority Concerns

The public, in partnership with scientists and government managers, faces enormous challenges compounded by the population growth projected to continue in the coastal zone well into the 21st century. We will need to manage this growth more effectively to protect our coastal resources. Critical management areas that must be addressed include general growth and development, nonpoint sources, and natural habitat destruction.

Growth and Development

Coastal population growth and development patterns disrupt natural processes in coastal ecosystems and threaten both the ecologic and economic values of estuaries. As we approach the year 2000, we must improve conventional pollution controls and accelerate enforcement actions. However, new strategies are required to solve the more complex problems brought about by increasing pressure to develop rural areas and sensitive pristine areas.

Shoreline development often strips vegetation and eliminates wetlands, which exposes the land to erosion. Increased sedimentation in shallow waters chokes underwater grasses and threatens fish and shellfish habitats. Development near shorelines also damages life-sustaining habitats for shore birds and animals.

As development replaces vegetation with less pervious surfaces (such as buildings, parking lots, and roads), rainwater cannot seep slowly into the soil and replenish ground water. Instead, storm water runs off the impervious surfaces, collecting pollutants deposited from the air, and delivers the pollutants directly into surface waters. Without wetlands and other vegetated areas, the land cannot filter pollutants from storm water runoff before it enters estuarine waters. Looking ahead, our major challenge is controlling nonpoint sources resulting from population growth and their impacts on estuarine habitats.

Nonpoint Source Control

Section 319 of the Clean Water Act provides funding for some nonpoint source control projects in estuarine waters (see Chapter 11 for a full discussion of the Section 319 Nonpoint Source Program). States employ both voluntary and regulatory controls to encourage implementation of best management practices to minimize nonpoint source pollution generated by agriculture, construction, silviculture, marinas, and urbanization.

The 1990 amendments to the Coastal Zone Management Act (CZMA) require States with federally approved coastal zone management programs to develop nonpoint source pollution control programs in coastal areas. Each State's program will consist of selected management measures for source categories, such as construction, marinas, and agriculture. The States will develop and implement the coastal nonpoint source programs through existing State coastal zone management programs administered by NOAA under Section 306 of the CZMA and State nonpoint source programs administered by EPA under Section 319 of the Clean Water Act.

In January 1993, EPA issued *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* and NOAA and EPA jointly issued *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance*. Please turn to Chapter 15 for additional information about the Coastal Nonpoint Source Pollution Control Program.

Habitat Protection

NEP projects are looking beyond traditional pollution control approaches toward strategies that address total estuarine ecosystem health. These strategies base habitat protection plans on a scientific understanding of how ecosystems function. These long-term strategies require further coordination of research and monitoring activities performed by EPA, NOAA, individual NEP projects, marine academic institutions, and other Federal and State agencies.

While long-term strategies are being developed, management conferences act locally to address immediate threats to estuarine habitats. For example, management conferences limit fish harvesting, replant seagrass beds, seek building restrictions such as setback requirements, create land conservation areas, and curb harmful uses of waterways. Such efforts are not implemented in all NEP sites but will likely be more widespread in the future.

Management conferences will need to work even more closely with agencies such as the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers to improve our understanding of habitat problems and develop new technologies to mitigate adverse impacts. Examples of new technologies include stabilizing shorelines with vegetation instead of bulkheads and techniques for creating wetlands. EPA is working with Management Conferences to increase habitat mitigation activities, such as removing dams blocking fish migrations and eliminating freshwater diversions.

Steps in the Right Direction

The NEP recognizes that it may take decades to fulfill Congress' directive to restore and protect estuaries of national significance. In the short term, however, progress continues. Each estuary project in the NEP is focusing on the key environmental problems in its estuary and integrating protection efforts conducted by Federal, State, and local agencies. NEP projects are considering air and land pollution sources in addition to controls for traditional point source polluters. Finally, NEP projects are developing restoration and protection strategies based upon an understanding of estuarine ecosystem functions and encouraging the public to care for estuarine ecosystems.

The Great Waters Program

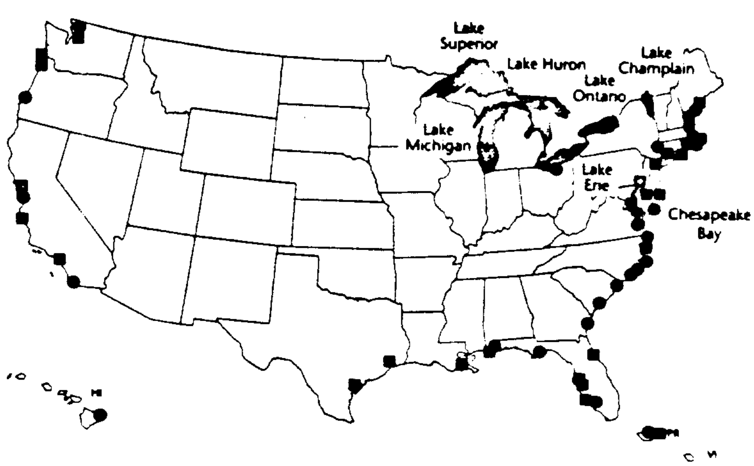
Introduction

Section 112(m) of the 1990 Amendments to the Clean Air Act directs EPA, in cooperation with NOAA, to assess the atmospheric deposition of hazardous air pollutants (HAPs) to the Great Lakes, Lake Champlain (bordering Vermont and New York), Chesapeake Bay, and coastal waters in the National Estuary Program and the National Estuarine Reserve System (Figure 12-15). The main objective of this assessment is to provide a biennial report to Congress on the issue of atmospheric deposition to the Great Waters. The essential goal of the Great Waters Program is to evaluate whether the problem of atmospheric deposition to these aquatic ecosystems is a significant one, and, if so, what should be done to prevent adverse effects on human health and the environment.

Specifically, Section 112(m) requires that EPA establish deposition monitoring networks in the Great Waters, as well as conduct additional study, such as assessing sources and deposition rates, evaluating adverse effects, research on monitoring methods, and biotic sampling. The reports to Congress address three main issues: (1) the contribution of atmospheric deposition to total pollutant loading to the Great Waters; (2) the adverse effects on human health and the environment; and (3) sources of the pollutants. In addition, EPA must determine whether the other regulatory programs under Section 112 are "adequate to prevent serious adverse effects to public health and serious or widespread environmental effects, including those effects resulting from indirect exposure pathways." EPA must then promulgate such changes under Section 112 that may be necessary to prevent adverse effects and make recommendations regarding any regulatory changes under any other applicable Federal legislation necessary to ensure protection of human health and the environment.

Figure 12-15

Locations of Designated Great Waters



- ✦ Great Waters designated by name
- ■ EPA National Estuary Program (NEP) Sites
- ● NOAA NERRS Designated Sites*
- ◻ Existing EPA and NOAA NERRS Designated Sites
- ◻ Existing EPA and NOAA NERRS Proposed Sites

*NOAA = National Oceanic and Atmospheric Administration
NERRS = National Estuarine Research Reserve System

Progress Under Section 112(m)

EPA has made progress implementing the specific monitoring requirements of Section 112(m). In 1992, EPA established five master (regional background) stations to collect wet and dry toxics deposition samples at each of the Great Lakes as part of the Integrated Atmospheric Deposition Network, a joint effort between the United States and Canada. EPA and the

Chesapeake Bay States began collecting toxics samples at three stations on the Bay in 1990. EPA is also involved in mercury deposition monitoring on Lake Champlain and interacts with a State-run toxics deposition program for the Lake.

EPA has implemented many other activities to expand our understanding of atmospheric deposition of HAPs and related risks to human health and the environment:

- Conducted an extensive literature review and supported the development of three background documents leading up to preparation and release of the first Great Waters Program Report to Congress in May 1994

- Assessed the 1990 Amendments' list of 189 HAPs to determine which HAPs are most likely to be problematic when deposited in aquatic systems

- Preparing a national screening level emission inventory for specific pollutants in Section 112(c)(6), as well as assisting the Great Lakes States in developing a comprehensive toxics emission inventory and database system

- Developing prototype long-range mercury transport models and indirect mercury exposure models

- Conducting sampling to evaluate deposition to Galveston Bay and Tampa Bay with methods that will complement other Great Waters work

- Analyzing existing ambient air metals samples for the Gulf of Mexico States

- Conducting a scoping level mass-balance for nitrogen in the Gulf of Mexico

- Assessing the urban contribution to atmospheric loading, as well as evaluating other processes and parameters through field measurements for use in modeling

- Evaluating chemical exposure and health effects from consumption of Great Lakes fish with the Center for Disease Control's Agency for Toxic Substances and Disease Registry (ATSDR)

- Monitoring air toxics with EPA Region 5, the Southeast Chicago Initiative, and ATSDR

- Participating in development of a Lake Michigan Mass Balance for four high-priority chemicals.

Many of these activities are performed with cooperating Federal, State, and local agencies. EPA also leverages relevant activities performed by other agencies, including the Lake Michigan Urban Air Toxics Study, metals and NO_x monitoring in Chesapeake Bay, sample analysis for the Integrated Atmospheric Deposition Study, the Great Lakes regional toxics emission inventory, and the compilation of available emissions inventory data on a national scale.

The Great Waters Report to Congress

In May of 1994, EPA's Office of Air Quality Planning and Standards submitted the first Great Waters Program Report to Congress, *Deposition of Air Pollutants to the*

Great Waters. This first Report to Congress summarizes the current understanding of atmospheric deposition of toxic chemicals to the Great Waters and identifies key regulatory and research needs.

EPA and NOAA relied heavily on participation by independent scientists to help prepare *Deposition of Air Pollutants to the Great Waters*. As a first step, EPA sponsored a literature search on the topic of atmospheric deposition of chemicals to surface waters, identifying more than 1,100 scientific publications. EPA then convened three committees of leading independent scientists and charged them with evaluating and summarizing the literature in the three areas identified in Section 112(m):

- Adverse human health and environmental effects of atmospheric deposition to the Great Waters

- Relative atmospheric loadings to the Great Waters

- Sources contributing to atmospheric deposition in the Great Waters.

Each committee prepared a draft paper that was the topic of discussion at a workshop sponsored by EPA in the fall of 1992. Attendees of the workshop included committee members, other independent scientists, EPA scientists, EPA program representatives, and representatives from groups such as NOAA, State agencies, industry, and environmental groups. Following the workshop, the committees prepared final background documents that became the foundation for the Report to Congress. The contents of the Report to Congress are summarized below.

Exposure and Effects of Atmospheric Deposition

Over the past three decades, scientists have collected a large and convincing body of evidence showing that toxic chemicals released to air can travel long distances and be deposited on land or water at locations far from their original sources. Perhaps most notably, it appears that PCBs and some other pollutants that are persistent in the environment (including several pesticides that have not been used in significant amounts in the United States since the 1970s) have become widely distributed in the environment. These toxic chemicals remain in our environment and continue to cycle between air, water, soil, and biota (living organisms) even after their manufacture, use, or release has stopped. Their persistence increases the potential for exposure to these toxic chemicals.

Pollutants of concern (see sidebar) also accumulate in body tissues and magnify up the food web, with each level accumulating the toxics from its diet and passing the burden along to the animal in the next level of the food web. Top consumers in the food web, usually consumers of large fish, may accumulate chemical concentrations many millions of times greater than the concentrations present in the water. Fish consumption advisories have been issued in hundreds of waterbodies nationwide, including the Great Lakes, as a result of unsafe concentrations of chemicals in fish

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due to biomagnification (see Chapter 7 for more information about fish consumption advisories).

Significant adverse effects on human health and wildlife have been observed due to exposure (especially through fish consumption) to persistent pollutants that bioaccumulate. Adverse effects range from immune system disease and reproductive problems in wildlife to subtle developmental and neurological impacts on children and fetuses. Although most of the chemicals of concern are probable human carcinogens, many are also developmental toxicants capable of altering the formation and function of critical body systems and organs. Therefore, developing embryos, fetuses, and breast-fed infants are particularly sensitive to these chemicals through exposure of the mother.

Ecological effects attributable to pollutants of concern are significant and can be subtle or delayed in onset, such as immune function

Bioaccumulative Chemicals of Concern	Potential Bioaccumulative Chemicals of Concern
Aldrin	Benzo[*a*]pyrene; 3,4-benzopyrene
4-Bromophenyl phenyl ether	3,4-Benzofluoranthene; benzo[*b*]fluoranthene
Chlordane	11,12-Benzofluoranthene; benzo[*k*]fluoranthene
4,4-DDD; p,p-DDD; 4,4-TDE; p,p-TDE	1,12-Benzoperylene; benzo[*ghi*]perylene
4,4-DDE; p,p-DDE	4-Chlorophenyl phenyl ether
4,4-DDT; p,p-DDT	1,2:5,6-Dibenzanthracene; dibenz[*a,h*]anthracene
Dieldrin	Dibutyl phthalate; di-n-butyl phthalate
Endrin	Indeno[1,2,3-cd]pyrene; 2,3-o-phenylene pyrene
Heptachlor	Phenol
Heptachlor epoxide	Toluene; methylbenzene
Hexachlorobenzene	
Hexachlorobutadiene; hexachloro-1,3-butadiene	
Hexachlorocyclohexane; BHC	
a-Hexachlorocyclohexane; α-BHC	
b-Hexachlorocyclohexane; β-BHC	
d-Hexachlorocyclohexane; δ-BHC	
Lindane; γ-BHC; γ-hexachlorocyclohexane	
Mercury	
Methoxychlor	
Mirex; dechlorane	
Octachlorostyrene	
PCBs; polychlorinated biphenyls	
Pentachlorobenzene	
Photomirex	
2,3,7,8-TCDD; dioxin	
1,2,3,4-Tetrachlorobenzene	
1,2,4,5-Tetrachlorobenzene	
Toxaphene	

Source: U.S. Environmental Protection Agency, Proposed water quality guidance for the Great Lakes system: Proposed rule and correction, *Federal Register* 58:20802-21047, April 16, 1993.

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impairment, reproductive problems, or neurological changes—all of which can affect population survival. Other adverse ecological effects are caused by nitrogen compounds. Atmospheric sources of nitrogen exacerbate nutrient enrichment (or eutrophication) of coastal waterbodies, which results in impacts that range from nuisance algal blooms to the depletion of oxygen and resultant fish kills.

Relative Pollutant Loadings from Atmospheric Deposition

Studies show that significant portions of loadings to the Great Waters of the pollutants of concern are coming from the atmosphere. For example, 76% to 89% of the loadings of PCBs to Lake Superior and up to 40% of the loadings of nitrogen into the Chesapeake Bay are estimated to come from air pollution. However, insufficient data are available to quantify the overall relative atmospheric loadings for all of the HAPs entering all of the Great Waters. Therefore, relative loadings estimates are, and will continue to be, chemical-specific and waterbody-specific. The absolute quantity of atmospheric loadings also warrants attention because even small loadings of pollutants that bioaccumulate can result in significant pollutant burdens in fish and, ultimately, in humans.

Sources of Atmospheric Pollutant Loadings

Pollutants of concern in the Great Waters originate from both local and distant sources. Many sources of atmospheric pollutants that enter the Great Waters have been identified, including waste incinerators at industrial and municipal facilities, power plants, petroleum refineries, motor vehicles, various manufacturing processes, and residential combustion of fossil fuels. However, determining the particular sources responsible for deposited pollutants is quite difficult because a combination of sources generate the atmospheric loadings entering any particular waterbody, and transport distances vary depending on the characteristics of the chemicals, emissions, and weather conditions. Additional data are needed to identify and characterize the specific sources responsible for pollutants that are deposited to the Great Waters.

Recommendations and Actions

EPA considered the implications of action and inaction, while also recognizing that Section 112(m) mandates that EPA should act to "prevent" adverse effects and to "assure protection of human health and the environment." EPA recommends that reasonable actions are justified by the available scientific information and should be implemented now while research continues. Although there are significant uncertainties in the available information, there is enough convincing evidence to prompt action. Adverse effects of the chemicals of concern are evident and studies of selected waters show that significant proportions of toxic pollution come from the atmosphere. EPA believes that the characteristics of toxicity, persistence, and tendency to bioaccumulate warrant special treatment of the

Great Waters pollutants of concern. However, the actions recommended by EPA focus on chemicals of concern rather than specific sources because the linkage between specific sources and subsequent deposition and effects has yet to be demonstrated. NOAA concurs with the principles of this policy.

EPA's recommendations for action fall into three strategic themes. First, EPA will continue ongoing efforts to implement Section 112 and other sections of the Clean Air Act and use the results of the Report to Congress in the development of policy that will reduce emissions of Great Waters pollutants of concern. Under this theme, EPA will take actions that include: publishing emission standards affecting important chemicals of concern ahead of schedule, where possible; evaluating the adequacy of control technologies for important pollutants; publishing an advance notice of proposed rulemaking (ANPR) for establishment of lesser-quantity emission rates (LQERs) to define smaller sources to be regulated as major sources and evaluating which Great Waters pollutants warrant establishment of an LQER; evaluating which area sources should be regulated with maximum achievable control technology (MACT); and considering appropriate emission levels requiring regulation when sources are modified.

Second, EPA recognizes the need for an integrated multimedia approach to the problems of the Great Waters and, therefore, will utilize authorities beyond the Clean Air Act to reduce human and environmental exposure to pollutants of concern. Under this theme, EPA will take actions that include using the Great Waters Core Project Management Group as a coordinating body to communicate with other offices and agencies. The objectives will be to coordinate work and especially to identify lead offices to implement recommendations; support changes to the Clean Water Act that address nonwaterborne sources of water pollution; address the exportation of banned pesticides; emphasize pollution prevention efforts to reduce environmental loadings of pollutants of concern; and facilitate information sharing between EPA and other agencies.

Third, EPA will continue to support research activities and will develop and implement a program strategy to define further necessary research. Under this theme, EPA will take actions that include focusing research planning on a mass-balance approach to determine relative loadings; using an appropriate mix of monitoring, modeling, and emission inventory tasks in conducting mass-balance work; assessing the need for tools to be developed for risk assessment for total exposure to pollutants of concern and for regulatory benefits assessment; and continuing to support ongoing research efforts.

Copies of the first Great Waters Program Report to Congress, *Deposition of Air Pollutants to the Great Waters*, can be obtained, as supplies permit, from the Library Services Offices (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, or, for a nominal fee, from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161, phone: 1-800-553-NTIS or 703-487-4650. The NTIS number for the Report to Congress is PB94-203 320. The following technical support documents may also be obtained from NTIS: the Effects Support Document (PB95-166 997), the Relative Loading Support Document (PB95-166 963), and the Sources Support Document (PB95-155 040).

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Waters of the Ohio River and Tennessee River Basin – A Vital Natural Resource

About This Highlight...

You may notice that this highlight is a little different from the rest of this report. It covers an entire river basin rather than a single State, it summarizes information on use support by hydrologic unit, and the style and format are (hopefully) easier for general audiences to understand.

These features are the result of recommendations on how to improve communication of environmental information to the public that were developed by the Intergovernmental Task Force on Monitoring, a group working to improve water quality monitoring nationwide. The chapter also incorporates similar suggestions from an EPA working group. If these changes are well received, we will incorporate them more extensively in the next *National Water Quality Inventory* and in other related publications.

From trout streams in the mountains of western Pennsylvania to industrial ports along the Ohio and Tennessee Rivers, waters of the Ohio River and Tennessee River basin play a vital role in the economy and quality of life in a part of the United States roughly the size of France. Covering parts of 14 States, the Ohio and Tennessee River basin provides a place to live and work for over 26 million people.

Water Uses

Pittsburgh, Cincinnati, Louisville, Columbus, Indianapolis, Chattanooga, Nashville, and hundreds of other towns depend on the basin's rivers to provide water for their residents and industries. Shippers rely on the nearly 2,600 miles of navigable waterways for reliable, cost-effective transportation of raw materials and other commodities.

Power plants in the Ohio and Tennessee River basin produce about 10% of the Nation's electricity and are strategically located along waterways so they will have adequate supplies of cooling water for operation. Farmers irrigate their crops with water from these streams and lakes to help feed their families and the Nation.

Boaters, skiers, swimmers, anglers, kayakers, and other water sports enthusiasts use the basin's many lakes and streams to satisfy their recreational interests, pumping millions of dollars into local economies. And the thousands of species of fish, mussels, insects, birds, and other wildlife that spend at least part of their lives in the basin's lakes and streams are the food web that supports recreational and commercial fishing, waterfowl hunting, and many other commercial enterprises.

Water Use Designation and Criteria

To help ensure that the Ohio and Tennessee River basin's waters are clean enough to support these varied uses, each State specifies the uses each of the

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waters in its borders should support. For each designated use, the States and EPA have developed a set of water quality criteria that the waterbodies must meet.

These criteria include limits on chemical contaminants, and many States now include standards for the integrity of aquatic biological communities, particularly for those waters classified for supporting aquatic life uses.

How Clean Are the Waters of the Ohio River and Tennessee River Basin?

Good News for Aquatic Life

About 75% of the streams and river miles surveyed in the Ohio and Tennessee River basin fully support aquatic life uses, and another 15% partially support those uses. For 5% of the fully supporting category, there is some threat to that status. Only 10% of surveyed stream miles are judged as not supporting aquatic life uses, based on evaluation guidelines recommended by EPA.

. . . And for Recreation

For water contact recreation such as swimming, wading, and skiing, 78% of surveyed miles fully support those uses, with about 5% of that category also threatened. For 14% of the surveyed miles, water quality is not good enough to support contact recreation.

How About Drinking Water?

Only about 2% of the basin's waters were evaluated for their suitability as sources of drinking water supplies. Most of the surveyed reaches (78%) fully support this use, with that support threatened for about 5%. For only 7% is water quality so poor that, based on EPA guidelines, they do not support this use.

What's the Big Picture for the Ohio River and Tennessee River Basin?

Although it's reassuring that most of the streams surveyed in the Ohio and Tennessee River basin fully support a variety of uses, most of us want to know how our area compares with others, and whether any of the problem streams are nearby.

Figure 1 summarizes information on aquatic life use support for the whole Ohio and Tennessee River basin. Each area in the map represents land that drains into one moderate-sized stream or stream segment. Each area is shaded with one of five patterns based on the relative amount of stream miles that fully support aquatic life uses versus the amount that does not support aquatic life uses, according to EPA guidance.

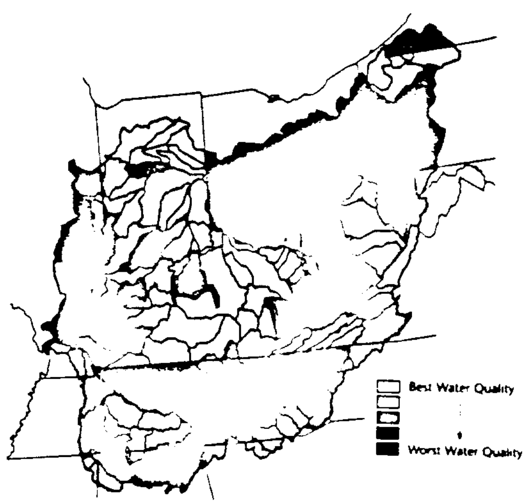

Figure 1. Aquatic life use support: Ohio River and Tennessee River subbasins.

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The map points out some important facts about comparing information across broad areas. How well you can evaluate use support throughout a large basin depends on the availability of enough of the right information and on States using comparable assessment techniques and interpretations. For example, there is a distinct boundary along the Ohio-Indiana border between relatively good conditions for aquatic life use support in Indiana and relatively poor conditions in Ohio. In reality, there probably isn't much difference in stream quality, but Ohio has much more information available, and depends heavily on biological data to evaluate aquatic life use support. Similar use support boundaries are apparent along several other State lines in this map.

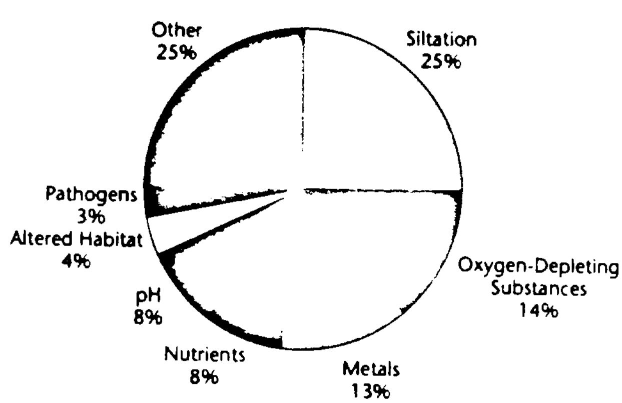


Figure 2. Pollutants and processes impairing aquatic life use in the Ohio River and Tennessee River Basin.

What Are the Main Pollutants? And Where Do They Come From?

Pollutants

As Figure 2 illustrates, Ohio and Tennessee River basin States report that siltation impairs aquatic life in more stream miles than any other pollutant. Organic enrichment, such as inadequately treated wastes, runoff from confined animal production operations, and some types of industrial wastes, is the second largest category of pollutant impairing aquatic life uses.

The States report that bacterial contamination is the main reason some streams are not suitable for swimming and other contact recreation uses. Only two States reported on causes of nonsupport for drinking water supply uses, citing pesticides and other toxic organic chemicals as the main problem.

The most common contaminants that cause Sates to issue advisories about limiting or avoiding consumption of certain fish are PCBs, chlordane, and mercury.

Sources

Mining and other types of resource extraction, including petroleum extraction and processing, are the most common source of pollutants in the Ohio and Tennessee River basin (see Figure 3). Without proper controls, these types of activities are sources of siltation, acidity, and metals contamination of streams.

Agricultural sources are the second largest source category, contributing silt, nutrients, bacteria, and organic enrichment to streams. Within this category, cropland and pastureland are the largest sources, followed by animal holding and management areas and feedlots.

But Isn't Sewage Responsible for Most Pollution?

The third largest category of pollutant sources is all types of urban activities. Together, urban runoff and wastewater treatment plant discharges account for almost as many impaired stream miles as do agricultural sources.

So, What's the Bottom Line?

The most important message from this summary of conditions throughout the Ohio and Tennessee River basin is that our Nation's water pollution control programs are working. Most of the region's streams are suitable for people to use for fishing, swimming, and obtaining water to be treated and distributed to their homes.

In addition, the basin's streams and rivers support a productive economy, providing habitat for fish, cooling and process waters for industries, navigation for raw materials, and a place for the public to recreate.

Perhaps the second most important message is that the work of protecting and improving water quality is never done, and it is everyone's business. As control of wastewater discharges improves, runoff from city streets, home lawns, pastures and croplands, and other land disturbances become a bigger part of the equation.

But these "nonpoint" sources are much more difficult to control. Effective reduction of pollution from these sources requires individuals to accept responsibility for how their actions affect water quality. All of us—farmers, homeowners, contractors, students, motorists—have to recognize our contributions to the problem and change the way we do things!

Where Did the Data Come From? How Complete Are They?

The information in this chapter is based on assessments reported by the 14 Ohio River and Tennessee River basin States. Of the basin's 255,000 miles of streams, they collectively reported on 83,000 miles (33%) for aquatic life use support, 44,000 miles (17%) for contact recreation, and 6,200 miles (2%) for drinking water. No information on lakes, wetlands, or ground water is included in this highlight, simply because it wasn't practical to try to evaluate that information for the whole Ohio and Tennessee River basin with the time and resources available.

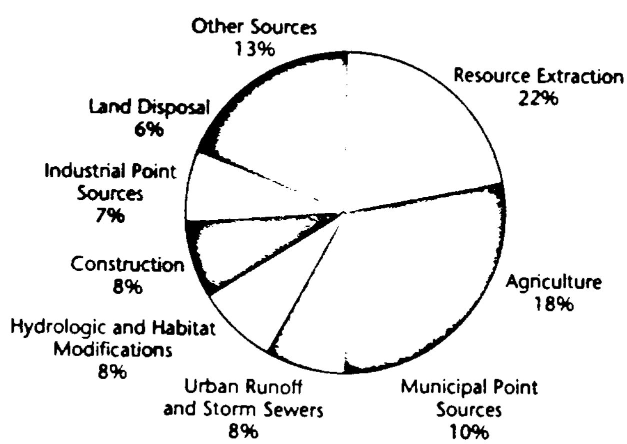
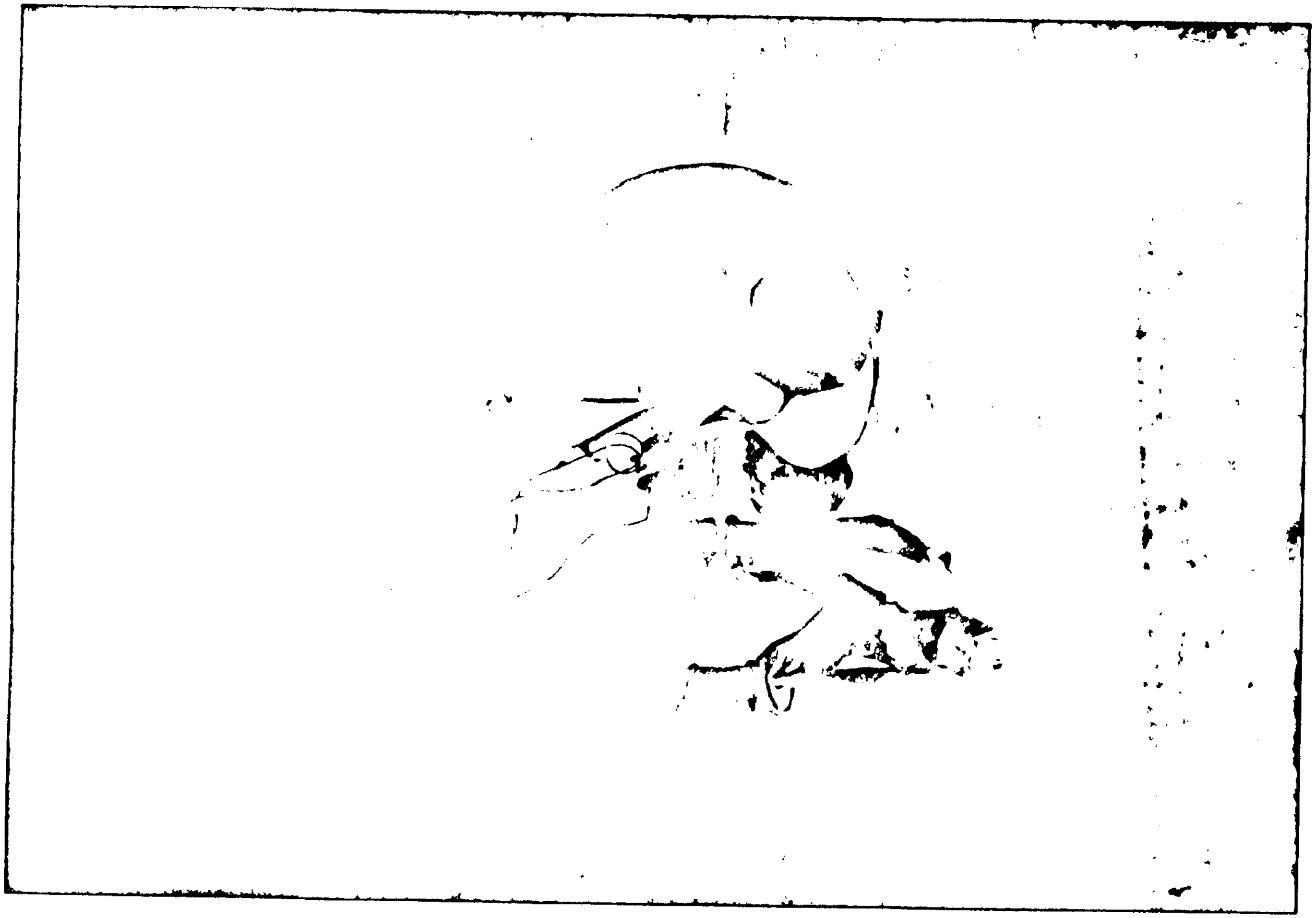


Figure 3. Sources of pollutants and processes impairing aquatic life use in the Ohio River and Tennessee River Basin.

Phil Johnson, U.S. EPA, Region 8



Water Monitoring and Assessment Programs

Introduction

Water quality monitoring is essential for an understanding of the condition of water resources and to provide a basis for effective policies that promote wise use and management of those resources. A large number of Federal, Tribal, State, and local agencies and private sector organizations currently collect water quality information for a wide range of purposes that can generally be divided into five categories: (1) status and trends, (2) detection of existing and emerging problems and setting priorities among them, (3) designing and implementing programs, (4) evaluating program or project success, and (5) emergency response monitoring.

Numerous public and private groups conduct many and varied monitoring programs to fulfill one or more of these purposes. This chapter discusses current conditions of water resource quality monitoring in the United States and efforts to establish an integrated nationwide monitoring strategy.

Overview of National Monitoring Activity

Water resource quality monitoring is conducted by Federal, interstate, State, local, and Tribal agencies, as well as public, private, and volunteer organizations. A recent study undertaken by the Intergovernmental Task Force on Monitoring Water Quality indicates that 18 Federal agencies conduct approximately 141 separate monitoring programs across the country, as do all States and Territories, local governments, and an increasing number of American Indian Tribes.

At the Federal level, ambient water quality data are collected by the U.S. Geological Survey, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the Bureau of Reclamation, the National Park Service, EPA, National Oceanic and Atmospheric Administration, the Tennessee Valley Authority, the Bonneville Power Administration, the U.S. Army Corps of Engineers, the Bureau of Land Management (BLM), and various other organizations within the Departments of Agriculture (USDA), Energy, Defense (DOE), and Interior. Of this group, the USGS, FWS, EPA, NOAA, and TVA have either long-term regional or both regional and national programs for water quality monitoring. The other agencies and organizations monitor ambient water quality primarily at site-specific or project scales, usually for limited periods of time.

Results from Federal monitoring programs have provided important information at the national and

In addition to monitoring performed by States, Tribes, and Territories,

18 FEDERAL AGENCIES

conduct 141 monitoring programs across the country.

MONITORING DATA are needed to characterize water quality and assess the effectiveness of water management and regulatory programs.

regional scales. For example, USGS data indicate that fecal bacteria counts and total phosphorus concentrations have decreased at a considerable number of stations across the United States from the late 1970s to the late 1980s. The FWS and NOAA data show that bioaccumulation of trace elements, pesticides, and trace industrial compounds has occurred at many locations in our rivers, estuaries, and near-coastal areas. And data from EPA monitoring indicate substantial improvement in the phosphorous concentrations of the Chesapeake Bay during the past 6 years.

Similarly, within each State, both State and local monitoring programs have provided the data to characterize State water resource quality and assess the effectiveness of water management and regulatory programs. A growing number of Tribes are also monitoring their water resources. Contributing to the picture are the monitoring programs run by industrial and municipal dischargers, by private groups, and by volunteer monitoring organizations.

This wealth of information from individual agencies, however, cannot be easily aggregated to provide an overview of national water quality conditions because of inconsistencies among the various agencies in monitoring purpose and design as well as data collection methods and assessment procedures. In addition, data are often stored without accompanying descriptors, thus other data users cannot determine if they can use the data for their own purposes.

Effects of Changes in Water Programs

In addition to this multiplicity of effort, water programs themselves are changing, necessitating similar changes in water monitoring activities. The country is moving beyond single-media command-and-control programs into more holistic management programs based on risk assessment and reduction. New emphases include watershed, ecoregion, and geographically based programs; a focus on biological, ecological, and habitat integrity and diversity; wet weather runoff control programs such as those for nonpoint sources, stormwater, and combined sewer overflows; and wetlands and sediment contamination programs. Traditional monitoring programs must be expanded to include assessment of biological and ecological resources and new methods must be developed to identify and control pollution from hard-to-trace, diffuse sources of pollution such as wet weather runoff and sediment contamination.

Intergovernmental Task Force on Monitoring Water Quality

In January of 1992, representatives from EPA, USGS, NOAA, FWS, COE, USDA, DOE, Office of Management and Budget (OMB), and seven State agencies and one interstate agency formed a 3-year

Intergovernmental Task Force on Monitoring Water Quality (ITFM) to prepare a strategy for improving water quality monitoring nationwide. The Tennessee Valley Authority, National Park Service, one State, and one American Indian Tribe, have since been added. The ITFM is part of the implementation of OMB memorandum 92-01 to strengthen coordination of water information across the country. The USGS has lead responsibility for this under its Water Information Coordination Program.

The ITFM is chaired by the U.S. EPA with the USGS as vice chair and Executive Secretariat. To date, over 100 additional Federal, State, and interstate agency representatives have been involved in the deliberations of the ITFM and its six task groups:

- Institutional Framework
- Environmental Indicators
- Methods
- Data Management Sharing
- Assessment and Reporting
- Ground Water.

The ITFM is considering the full range of nationwide water resources, including surface and ground waters, near-coastal waters, associated aquatic communities and habitat, wetlands, and sediment. Water resource protection factors include human and ecological health and the uses designated for the Nation's waters through State and Tribal water quality standards. Monitoring activities include gathering data on physical, chemical/toxicological, and biological/ecological/habitat parameters.

The mission of the ITFM is to develop and implement a national strategic plan to achieve effective collection, interpretation, and presentation of water quality data and to improve the availability of existing information for decisionmaking at all levels of government. To accomplish this, the ITFM has recommended and will facilitate implementation of an integrated nationwide voluntary strategy that will meet the nationwide objectives of various monitoring programs, make more efficient use of available resources, distribute information more effectively, and provide comparable data and consistent reporting of water quality status and trends.

A permanent National Monitoring Council will provide guidelines and support for comparable field and laboratory methods, quality assurance/quality control, environmental indicators, data management and sharing, ancillary data, interpretation techniques, and training. Regional data collection under the national guidelines would provide the needed information for nationwide assessment of water resource quality.

The ITFM and its successor, the National Monitoring Council, are also producing products that can be used by monitoring programs nationwide, such as an outline for a recommended monitoring program, environmental indicator selection criteria, and a matrix of indicators to support assessment of State and Tribal designated uses.

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Major Nationwide Monitoring Programs

■ Environmental Monitoring and Assessment Program (EMAP)

EPA's Office of Research and Development initiated EMAP in 1990 to provide information on the current status and long-term trends in the condition of the ecological resources of the United States. EMAP develops indicators to measure ecological condition, monitors for those indicators, and presents analyses of data in periodic reports. Site selection is based on a random design within natural resource areas so individual results can be interpolated with confidence to the condition of the Nation as a whole. EMAP, in cooperation with NOAA and the FWS, monitors seven resource groups: Near Coastal Waters, Surface Waters, Wetlands, Forests, Arid Lands, Agroecosystems, and Great Lakes.

■ National Acid Precipitation Assessment Program (NAPAP)

During the 1970s, the effects of acid rain on the environment and human health became a major concern for many scientists, public policy officials, public interest groups, the media, and the general population. Reports were published linking emissions from industry, electric power plants, and automobiles with acid rain. Many believed that acid rain damages crops, forests, buildings, animals, fish, and human health. Congress established NAPAP under the Acid Precipitation Act of 1980 to provide the information needed for policy and regulatory decisions on acidic deposition. The areas of investigation addressed by NAPAP Task Groups are Emissions and Controls, Atmospheric Processes, Atmospheric Transport and Modeling, Atmospheric Deposition and Air Quality Monitoring, Terrestrial Effects, Aquatic Effects, and Effects on Materials and Cultural Resources. NAPAP has also developed Assessment Work Groups in the areas of Atmospheric Visibility, Human Health Effects, and Economic Valuation.

■ U.S. Geological Survey, National Water Quality Assessment Program (NAWQA)

The USGS developed NAWQA to provide a nationally consistent description of current water quality conditions for a large part of the Nation's water resources; to define long-term trends (or lack thereof) in water quality; and to identify, describe, and explain, to the extent possible, the major factors that affect observed water quality conditions and trends. This program is concerned with both ground and surface water quality; ultimately, 60 drainage basins will be monitored under this program.

■ U.S. Geological Survey, National Stream Quality Accounting Network (NASQAN)

This network is composed of 420 stations on large rivers, located at the outlets of major drainage basins to collectively measure a large fraction of total runoff in the United States. The stations reflect general water quality conditions in the country. Measurements at NASQAN sites include inorganic constituents, radionuclides, and bacteria, but exclude routine analyses for organic chemicals.

■ U.S. Geological Survey, the Hydrologic Benchmark Network (HBN)

Composed of 55 stations located in relatively pristine headwater basins, this network is designed to define baseline water quality conditions and the effects of atmospheric deposition on water quality. The Network measures inorganic constituents, radionuclides, and bacterial contamination, among other parameters.

Both NASQAN and HBN achieve their objectives but neither is designed to provide a statistically representative sample of basins throughout the Nation, nor are stations in NASQAN purposefully located downstream from industry, municipal, and urban runoff outfalls to isolate and measure maximum impacts. These network design considerations are a component of the NAWQA program.

■ U.S. Geological Survey, the National Atmospheric Deposition Program/National Trends Network

Composed of 200 sampling sites within the interagency NAPAP, this network is designed to determine spatial patterns and temporal trends in chemical wet-only deposition. It supports research into impacts on aquatic and terrestrial ecosystems. Measurements are limited to inorganic constituents only.

■ U.S. Army Corps of Engineers Water Resource Monitoring

The COE routinely monitors physical and chemical water quality parameters at most of its 541 reservoir projects. The Corps monitors to aid in day-to-day operational decision-making, determine status and trends, identify and solve problems, evaluate project performance, and respond to emergencies. In addition, the Corps collects and evaluates water quality data for its hazardous and toxic waste site cleanup program, for special studies such as the Chesapeake Bay Program, and for many other Corps mission responsibilities. Many of these project data sets are temporary and spatially quite extensive, often covering much of a project's watershed and tailwater. There has been a gradual trend toward increasing biological monitoring to evaluate project performance. All data are maintained at local Corps offices.

■ U.S. Fish and Wildlife Service, National Contaminant Biomonitoring Program (NCBP)

This program, now being revised, determines tissue residue levels in fish and birds nationwide. The fish tissue part of the program consists of 110 stations at nonrandomly selected points along the Nation's major rivers and in the Great Lakes. Fish tissues are analyzed for organic contaminants (pesticides and industrial chemicals) and seven elements. Sampling has been conducted on a 2- to 4-year basis since the mid-1960s.

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The National Biological Service

Secretary of the Interior, Bruce Babbitt, proposed the creation of an independent, non-advocacy biological science bureau within the Department of the Interior. The National Biological Service (NBS) provides information and technical assistance. The NBS was created by incorporating elements from eight bureaus within the Department. The NBS has three major functions:

- *biological and ecological research*
- *inventory and monitoring of the Nation's biological resources*
- *information transfer activities.*

The NBS became operational on November 11, 1993.

■ U.S. Fish and Wildlife Service, Biomonitoring of Environmental Status and Trends (BEST) Program

This program, now under development, has three major goals: (1) to determine the status and trends of contaminants and their effect on natural resources; (2) to identify and assess the major factors affecting resources and provide current and predictive information to alleviate impacts; and (3) to provide summary information in a timely manner to decisionmakers and the public. The BEST Program has two major components: FWS lands and FWS trust species and their habitats. Activities include collection and evaluation of existing data for site characterization and bioassessment data from four general categories–ecological surveys, tissue residue, organism health or biomarkers, and toxicity tests/bioassays.

■ U.S. Fish and Wildlife Service, National Wetlands Inventory (NWI) Program

This program determines status and trends of U.S. wetlands to produce comprehensive, statistically valid acreage estimates of the Nation's wetlands. This information is widely distributed and mandated by the Emergency Wetland Resource Act of 1986. To date, more than 32,000 detailed wetlands maps have been completed covering 72% of the coterminous United States, 22% of Alaska, and all of Hawaii and Puerto Rico.

■ National Oceanic and Atmospheric Administration, National Status and Trends Program (NS&T)

NOAA conducts the NS&T, which includes the Benthic Surveillance Program and the Mussel Watch Program. Indicators for determining the effects on marine biotas of contaminated sediments are currently under development. Parameters that are sampled for NS&T include accumulated compounds in the tissues and conditions of physical features of selected biota as well as sediment chemistry.

■ National Oceanic and Atmospheric Administration, National Estuarine Research Reserves

The National Estuarine Research Reserve System was created to protect representative areas of the estuarine environment and to provide a system of protected sites for long-term monitoring and research. It is a State-Federal partnership managed by NOAA under the Coastal Zone Management Act. The Act requires nomination of a reserve site by the Governor of a State and designation by the Secretary of Commerce. Since 1972, NOAA has kept this partnership, and the evolving statutory mission of the program, by providing resources and guidance to the States, by developing national programs, and by shaping the legislation into an operating program. Twenty-one reserves have been designated including sites in Hawaii, Puerto Rico, the Great Lakes, the Gulf of Mexico, the Atlantic Coast, and the West Coast.

■ Tennessee Valley Authority, Water Resource Monitoring

TVA conducts a regional water resource monitoring program to evaluate ecological health and suitability for body-contact recreation of reservoirs and major streams in the Tennessee Valley and to evaluate the suitability for human consumption of fish in those waters. The program includes systematic measurement of physical, chemical, and biological variables at strategic locations. Results are used to draw attention to pollution problems, to set cleanup goals, and to measure the effectiveness of water quality improvement efforts over time. TVA also monitors aquatic plant and mosquito populations around TVA lakes to help target management efforts. Monitoring of conditions in tailwaters below several dams focuses on prioritizing facilities for reaeration of reservoir releases and providing data to evaluate the effectiveness of those efforts.

■ U.S. Department of Agriculture, Resource Conservation Act of 1977

Mandated by the Resource Conservation Act (RCA) of 1977, the USDA is "to provide for furthering the conservation, protection, and enhancement of the Nation's soil, water, and related resources for sustained use." In recognition of the importance of, and need for, obtaining and maintaining information on the current status of soil, water, and related resources, USDA makes a continuing appraisal of the soil, water, and related resources of the Nation. The objective of the appraisal currently under way is to present information to assist policy decisionmakers and program managers to form better policies and programs to address soil, water, and other environmental concerns for the next 2 decades.

RCA appraisals include data on: the quality and quantity of soil, water, and related resources, including fish and wildlife habitats; the capability and limitations of those resources for meeting current and projected demands on the resource base; the changes that have occurred in the status and condition of those resources resulting from various past uses, including the impact of farming technologies, techniques, and practices; and the current Federal and State laws, policies, programs, rights, regulations, ownerships, and their trends and other considerations relating to the use, development, and conservation of soil, water, and related resources.

Developed by the Interagency Work Group on Water Quality, the *Guide to Federal Water Quality Programs and Information* is an attempt to inventory all significant Federal water quality programs and information of national scope or interest. The guide contains information on (1) factors affecting water quality including underlying demographic pressures; use of the land, water, and resources; and pollutant loading; (2) ambient water quality information, including biological, chemical, and physical/ecological conditions; (3) other effects of water pollution including waterborne disease outbreaks; and (4) a listing of programs established to preserve,

For a description of other Federal water quality programs, see the Guide to Federal Water Quality Programs and Information, *available from EPA's Public Information Clearinghouse at (202) 260-7751.*

protect, and restore water quality. For a copy of the Guide, contact EPA's Public Information Clearinghouse (PIC) at (202) 260-7751.

Office of Water Programs to Support Monitoring

Environmental Indicators

The EPA Office of Water (OW) is developing a strategic plan that outlines its future directions and articulates its goals. To measure success toward these goals, OW is establishing indicators to accurately characterize the health of national water resources and measure how well the waters meet their designated uses. This effort has identified data sources to track the indicators. Future indicator development activities include developing comparable monitoring and reporting mechanisms by working with other agencies and national trends programs, such as EPA's EMAP and USGS' NAWQA, through the ITFM.

> EPA's OFFICE OF WATER is developing indicators to characterize the health of national water resources.

Monitoring Program Grant Guidance

EPA gives grants to States to assist them in administering pollution prevention and control programs, including monitoring activities. EPA, working with States and the ITFM, has developed an outline for a recommended monitoring program. A comprehensive monitoring program would include both ambient monitoring and monitoring to determine the effectiveness of individual projects and individual programs designed to protect waterbodies or control sources of pollution. Recommended elements of a monitoring program include monitoring program objectives; a monitoring design description; written protocols that are comparable with others; analytical laboratory support; quality assurance and quality control procedures; data storage, management, and sharing; water resource assessment and reporting; training; and integration of work with partners, including volunteer monitoring groups.

305(b) Consistency Workgroup

The 305(b) Consistency Workgroup, convened in 1990, was expanded in 1992 and 1994 to address issues of consistency in water quality reporting and to improve accuracy and coverage of State assessments. The 1994 305(b) Consistency Workgroup consists of representatives of 23 States, 3 Tribes, 1 Territory, 1 Interstate Commission, 6 Federal agencies, the 10 EPA Regions, and EPA Headquarters. This standing workgroup, which will develop future 305(b) guidance, makes recommendations to improve each iteration of guidance to the States. Recent recommendations have included refining total State waters estimates and providing more detailed guidance for aquatic life use support assessments, including appropriate methods for using biological data along with physical and chemical data.

Water Monitor Newsletter

Since the early 1980s, EPA has issued a regular status report on monitoring activities at EPA and among the States. Now known as the *Water Monitor*, this report provides monthly updates on State, EPA Regional, and EPA Headquarter activities in areas such as biological monitoring, total maximum daily load development, biological criteria and protocol development, volunteer monitoring, and the watershed approach. New documents and upcoming meetings are highlighted. To obtain a copy or be placed on the mailing list for the *Water Monitor*, write to Editor, *Water Monitor*, AWPD (4503F), 401 M St. SW, Washington, DC 20460.

Biological Monitoring

The Biological Criteria Program

Priorities established since 1987 (initiated jointly by the States and EPA) encourage the States to first develop, and then adopt as appropriate, narrative and quantitative biological criteria (biocriteria) into their water quality standards and assessment programs. This successful approach has resulted in about 30 States developing quantitative biocriteria, including three States that formally adopted quantitative biocriteria into their water quality standards. For the status of specific State programs, please refer to Appendix G.

To support this priority, the Agency has provided guidance for development and implementation of biocriteria (see sidebar). Several future guidance documents will provide additional technical information to facilitate activities directed toward that implementation. When fully implemented, biocriteria will expand and improve water quality standards programs, help to quantify impairment of beneficial uses, and aid States and Tribes in setting program priorities. These criteria will be useful because they provide for

BIOLOGICAL CRITERIA directly measure the condition of the living resource at risk.

EPA Publications About Developing and Implementing Biocriteria

USEPA. 1993. *EPA Region 10 In-Stream Biological Monitoring Handbook (for Wadeable Streams in the Pacific Northwest).* G.A. Hayslip (ed.). EPA-910-9-92-013. Region 10, Environmental Services Division, Seattle, Washington.

USEPA. 1992. *Procedures for Initiating Narrative Biological Criteria.* EPA 822-B-92-002. Office of Water, Office of Science and Technology, Washington, DC.

USEPA. 1991. *Biological Criteria: State Development and Implementation Efforts.* EPA-440-5-91-003. Office of Water, Washington, DC.

USEPA. 1991. *Biological Criteria: Guide to Technical Literature.* EPA-440-5-91-004. Office of Water, Washington, DC.

USEPA. 1991. *Biological Criteria: Research and Regulation. Proceedings of a Symposium.* EPA-440-5-91-005. Office of Water, Washington, DC.

USEPA. 1991. *Policy on the Use of Biological Assessments and Criteria in the Water Quality Program.* Office of Water, Office of Science and Technology, Washington, DC.

USEPA. 1991. *Technical Support Document for Water Quality-based Toxics Control.* EPA 505-2-90-001. Office of Water, Washington, DC.

USEPA. 1990. *Biological Criteria: National Program Guidance for Surface Waters.* EPA 440-5-90-004. Office of Water Regulations and Standards, Washington, DC.

USEPA. 1990. *Proceedings of the 1990 Midwest Pollution Control Biologists Meeting.* W.S. Davis (ed.). EPA-909-9-90-005. Region 5, Environmental Sciences Division, Chicago, Illinois.

USEPA. 1987. *Report to the National Workshop on Instream Biological Monitoring and Criteria.* Office of Water Regulations and Standards, Instream Biological Criteria Committee, Region 5, and Environmental Research Laboratory-Corvallis, Washington, DC.

USEPA. 1987. *Surface Water Monitoring: A Framework for Change.* Office of Water and Office of Policy, Planning, and Evaluation, Washington, DC.

direct measurement of the condition of the living resource at risk, detect problems that other methods may miss or underestimate, and provide a systematic process for measuring progress resulting from the implementation of water resource quality programs. Biocriteria are intended to supplement, rather than replace, chemical and toxicological methods.

Bioassessment Protocols

In 1989, EPA's Office of Water issued rapid bioassessment protocols (RBPs) for streams as a tool intended to provide States with biological monitoring methods to supplement traditional instream chemical analyses. The key concept underlying these protocols is the comparison of the structure and function of the aquatic community in the context of habitat quality at a given stream study site to that of an ecological reference site or condition. On the basis of this comparison, a water resource quality assessment can be made. EPA has provided technical support and training to States to encourage the implementation of the RBPs and biological criteria. Currently, over 30 States have active RBP-based water resource monitoring programs for streams, another three are under development, and three States go beyond the guidelines. Updated RBP guidance is being developed to aid States in adapting the original protocol framework to go beyond a single reference site approach to including ecoregional reference conditions that fit a variety of ecological regions. Over 30 States either have, or are developing, ecoregional reference conditions. Modified RBPs are also being prepared for other water resource types including lakes/reservoirs and estuaries. Work is also under way to evaluate the effectiveness of RBPs for assessing combined sewer overflows. In addition, a generic quality assurance/quality control (QA/QC) guidance will be available in the Fall of 1995. For a copy, please contact the EPA Monitoring Branch at 202-260-7046.

Quality Assurance/Quality Control for Biological Monitoring and Biological Assessment

The U.S. EPA Office of Water and Office of Research and Development are assembling generic guidance documents for production of quality assurance project plans for biological monitoring and assessment. This work is currently under way and involves review and input from State and EPA regional monitoring personnel.

Fish Advisory Guidance and Databases

In response to interest on the part of States to have nationally consistent methods for issuing fish consumption advisories, EPA's Office of Science and Technology (OST), Standards and Applied Science Division, is developing national guidance documents. This guidance, developed in cooperation with States, Tribes, and others, is presented in a four-volume set of documents titled *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume I: Fish Sampling and Analysis* (September

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1993); *Volume II: Risk Assessment and Fish Consumption Limits* (June 1994); *Volume III: Risk Management* (FY95); and *Volume IV: Risk Communication* (FY95).

In addition to this guidance, OST has developed two databases, one for States to report fish advisory information and another that contains fish tissue contaminant data. The Fish Advisory Database contains fish advisory information reported nationwide by States including the waterbody affected, the type of fish species, the type of advisory, and a contact person. It is updated annually and can be obtained by contacting the EPA Fish Contaminants Section at the following address or by calling (202) 260-1305:

Fish Advisory Database Coordinator
U.S. EPA (4305)
Office of Science and Technology
401 M Street, SW
Washington, DC 20460

OST established the National Fish Tissue Data Repository (NFTDR) to (1) simplify data exchange by improving the comparability and integrity of fish tissue data;
(2) encourage greater regional and interstate cooperation; and (3) assist States and Tribes in their data collection efforts by providing ongoing technical assistance. Currently, the NFTDR is part of EPA's Ocean Discharge Evaluation System (ODES) Database and there is relatively little fish tissue data in the NFTDR. To make the NFTDR more accessible, EPA intends to modify the NFTDR and incorporate it as a major prototype during the modernization (Phase III) of EPA's STORET (STOrage and RETrieval) Database (see page 374 for more information about STORET and ODES). The use of real fish tissue data during prototype development should help EPA identify needed data fields and test the data structure.

During 1996, EPA intends to completely convert the NFTDR to a STORET-based fish tissue database. The primary benefit of including the NFTDR as a subset of STORET is that one "platform" will be able to store both water quality data and biological data, such as fish tissue information. Existing data sets would be able to easily migrate to the new STORET system when it is completed in 1997. Additional information may be obtained by writing to the following address:

NFTDR
U.S. EPA (4305)
401 M Street, SW
Washington, DC 20460

National Study of Chemical Residues in Fish

In late 1992, EPA issued a report on results of the EPA National Study of Chemical Residues in Fish (NSCRF), formerly called the National Bioaccumulation Study. This study is a followup to the EPA National Dioxin Study and substantially broadens that work with regard to both the number of chemicals analyzed and the number of sites examined. The NSCRF was a screening study designed to determine the extent to which water pollutants are bioaccumulating in fish and to identify correlations with sources of the contamination within a watershed/drainage basin.

For further information about databases and information systems, see the Office of Water Environmental and Program Information Systems Compendium available from the EPA Office of Water at (202) 260-5684.

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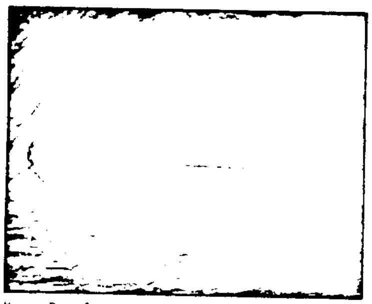

Kings Park Elementary, 3rd Grade, Springfield, VA

Specific Water Program Monitoring

National Estuary Program Monitoring Guidance

EPA is developing guidance on the design, implementation, and evaluation of estuary monitoring programs required under Section 320 of the Clean Water Act. The guidance document identifies the major steps involved in developing and implementing estuary monitoring programs, documents existing monitoring methods, and describes their use in monitoring the effectiveness of estuarine management actions. Case studies of existing programs are included.

Nonpoint Source National Monitoring Program

EPA developed the Section 319 National Monitoring Program to improve our understanding of nonpoint source (NPS) pollution and to scientifically evaluate the effectiveness of NPS pollution control activities. Under this program, EPA's Regional Offices nominate projects by forwarding State proposals to EPA Headquarters for review and concurrence. Projects are selected on a competitive basis from within each of the EPA Regions. EPA works with project sponsors to develop approvable 6- to 10-year projects. The project sponsors then work through the State/EPA Section 319 process to obtain approval and funding. As of June 1995, 11 projects have been approved. More information about the Section 319 National Monitoring Program is provided in Chapter 15.

Wetlands Monitoring

EPA's Wetlands Division is now working closely with FWS and EPA's EMAP-Wetlands Program to characterize the ecological status and trends of existing wetlands. Standardized protocols are being developed for measuring wetlands conditions. See Chapter 15 for further information about EPA and State wetlands monitoring and protection programs.

Ground Water Monitoring

EPA's support for State Ground Water Protection Programs has expanded in line with the Ground Water Task Force's recommendations in the report *Protecting the Nation's Ground Water: EPA's Strategy for the 1990's*. This document addresses the development of consistent data collection protocols to improve accessibility, quality, and the usefulness of ground water quality data. To that end, the Ground Water Minimum Set of Data Elements for Ground Water Quality was finalized requiring their use for EPA ground water monitoring.

Volunteer Monitoring Programs

EPA's Office of Water encourages all citizens to learn about their water resources and supports volunteer monitoring because of its many benefits. Volunteer monitors

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- build awareness of pollution problems
- become trained in pollution prevention
- help clean up problem sites
- provide data for waters that may otherwise be unassessed, with accompanying data on the methods used to collect the data
- increase the amount of water quality information available to decisionmakers at all levels of government.

Among the uses of volunteer data are delineating and characterizing watersheds, screening for water quality problems, and measuring baseline conditions and trends.

EPA supports volunteer monitoring by providing technical guidance and forums for exchanging volunteer information. For example, EPA sponsors biennial national conferences that bring together volunteer organizers, State and local agencies, environmental groups, school groups, and the business sector. EPA also maintains an electronic bulletin board forum for volunteer monitors, distributes a national newsletter for volunteers, and maintains a directory of volunteer monitoring programs across the Nation. EPA has released guidance for planning and implementing volunteer monitoring programs as well as guidance covering volunteer monitoring methods.

Many of EPA's 10 Regional Offices are actively involved in volunteer monitoring. Their support activities include providing technical assistance related to quality assurance and quality control, serving as contacts for volunteer programs in the Region, managing grants to State agencies that include provisions for volunteer water monitoring and public participation, and providing information exchange

EPA Volunteer Monitoring Materials

EPA's Volunteer Monitoring Program. EPA-841F-95-001. February 1995. Contains a general description of EPA activities to promote volunteer monitoring.

Volunteer Monitoring. EPA-800-F-93-008. September 1993. A brief fact sheet about volunteer monitoring, including examples of how volunteers have improved the environment.

Starting Out in Volunteer Water Monitoring. EPA-841-B-92-002. August 1992. A brief fact sheet about how to become involved in volunteer monitoring.

National Directory of Citizen Volunteer Environmental Monitoring Programs, Fourth Edition. EPA-841-B-94-001. January 1994. Contains information about 519 volunteer monitoring programs across the Nation.

Proceedings of the Fourth National Citizen's Volunteer Water Monitoring Conference. EPA-841-R-94-003. February 1995. Presents proceedings from the fourth national conference held in Portland, Oregon, in 1994.

Proceedings of the Third National Citizen's Volunteer Water Monitoring Conference. EPA-841/R-92-004. September 1992. Presents proceedings from the third national conference held in Annapolis, Maryland, in 1992.

Volunteer Stream Monitoring: A Methods Manual. EPA-841-D-95-001. 1995. Presents information and methods for volunteer monitoring of streams.

Volunteer Estuary Monitoring: A Methods Manual. EPA-842-B-93-004. December 1993. Presents information and methods for volunteer monitoring of estuarine waters.

Volunteer Lake Monitoring: A Methods Manual. EPA-440/4-91-002. December 1991. Discusses lake water quality issues and methods for volunteer monitoring of lakes.

Volunteer Water Monitoring: A Guide for State Managers. EPA-440/4-90-010. August 1990. Discusses the importance of volunteer monitoring, quality assurance considerations, and how to plan and implement a volunteer program.

The Volunteer Monitor. A national newsletter, published twice yearly, that provides information for the volunteer monitoring movement. Produced through an EPA grant.

The Water Monitor. A monthly newsletter published by EPA to exchange surface water assessment information among States and other interested parties.

Volunteer Monitoring on the Nonpoint Source Electronic Bulletin Board System. A 2-page fact sheet on EPA's electronic forum for volunteer monitors.

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services for volunteers. Some offices hold Regional workshops to bring volunteers together and build partnerships.

In the coming years, EPA plans to continue developing technical tools for volunteers, including guidance on assuring quality data collection. EPA will also continue encouraging cooperation and information exchange among volunteer programs and between volunteers and State, local, Tribal, and Federal agencies. A common theme of all of these activities will be a commitment to increase the diversity of the volunteer monitoring community nationwide.

EPA Data and Information Systems

Storet Modernization

The STORET (STOrage and RETrieval) Database of ambient water quality data, first developed in 1964, is one of the oldest and largest water information systems currently in use. It is maintained by the Office of Wetlands, Oceans, and Watersheds. STORET stores information on ambient, intensive survey, effluent, and biological water quality monitoring and provides users with an array of analytical tools and linkages to other data systems. STORET primarily contains chemical and physical water quality monitoring data, with biological sampling and site information stored in the associated BIOS (Biological System) Database, another major component. ODES (Ocean Data Evaluation System) is a separately maintained and linked information system specifically for water quality and biological data for marine, estuarine, and freshwater environments. ODES users can access STORET information for further manipulation using ODES graphical and modeling tools.

EPA information systems are being called upon to respond to new program needs, including geographically oriented management approaches, storage of ground water quality and associated geologic data and biological and habitat assessment information, and to enhance sharing of data (across EPA, other Federal, State, and local programs). STORET, BIOS, and ODES are undergoing a major modernization scheduled to be complete in 1997 with interim products throughout, including a full prototype in late 1995. This effort will result in a more flexible, efficient, and usable state-of-the-art information system, which, in turn, will provide improved tools for ground and surface water quality decisionmaking.

For more information on STORET modernization and the prototype now available for testing, contact:

Phil Lindenstruth
U.S. EPA (4503F)
Assessment and Watershed
Protection Division
401 M Street, SW
Washington, DC 20460
(202) 260-6549

The Waterbody System

The Waterbody System (WBS) is a data management tool used by States to record assessments of ambient water quality for surface waters. Although originally designed to facilitate the reporting under

Section 305(b), the WBS is used by many States to track results of all their ambient water quality assessments. During the 1994 reporting cycle, 27 States, Territories, and Interstate Water Commissions submitted WBS data files.

The Waterbody System contains information that program managers can access quickly on the water quality status of a particular waterbody. Data elements include waterbody identification, water quality status, assessment information, designated use evaluations, causes of impairment (nutrients, pesticides, siltation, etc.), and sources of impairment (municipal treatment plants, agricultural runoff, etc.).

Enhanced twice since it was originally developed in 1988, system users communicate regularly with each other and can receive user information and support from the Monitoring Branch at EPA Headquarters.

The Permit Compliance System

The Permit Compliance System (PCS) is an information management system maintained by the Office of Wastewater Enforcement and Compliance (OWEC) to track the permit, compliance, and enforcement status of facilities regulated by the National Pollutant Discharge Elimination System program under the Clean Water Act. PCS tracks information about wastewater treatment and industrial and Federal facilities discharging into navigable rivers. Tracked items include facility and discharge characteristics, permit conditions, inspections, enforcement actions, and compliance schedules. PCS distinguishes between major and minor facilities based on the potential threat to human health or the environment. Only major facilities must provide complete records to PCS, currently numbered at around 7,100; however, States and Regions do submit information for approximately 56,300 minor facilities. PCS users are able to use graphical and statistical tools to analyze PCS data and can use a PCS/STORET interface to link the systems and support additional analyses.

The Toxics Release Inventory

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 established the Toxics Release Inventory (TRI), a public database that contains information about toxic chemical releases to water, air, and land from manufacturing facilities. The TRI contains data submitted annually by individual manufacturing facilities subject to the EPCRA reporting requirements. The EPCRA reporting requirements apply to manufacturing facilities that

- Employ 10 or more full-time employees

- Manufacture or process over 25,000 pounds of any chemical or chemical category listed in the EPCRA, or use more than 10,000 pounds of any chemical or chemical category listed in the EPCRA

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Standard Industrial Codes (SICs)

SIC	Industry Group
20	Food
21	Tobacco
22	Textiles
23	Apparel
24	Lumber and Wood
25	Furniture
26	Paper
27	Printing and Publishing
28	Chemicals
29	Petroleum and Coal
30	Rubber and Plastics
31	Leather
32	Stone, Clay, and Glass
33	Primary Metals
34	Fabricated Metals
35	Machinery (excluding electrical)
36	Electrical and Electronic Equipment
37	Transportation Equipment
38	Instruments
39	Miscellaneous Manufacturing

- Conduct selected manufacturing operations in the industry groups specified in the U.S. Government Standard Industrial Classification (SIC) Codes 20 through 39, including chemicals, petroleum refining, primary metals, fabricated metals, paper, plastics, and transportation equipment (see sidebar).

The EPCRA regulations require that eligible manufacturing facilities identify the toxic chemicals they released (from a list of more than 300 individual chemicals and 20 chemical categories); the quantity of each chemical released to the air, water, and land; and the quantity of each chemical transferred off site for treatment, disposal, or recycling. In response to the Pollution Prevention Act of 1991, facilities are also required to report additional information about waste management and source reduction activities. The reported data are stored in the TRI and in State files available to the public.

The TRI database provides the public with direct access to toxic chemical release and transfer data at the local, State, regional, or national level. The public can use the TRI data to identify potential concerns in local waterbodies or throughout the Nation. With TRI data, the public can work with industry and government to reduce toxic chemical releases and the risks associated with them.

Industry can use the TRI data to obtain an overview of use and release of toxic chemicals, to identify and reduce costs associated with toxic waste, to identify promising areas of pollution prevention, to establish reduction targets, and to measure and document progress toward chemical release reduction goals. The public access of the TRI data has prompted many facilities to work with their communities to develop effective strategies for reducing environmental and human health risks posed by toxic chemical releases.

Federal, State, and local governments can use the TRI data to identify hot spots, compare facilities or geographic areas, evaluate pollution control and prevention programs, and track progress in reducing waste. The Office of Water has used TRI data with other pertinent exposure and toxicity data to identify and prioritize contaminants in drinking water, to identify and quantify inputs of toxic chemicals into the Gulf of Mexico, and to compile data on toxic releases into municipal treatment plants.

The TRI database has some limitations. TRI captures only a portion of all toxic chemical releases nationwide because nonindustrial sources, such as dry cleaners and auto service stations, are not required to submit TRI data. In addition, the TRI data alone are not sufficient to calculate potential adverse effects on human health from toxic chemicals because TRI does not track exposure of the public to released chemicals.

The TRI data are available to the public online through the National Library of Medicine's TOXNET system and through the Right-to-Know Network (RTK NET), which is sponsored by the Unison Institute, a nonprofit organization. TRI data are also available on CD-ROM and on individual State diskettes. For information about obtaining TRI data, the public can call the TRI User Support Service (202-260-1531) or the EPCRA Information Hotline (1-800-535-0202).

TRI users can obtain additional information about health effects and ecotoxicity of chemicals in the TRI database from PC-TRIFACTS, an auxiliary software package developed by EPA.

Contaminated Sediment Strategy

In early 1993, EPA issued its Contaminated Sediment Management Strategy: A Proposal for Discussion. Then, in August 1994, the Strategy Document, *EPA's Contaminated Sediment Management Strategy*, was announced in the *Federal Register*. One of its main objectives is to describe EPA's current understanding of the extent and severity of sediment contamination. EPA's Contaminated Sediment Management Strategy describes actions that the Agency will take to accomplish the following four strategic goals: (1) prevent further sediment contamination that may cause unacceptable ecological or human health risks; (2) when practical, clean up existing sediment contamination that adversely affects the Nation's waterbodies or their uses, or that causes other significant effects on human health or the environment; (3) ensure that sediment dredging and dredged material disposal continue to be managed in an environmentally sound manner; and (4) develop and consistently apply methodologies for analyzing contaminated sediments. To accomplish these goals, EPA will continue to develop and improve methods for identifying contaminated sediments, to provide a basis for assessment of sediment contamination, to outline steps to reduce risk supported by sound science, and to outline a strategy for assessing the extent and severity of sediment contamination.

One of the initial steps to implement not only this strategy but to meet mandated statutory requirements to address and resolve contaminated sediment problems is to develop national inventories of contaminated sediment sites and pollutant sources (point and nonpoint). During the past 3 years, EPA's Office of Science and Technology has compiled the National Sediment Inventory (NSI), an extensive geographically referenced database of sediment quality monitoring and pollutant source information for the Nation's freshwater and estuarine ecosystems. The Site Inventory component of the NSI contains detailed monitoring data on sediment chemistry and biological effects collected by Federal and State agencies beginning in 1980. The Point Source Inventory component of the NSI contains over 22,000 individual records of point source discharges of 118 different chemicals from municipal, Federal, and industrial facilities in 1992. The NSI database will be continually updated and improved. Based on an evaluation of current data, OST will produce an assessment of the national extent and severity of sediment contamination across the country and present the results in a Report to Congress in early 1996.

For more information about the NSI, contact the OST Standards and Applied Science Division:

THE NATIONAL SEDIMENT INVENTORY documents the extent, severity, and causes of sediment contamination across country.

National Sediment Inventory
U.S. EPA (4305)
Office of Science and
Technology
401 M Street, SW
Washington, DC 20460

Nonpoint Source Information Exchange

The Nonpoint Source Information Exchange, housed at the Assessment and Watershed Protection Division of EPA's Office of Water, is designed to serve as a national center for the exchange of information concerning (1) the nature of nonpoint source pollution, (2) NPS management techniques and methods, and (3) institutional arrangements for the planning and implementation of NPS management including financial arrangements.

The Exchange contains two major activities: a technical bulletin, the *NPS News-Notes*, published approximately eight times per year, and the NPS Electronic Bulletin Board System (NPS BBS). The target audience for the *News-Notes* is State and local water quality managers although, with a circulation of over 10,000, other interested parties including public officials, environmental groups, private industry, citizens, and academics receive *News-Notes* regularly.

The NPS BBS, first opened in 1991, provides timely and relevant NPS and other information to a similar audience. There are more than 1,200 users of the NPS BBS who, through the system, can access several special interest areas: Agricultural Issues, Fish Consumption Advisories and Bans, Waterbody System Users Group, NPS Research, Watershed Restoration Network, Total Maximum Daily Loads, Coastal Nonpoint Source Pollution, and Volunteer Monitoring. Also available are on-line searchable databases such as the Clean Lakes Clearinghouse, *NPS News-Notes* database, the Fish Consumption Bans and Advisories database, and the National Registry of Watershed Projects.

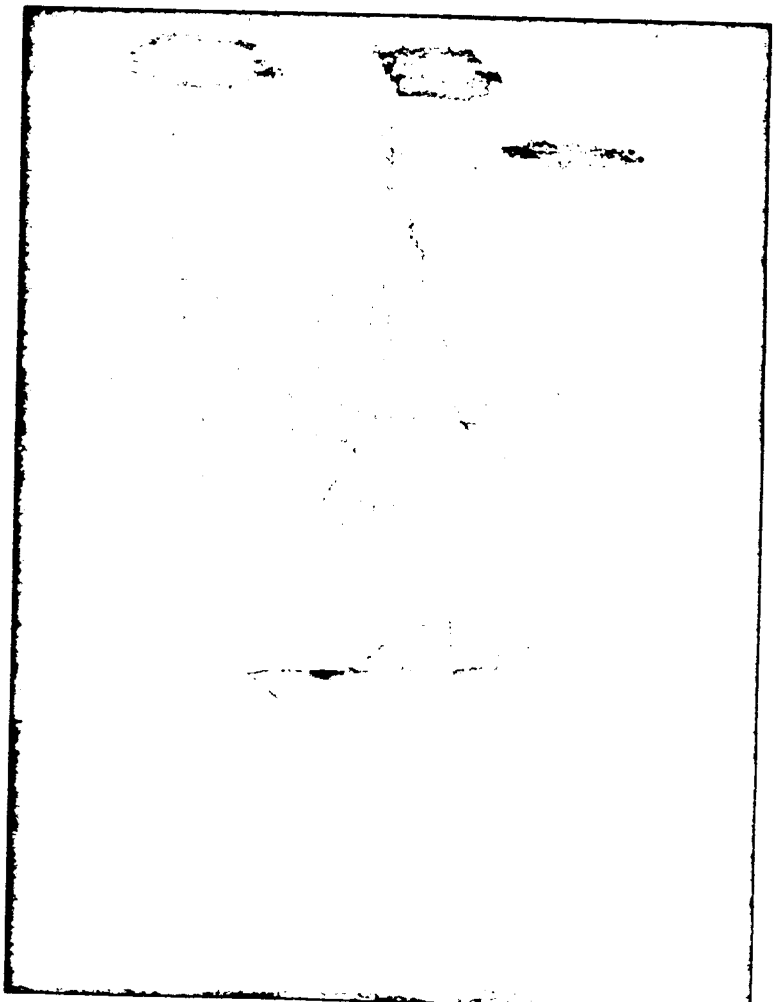
Great Lakes Envirofacts

The Great Lakes National Program Office (GLNPO) is initiating a computer system development pilot effort called Great Lakes Envirofacts (GLEF) to assist managers and technical staff in developing strategies to reduce toxic chemical loadings. The keystone goal of GLNPO's data integration program is the development of a system to enable technical staff to access, display, analyze, and present Great Lakes multimedia and geographic information from their desk top, providing environmental decisionmaking support for Great Lakes Program managers. The GLEF pilot project will explore both the system requirements of Great Lakes Program staff and the technical means (hardware, software, and telecommunications) to begin realizing its keystone goal.

The GLEF will build upon the Envirofacts/Gateway system developed by EPA's Office of Information Resources Management (OIRM) Program Systems Division (PSD). The Envirofacts database stores environmental monitoring and program (e.g., PCS, TRIS, FINDS) information in a relational structure. Gateway is a graphical user interface that provides spatially referenced access to the Envirofacts database. The Great Lakes Envirofacts project will be the first implementation of the Gateway/Envirofacts concept, testing its capability and utility for the Great Lakes Program.

Other Information Clearinghouses & Electronic Bulletin Boards

Several other clearinghouses, electronic bulletin boards, newsletters, and information updates on water quality activities have been developed by EPA for use by State and local governments, Federal agencies, and the public. These include COASTNET bulletin board for coastal waters and estuary protection activities, the Clean Lakes Clearinghouse, the *Contaminated Sediment News* bulletin, and the Office of Science and Technology's Resource Center.



Nickolas Lantz, age 8, Bruner Elementary, North Las Vegas, NV

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EPA's Water Channel

The Office of Water's Office of Wetlands, Oceans, and Watersheds has established the Water Channel on EPA's Internet site. The Water Channel broadcasts water information and tools for communities and American citizens to understand and use in managing their own environmental resources. It is a means to promote and strengthen partnerships to manage, protect, and restore America's water resources. Information is meant to flow from those who have it to those who need it.

You can get to know EPA's water programs and people. You can browse newsletters, fact sheets, brochures, publications, regulations, press releases, and congressional testimony. You can learn about the quality of our Nation's water resources and our environmental goals. You will get ideas about how you can get involved, like volunteer monitoring. You can choose from an array of opportunities to learn more by using the Wetlands and Drinking Water hotlines or ordering publications on-line. Those looking for technical assistance and data will find water quality monitoring methods, tools, and access to STORET water quality data. You can connect to countless other sources of environmental information at other Internet sites. You can send EPA comments, suggestions, or requests for information not yet available on the Water Channel.

The Water Channel offerings will continue to grow. Watch for new information, links to partners, homepages, and services. Visit frequently and stay in touch with EPA water programs at work across the Nation to help you manage and protect the environment.

The Water Channel utilizes EPA's public access servers with Internet connectivity. It can be accessed over the World Wide Web or Gopher. Enter the Universal Resource Locator (URL) for the EPA homepage (**http://www.epa.gov**) and go to EPA Offices and Regions and then to Office of Water or enter **http://www.epa.gov/OWOW** for direct access. Users need an Internet provider with an Internet Protocol (IP) address, at least a 386 or comparable personal computer, 4 megabytes of RAM, and tools for viewing the graphics on the World Wide Web.

For more information on the Water Channel, call Karen Klima at 202/260-7087 or send an e-mail to OW-OWOW-Internet-Comments@EPAMAIL.EPA.GOV. If you encounter problems with EPA's public access server, contact EPA via e-mail at internet_support@unixmail.rtpnc.epa.gov.

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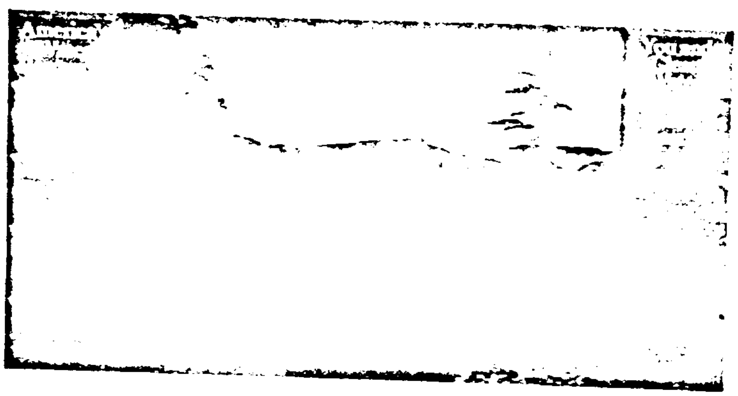
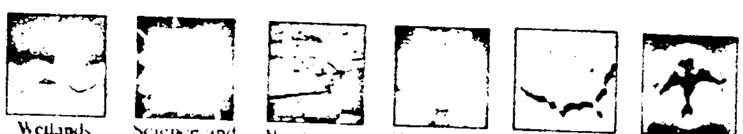
United States Environmental Protection Agency

Office of Water



EPA Programs Working in Partnerships to Protect and Restore America's Water Resources



Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it.
WILLIAM ASHWORTH, Nor Any Drop to Drink, 1982

There is also a [illegible] version of this homepage available.

Caution: The Office of Water Home Pages are under development. Your [illegible] are welcome.

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Nutrients in Ground Water and Surface Water of the United States—An Analysis of Data through 1992 by the U.S. Geological Survey

Historical data on nutrient (nitrogen and phosphorus) concentrations in ground and surface water samples were compiled from 20 study units of the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program and five supplemental study areas. The resultant data sets contain analyses of about 12,000 ground water and more than 22,000 surface water samples. These data were interpreted on regional and national scales by relating the distributions of nutrient concentrations to ancillary data, such as land use, soil characteristics, and hydrogeology.

Nitrate was the nutrient of greatest concern in ground water. It is the only nutrient that is regulated by a national drinking water standard. Nitrate concentrations in ground water were elevated primarily in agricultural areas (see Figure 1). Concentrations in about 16% of the samples collected in agricultural areas exceeded the drinking water standard. Concentrations were highest in shallow ground water, less than 100 feet below land surface. The standard was exceeded in only about 1% of samples collected from public supply wells.

A variety of factors influenced nitrate concentrations in ground water beneath agricultural areas. Concentrations were higher in areas where soil and geologic characteristics promoted rapid movement of water to the aquifer. Elevated

Figure 1. Nitrate Concentrations in Ground Water Beneath Agricultural Areas in NAWQA Study Units.

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concentrations commonly occurred in areas underlain by permeable materials, such as carbonate bedrock or unconsolidated sand and gravel, and where soils are generally well drained.

In areas where water movement was impeded, denitrification might lead to low concentrations of nitrate in the ground water. Low concentrations were also related to interspersion of pasture and woodland with cropland in agricultural areas. Elevated nitrate concentrations in areas of more homogeneous cropland probably were a result of intensive nitrogen fertilizer application on large tracts of land. Because of the time involved for ground water to move vertically in some areas, the full effect of current nitrogen fertilizer applications might not be noted in some aquifers for many years. Likewise, the effects of implementing management practices to improve water quality might not be evident for many years.

Certain regions of the United States seemed more vulnerable to nitrate contamination of ground water in agricultural areas. Regions of greater vulnerability included parts of the Northeast, Midwest, and West Coast. The well-drained soils typical in these regions have little capacity to hold water and nutrients; therefore, these soils receive some of the largest applications of fertilizer and irrigation in the Nation. The agricultural land is intensively cultivated for row crops, with little interspersion of pasture and woodland. Regional patterns and the distribution of local characteristics could be useful in identifying areas of potential nitrate problems.

Nutrient concentrations in surface water also were generally related to land use. Nitrate concentrations were highest in samples from sites downstream from agricultural or urban areas (see Figure 2). However, concentrations were not as high as in ground water and rarely exceeded the drinking water standard. Elevated concentrations of nitrate in surface water of the northeastern United States might be related to large amounts of atmospheric deposition (acid rain). High concentrations in parts of the Midwest might be related to tile drainage of agricultural fields.

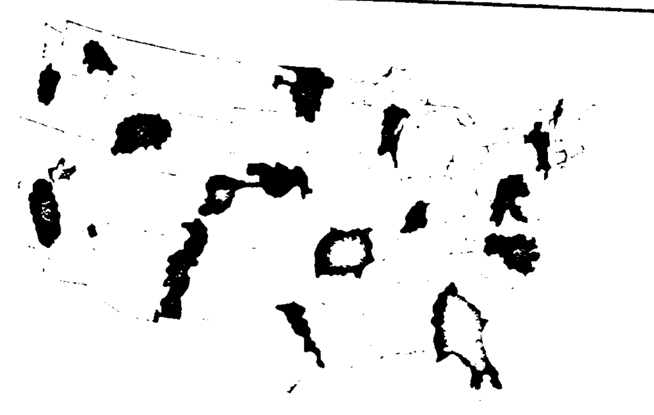

Figure 2. Nitrate Concentrations in Surface Water Downstream from Agricultural Areas in NAWQA Study Units.

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Ammonia and phosphorus concentrations were highest downstream from urban areas. These concentrations generally were high enough to warrant concerns about toxicity to fish and accelerated eutrophication. Recent improvements in wastewater treatment have decreased ammonia concentrations downstream from some urban areas, but the result has been an increase in nitrate concentrations. This condition limits the direct threat of toxicity but does not change the potential for eutrophication.

Information on environmental factors that affect water quality is useful to identify drainage basins throughout the Nation with the greatest vulnerability for nutrient contamination and to delineate areas where ground water or surface water contamination is most likely to occur. The results presented in this report suggest that the best management strategies will differ among regional areas of the Nation. Understanding the regional patterns and environmental factors that affect nutrient concentrations in ground water and surface water is critical for designing programs to manage and protect water resources.

Results from this study are summarized in the following report: David K. Mueller et al., 1995, *Nutrients in Ground Water and Surface Water of the United States—An Analysis of Data through 1992*, U.S. Geological Survey Water-Resources Investigation Report 95-4031, 74 pp. The report can be ordered from USGS Map Distribution, Box 25286, Bldg. 810, Denver Federal Center, Denver, CO 80025, phone 303-236-7477; FAX 303-236-1972.

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TVA "Vital Signs" Monitoring

About 10 years ago, the Tennessee Valley Authority (TVA) began a thorough review of its traditional water quality monitoring efforts. Familiar issues—budget pressures and the "data-rich, information-poor" syndrome—were the motivating factors. From that initial review and subsequent critical scrutiny, TVA has developed a "vital signs" monitoring program that reports to the public each spring on the fishability, swimmability, and ecological health of 30 TVA reservoirs and major tributaries.

The annual report is a user-friendly magazine, *RiverPulse*, that is mailed to about 13,000 individuals who have called to request it and is distributed through marinas, parks, TVA visitor centers, and other public outlets. Feedback from readers indicates that this annual report is well received and very effectively communicates technical information to nontechnical audiences. Many of its features are being adopted by other organizations that report to the public on environmental conditions.

RiverPulse summarizes monitoring information collected during the previous spring, summer, and fall. Informal technical reports document monitoring methods, analyses, and results. The monitoring program integrates physical and chemical monitoring of streams and reservoir waters with quantitative evaluations of benthic invertebrate and fish communities to develop an ecological health rating for each lake. A sediment chemistry and toxicity component of the rating was eliminated in 1995 as a result of budget constraints. Fish tissue contamination monitoring and associated State-promulgated fish consumption advisories provide information on fishability, and results of bacteriological sampling at beaches and informal recreation areas are the basis for the swimmability ratings.

Copies of *RiverPulse* can be obtained by calling (615) 751-2333. More information on TVA's monitoring program can be obtained by leaving a message at this number, by calling Dr. Neil Carriker at (615) 751-7330, or by sending an e-mail message to ncarrik@mhs-tva.attmail.com.

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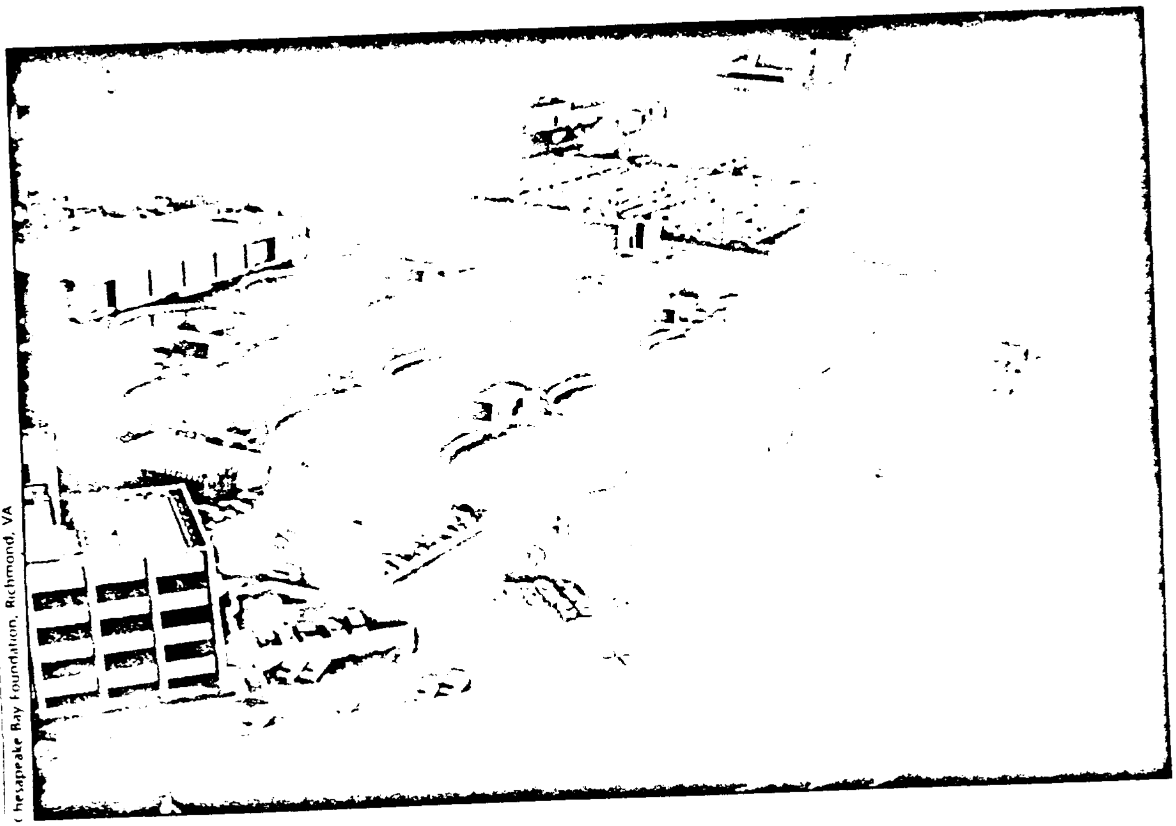

Chesapeake Bay Foundation, Richmond, VA

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Point Source Control Program

Treating Municipal Wastewater

Municipal treatment facilities receive wastewater from residential sources as well as from industry and storm water runoff. The array of pollutants that may be associated with these sources includes suspended solids, organics, pesticides, heavy metals, nutrients, acids, viruses, and bacteria.

Adequate treatment of municipal wastewater is important for the protection of the Nation's water resources and public health. Without adequate treatment, this pollution poses a serious threat to aquatic life, commercial and recreational opportunities, surface water drinking supplies, ground water drinking supplies, and the general health and stability of the Nation's stream, river, lake, estuarine, and coastal ecosystems.

The Clean Water Act requires municipalities to achieve treatment levels based on technology performance. The 1981 CWA amendments extended the deadline for eligible treatment plants to achieve "secondary treatment" to July 1, 1988. Secondary treatment removes at least 85% of several key conventional pollutants. If secondary treatment is not enough to meet water quality standards, the Clean Water Act mandates additional treatment as necessary.

Historically, under the Clean Water Act, EPA has been authorized to help municipalities solve their wastewater treatment problems by providing grants for construction. Since 1972, EPA, through the Construction Grants Program, has provided approximately $54 billion to municipalities to construct or improve their wastewater treatment systems.

In the 1987 Amendments to the Clean Water Act, Congress and the President agreed to phase out the Construction Grants Program. In its place, the State Revolving Fund (SRF) was created and has resulted in the creation of revolving loan funds in each State and Puerto Rico. The goal of the SRF program is to establish independent and permanent sources of funding in each State. Capitalization of these funds is provided by the Federal (80%) and State (20%) governments. Congress appropriated more than $10.3 billion through fiscal year 1995 for State Revolving Funds. In addition to providing loans for construction of wastewater treatment facilities, SRFs allow funding for many activities not previously eligible under the Construction Grants Program, including control of nonpoint source runoff and estuary protection projects.

THE STATE REVOLVING FUND PROGRAM provides grants to States to establish loan programs that finance a variety of water pollution control activities.

The Amendments of 1987 also included new water quality requirements. The primary programs with new enforceable requirements are those dealing with storm water, toxic discharges, and sludge use and disposal. The SRF loan program provides States with more discretion than ever before in selecting projects for funding. States are now able to finance projects they may consider to be of higher priority, such as nonpoint source, estuarine, combined sewer overflow, or storm water control projects. All States and Puerto Rico had approved SRF programs in place as of September 1990.

EPA has awarded over $11.1 billion to States to capitalize SRF programs since 1988. States have contributed about $2.2 billion to meet the 20% match requirement. In addition, 21 States have issued about $5.4 billion in leverage bonds to further capitalize their SRF programs. From these and other sources, capitalization of SRF programs totals about $19 billion through fiscal year 1995.

The Administration remains committed to the State Revolving Fund Program to continue capitalization of the program to a level such that 51 State programs are able to issue in excess of $2 billion in loans annually for the foreseeable future.

Funding Needs for Wastewater Treatment

The Needs Survey, a biennial report to Congress, is the primary mechanism for assessing municipal wastewater treatment needs nationwide. The 1992 Needs Survey focuses on the expanded CWA funding eligibilities under the SRF in the 1987 Amendments to the Clean Water Act. Models were used to supplement documented needs estimates for combined sewer overflows. Models were also used to develop preliminary urban storm water and agricultural and silvicultural nonpoint source pollution control implementation costs since very little documentation of specific projects or costs was available from the States.

EPA's needs estimates include those facilities and activities for which a water quality or public health problem could be documented using specific criteria established by EPA. The capital investment necessary to satisfy all categories of need is presented in Table 14-1. Costs for operation and maintenance are not eligible for SRF funding and therefore are not included. Additional nonconstruction estimates are included for program development costs associated with storm water and NPS control. The 1992 total documented and modeled needs are $137.1 billion to satisfy all categories of needs eligible for SRF funding for the design year (2012) population.

This amount included $50.1 billion in modeled needs for CSO, storm water, and NPS pollution control. For storm water and NPS, the estimates exclude operation and maintenance costs (O&M) since O&M costs are ineligible for SRF funding. However, O&M costs are the major costs associated with storm water and NPS program implementation. Only agriculture and silviculture NPS pollution control costs were estimated. Many types of NPS pollution were not addressed: abandoned mines, urban areas, septic systems, contaminated sediments, hydromodification, and atmospheric deposition.

The needs estimate for the Nation rose in constant dollars by $53.4 billion (39%) from 1990 to 1992. The increase was due to a variety of factors, primarily improved documentation of SRF eligibilities and the use of models to capture full CSO, as well as partial urban storm water and NPS costs.

Treating Industrial Wastewater

The Clean Water Act required EPA to establish uniform, nationally consistent effluent limitation guidelines for industrial discharges. At this time, EPA has established Best Available Technology Economically Achievable (BATEA) and Best Conventional Pollutant Control Technology (BCT) guidelines for about 28 industrial categories. EPA has also promulgated technology-based guidelines for approximately

Tab[illegible] Public[illegible] Wastewater Treatment [illegible] Dollars (in Billions)

Needs Category	Total Needs
Title II Eligibilities	
I Secondary Treatment	31.3
II Advanced Treatment	15.5
IIIA Infiltration/Inflow Correction	2.8
IIIB Replacement/Rehabilitation	3.6
IVA New Collector Sewers	17.9
IVB New Interceptor Sewers	14.7
V Combined Sewer Overflows	41.2 [a]
VI Storm Water (institutional source controls only)[b]	0.1 [a]
Total Categories I-VI	127.1
Other Eligibilities (Sections 319 and 320)	
Nonpoint Source (agriculture and silviculture only)	8.8 [a]
Ground Water, Estuaries, Wetlands	1.2
GRAND TOTAL	137.1

[a] Modeled needs.

[b] Includes SRF-eligible costs to develop and implement storm water plans but not eligible structural and construction costs.

NOTE: Costs for operation and maintenance are not eligible for SRF funding and therefore are not included.

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Tab [illegible]

	Major Permits	Minor Permits
Total Facilities	7,105	57,143
EPA-Issued Permits		
Total	2,070	7,243
Expired	217	4,055
Percent	10.5%	56%
State-Issued Permits		
Total	5,035	49,900
Expired	1,119	18,518
Percent	22.2%	37.1%

Source: Permit Compliance System, February 1993.

NOTE: A major permit is for a major facility or activity classified as such by the EPA Regional Administrator, or in the case of approved State Programs, the Regional Administrator in conjunction with the State Director. Others are classified as minor permits.

15 additional secondary industries that represent Best Practicable Control Technology Currently Available (BPT) levels. EPA is studying an additional dozen industries for future guidelines development.

In addition to these technology-based requirements, EPA, in 1984, issued a policy on the water-quality-based control of toxic pollutants discharged by point sources. In 1985, EPA issued the *Technical Support Document for Water Quality-Based Toxics Control* to support the national policy. EPA updated and enhanced this document in 1991. Both the policy and guidance recommend using overall toxicity as a measure of adverse water quality impact and as a regulatory parameter. In 1989, EPA amended its NPDES regulations to clarify the use of effluent discharge limitations for whole-effluent toxicity in addition to specific toxic chemicals. The use of whole-effluent toxicity as a regulatory tool coupled with controls for specific chemicals provides a powerful means of detecting and controlling toxic problems.

Permitting, Compliance, and Enforcement

EPA and the States use rigorous permit conditions to control point source discharges from industrial and municipal wastewater treatment facilities. During the early 1980s, the rate of permit issuance fell behind the rate of permit expiration, and large backlogs of unissued permits developed. Efforts to remedy these backlogs have been largely successful, especially for major permits. Table 14-2 illustrates the status of permit issuance as of February 1993.

Once the permit is established, compliance with these conditions is essential for achieving water quality improvements. Despite examples of water quality improvements associated with upgrading municipal facilities, 10% of major municipal treatment plants are in significant noncompliance with applicable permit conditions. Industrial permittees have historically achieved a higher rate of compliance; 7% of industrial facilities are in significant noncompliance with their permit conditions.

EPA and States with approved NPDES programs are responsible for ensuring that municipal and industrial facilities comply with the terms of their discharge permits. Currently, 40 States have approval from EPA to administer their own NPDES programs. This responsibility includes issuing permits, conducting compliance inspections and other compliance monitoring activities, and enforcing compliance. EPA has the lead implementation responsibility in the remaining States. EPA and the States evaluate compliance by screening self-monitoring reports submitted by the permitted facility. Facilities that are determined to be in noncompliance are subject to Federal as well as State enforcement action.

Figure 14-1 illustrates rates of significant noncompliance based on statistics maintained by EPA from March 1988 through December 1994. Significant noncompliance is based upon violations of a permit, administrative order, and judicial order requirements. Examples of violations for permits include exceedances of monthly average effluent limits at least twice during a

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6-month period or any exceedance of limits set by an administrative order. Discharge monitoring reports or pretreatment schedules more than 30 days late are also considered in significant noncompliance. Significant noncompliance rates for municipal and industrial facilities jumped in FY90 primarily because, for the first time, EPA calculated noncompliance directly from its automated database. Therefore, if data are not entered into the Permit Compliance System in a timely manner, the system will automatically determine that the facility is not in compliance. EPA is continuing to refine its tracking of compliance with permit conditions to better reflect instances of noncompliance by the regulated community.

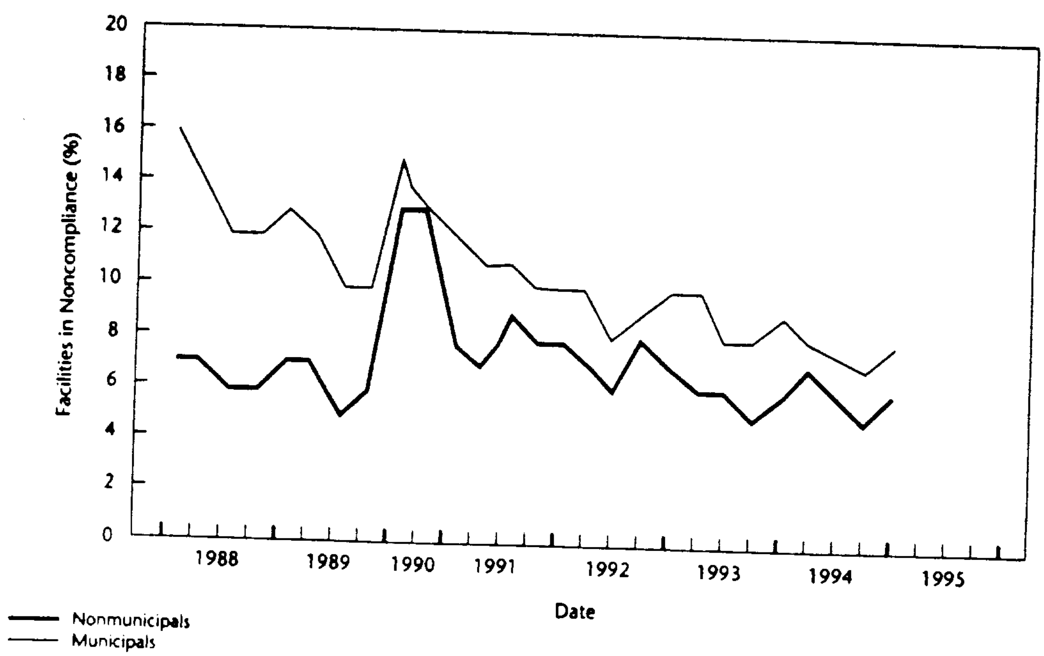
National Municipal Policy

Due to the generally poor municipal compliance record, and because of congressional concern over the performance of treatment works built primarily with Federal funds, EPA developed the National

INDUSTRIAL FACILITIES have a higher rate of compliance with discharge permits than do municipal facilities.

Figure 14-1

Percentage of Facilities in Significant Noncompliance with NPDES Permit Requirements



Source: USEPA Permit Compliance System, Summer 1995.

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Municipal Policy (NMP) to address the failure of publicly owned treatment works (POTWs) to meet treatment levels required for compliance with the CWA. On January 23, 1984, the EPA Administrator signed the NMP into effect. The NMP clarified and emphasized EPA's resolve to ensure that municipalities comply with the Clean Water Act as quickly as possible, regardless of whether Federal grant assistance was available for treatment plant construction.

The deadline established for full compliance with the Clean Water Act was July 1, 1988. By this date, all municipal treatment facilities were to be in compliance with the secondary treatment requirement of Section 301(b)(1)(B) of the CWA or with more stringent limitations established to meet State water quality standards. Of the total universe of 3,731 major municipal facilities, 1,478 facilities were identified as requiring construction to meet the 1988 deadline. By July 1, 1988, all but 423 municipal facilities had achieved compliance with the requirements. Since the 1988 deadline, 188 facilities have come into compliance, and, of the remaining 235 facilities, all but 50 have been placed on enforceable compliance schedules. EPA is continuing to track the progress of these facilities in meeting the requirements of the CWA.

In the 1987 Water Quality Act amendments to the CWA, EPA was given authority to seek administrative penalties from permittees in noncompliance with the Act's requirements. EPA issued guidance and delegated the authority for issuing these orders to the regional level in August 1987. The first Administrative Penalty Order (APO) was issued in September 1987. Through October 1990, 396 APOs have been issued assessing a total of $7.5 million in penalties. These orders have been an effective tool in expeditiously addressing violations of the CWA and represent an integral component of EPA's overall enforcement strategy.

Controlling Toxicants

The 1987 amendments to the Clean Water Act reinforced both the water-quality-based and technology-based approaches to point source control, requiring EPA to develop and update technology-based standards and adding specific direction as to how water-quality-based limits should be used to achieve additional improvements. One of the Act's primary emphases lay in strengthening the Nation's toxics control program.

Identifying Waters Impaired by Toxicants

Section 304(l) of the CWA required States to develop lists of impaired waters, identify point sources and the amounts of pollutants they discharge that cause toxic impacts, and develop an individual control strategy (ICS) for each such point source. These ICSs are NPDES permits with new or more stringent limits on the toxic pollutants of concern. The individual control strategies must be accompanied by supporting documentation to show that the permit limits are sufficient to meet water quality standards as

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soon as possible but no later than 3 years after establishment of the ICS. The general effect of Section 304(l) was to immediately focus national surface water quality protection programs on addressing known water quality problems due entirely or substantially to point source discharges of Section 307(a) toxic pollutants. Under Section 304(l), EPA and States identified 678 facilities in the United States that were required to have individual control strategies. ICSs have been established for 593 of these facilities.

In developing lists of impaired waters under Section 304(l), States used a variety of available data sources (including State Section 305(b) reports). At a minimum, dilution analyses were conducted based on existing or readily available data. EPA asked States to assemble data quickly to report preliminary lists of waters, point sources, and amounts of discharged pollutants by April 1, 1988, in their Section 305(b) reports. These lists were then to be refined and expanded by the statutory deadline of February 4, 1989

Through the 304(l) effort, 529 waterbodies were identified as being impaired entirely or substantially by point source discharges of Section 307(a) toxic pollutants. In addition, 678 point sources were listed as being responsible for impairing the quality of those waters. There are also 18,770 waters on the "long" list that includes all waters impaired by any pollutant from either point sources or nonpoint sources. Currently, approximately 87% of the ICSs required are in place as EPA-approved or drafted NPDES permits. The long list will be used for long-term planning and setting of priorities for activities such as monitoring, total maximum daily load development, nonpoint source controls, and permit revisions.

EPA implements control measures for all toxic pollutants as part of its ongoing surface water program. Section 304(l) emphasized implementing point source controls to protect particularly impaired surface waters for priority toxic pollutants. EPA will continue identifying impaired waters and controlling the discharge of toxic and other pollutants through existing reporting, standards setting, and permitting programs.

Toxicity Testing

On March 9, 1984, EPA issued a policy designed to reduce or eliminate toxics discharge and help achieve the objectives of the Clean Water Act. The "Policy for the Development of Water Quality-Based Permit Limitations for Toxic Pollutants" (49 FR 9016) described EPA's integrated toxics control program. The integrated program consisted of the application of both chemical-specific and biological methods to address the discharge of toxic pollutants. To support this policy, EPA issued the *Technical Support Document for Water Quality-Based Toxics Control (TSD)* guidance. EPA continued the development of the toxics control program by revising the TSD in 1991 and by including some aspects of the policy in NPDES regulations at 40 CFR 122.44(d)(1) in June 1989.

Toxicity reduction evaluations (TREs) identify and implement whatever actions are needed to reduce

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51 jurisdictions include ... effluent ... criteria in ... discharge permits.

effluent toxicity to the levels specified in the permit. TREs combine toxicity testing, chemical analyses, source investigations, and treatability studies to determine either the actual causative agents of effluent toxicity or the control methods that will reduce effluent toxicity. EPA is currently documenting successful TREs conducted by permittees, States, and EPA researchers. Methods and procedures for conducting TREs are described in several EPA guidance documents and referenced in the TSD.

In December 1994, EPA conducted a survey of 50 States, 7 Territories, and 3 Tribes to determine the extent of implementation of whole effluent toxicity (WET) controls for industrial and municipal point sources. Fifty-one jurisdictions incorporate WET limits in discharge permits based on numeric criteria or narrative criteria for toxics. Fifteen jurisdictions have numeric WET criteria (acute and/or chronic criteria) in their standards.

The National Pretreatment Program

29 STATES have EPA ... to ad... pret... program.

The primary goal of the National Pretreatment Program is to protect POTWs and the environment from the adverse impact that may occur when toxic, hazardous, and concentrated conventional wastes are discharged into sewer systems from industrial sources. To achieve this goal, the EPA has promulgated national pretreatment standards for pollutants that: (1) interfere with the operation of a POTW, including interference with its use or disposal of municipal sludge; or (2) pass through the POTW and contaminate the receiving stream or are otherwise incompatible with the operation of the treatment works. In addition, the program is intended to improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges. The prevention of interference, the prevention of pass-through, and the improvement of opportunities to recycle wastewater and sludge are the three regulatory objectives of the National Pretreatment Program. These objectives are accomplished through a pollution control strategy with two elements:

- **National Categorical Standards:** National technology-based standards developed by EPA Headquarters reflecting best available technology (BAT) in establishing effluent limits for the 126 "priority pollutants" as well as for conventional and nonconventional pollutants for specific industrial categories.

- **Prohibited Discharge Standards:**

General Prohibitions: National regulatory prohibitions established by EPA against pollutant discharges from any nondomestic user that cause pass-through or interference at the POTW.

Specific Prohibitions: National regulatory prohibitions established by EPA against pollutant discharges from any nondomestic user that cause: (1) fire or explosive hazard, (2) corrosive structural damage, (3) interference due to obstruction, (4) interference due to flow rate or

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concentration, (5) interference due to heat, (6) interference from petroleum-based oil, and (7) acute worker health and safety problems from toxic gases.

Local Limits: Enforceable local effluent limitations developed by POTWs on a case-by-case basis to reflect site-specific concerns and implement the Federal general and specific prohibited discharge standards as well as State and local regulations.

To ensure the success of the pretreatment program, EPA also issues guidance documents and has conducted scores of training seminars to assist POTWs in developing, implementing, and enforcing effective pretreatment programs.

The primary focus for pretreatment implementation is at the local level since the POTW is in the best position to regulate its industrial users. States may become involved in pretreatment implementation through a formal approval process in which the Federal Government transfers its oversight responsibilities to the State. The Federal Government, through the EPA, is involved in pretreatment through standard setting, policy development, and oversight of program implementation by approved States and POTWs in States without approved pretreatment programs. At present, 28 States have received approval from EPA to administer the pretreatment program, including five States that have chosen to directly regulate the industrial community in their States in lieu of local program approval and implementation. In addition, 1,481 local programs have been approved by either EPA or approved States, and another 50 programs are under development. The pretreatment program currently regulates approximately 30,500 significant industrial users (SIUs).

On July 24, 1990, the EPA promulgated the Domestic Sewage Study (DSS) final rule, which implements the recommendations made in the DSS. Specifically, the rule is designed to improve the control of hazardous wastes discharged to POTWs as well as strengthen the enforcement of pretreatment program requirements. In addition, the rule requires that POTWs conduct toxicity testing of their effluents. A continuing task will be to integrate the implementation of these requirements into the normal operations of the POTWs' pretreatment programs.

The environmental accomplishments of the National Pretreatment Program have been significant. Nationwide, EPA estimates that toxic pollutant loadings to POTWs have decreased by up to 75% through pretreatment. In many cases, the effects on surface water and sludge have been dramatic. Between 1975 and 1985, for example, 15 POTWs discharging to San Francisco Bay decreased their overall metals loadings by 80%, despite a 15% increase in POTW flows. In Wisconsin, 14 of 24 POTWs reported marked decreases in average total metals concentrations in their sludge after approval of their local pretreatment programs.

The compliance status of industrial users and POTWs is an indicator of the programmatic success of pretreatment implementation. Based

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on data reported by POTWs or States, approximately 54% of significant industrial users of sewage treatment plants are in significant noncompliance with discharge standards and/or reporting and self-monitoring requirements. This compares with a rate of 6% significant noncompliance for the major industries in the NPDES program, which discharge directly to waterbodies. According to data in EPA's national database, 39% of POTWs are failing to implement at least one significant component of their approved pretreatment programs.

EPA has focused its oversight and enforcement resources on ensuring that local municipalities properly implement their approved programs. Toward that end, on October 4, 1989, EPA announced the National Pretreatment Enforcement Initiative against cities for failure to adequately implement their approved pretreatment programs. In this action, EPA joined with several States in bringing civil judicial suits or administrative penalties against 61 cities. This effort was designed to alert cities as to their requirements under the pretreatment program and to ensure adequate implementation of the program. A followup announcement was made on May 1, 1991, containing 755 additional actions against both POTWs and significant industrial users.

In July 1991, EPA issued a report to Congress on the effectiveness of the pretreatment program as required under Section 519 of the CWA. This report analyzed the major strengths and weaknesses of the program and has provided direction for improving the program.

Managing Sewage Sludge

The need for effective sewage sludge management is continuous and growing. In the United States, the quantity of municipal sewage sludge produced annually has almost doubled since 1972. Municipalities currently generate approximately 5.3 million dry metric tons of wastewater sludge per year, or approximately 47 pounds per person per year (dry weight basis). Improper sewage sludge management could lead to significant environmental degradation of water, land, and air as well as adverse human health conditions.

Prior to the 1987 amendments to the Clean Water Act, the authorities and regulations related to the use and disposal of sewage sludge were fragmented and did not provide States and municipalities with adequate guidelines on which to base sludge management decisions. There was no single legislative approach or framework for integrating the various Federal laws to ensure that sludge would be used or disposed of in a consistent or environmentally acceptable manner.

Section 406 of the Water Quality Act of 1987, which amends Section 405 of the Clean Water Act, for the first time sets forth a comprehensive program for reducing the environmental risks and maximizing the beneficial uses of sludge. The program is based on the development of technical requirements for sludge use and disposal and the implementation of such requirements directly through the rule and through permits.

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In May 1989, EPA promulgated regulations for including sewage sludge conditions in NPDES permits and for issuing sludge-only permits. These rules also outline the requirements for States to seek EPA approval to implement the new statutory requirements.

EPA is the permitting authority for sewage sludge since there are currently no approved State programs. Initially, EPA is relying strongly on the self-implementing nature of the technical regulations. In February 1993, EPA amended the permitting regulations to establish a tiered permit application schedule. EPA is focusing its initial permitting efforts on

- Sewage sludge incinerators (which require site-specific pollutant limits)
- Facilities posing a threat to human health and the environment
- Facilities needing a permit to promote beneficial use
- Facilities with NPDES permits up for renewal.

In implementing the new sewage sludge requirements, EPA is also focusing on approving State programs and educating the general public and the regulated community.

On February 19, 1993, EPA published the Standards for the Use or Disposal of Sewage Sludge. This regulation pertains to land application, incineration, landfilling, and surface disposal of sewage sludge. The standards for each use or disposal practice consist of general requirements, pollutant limits, management practices, and operational standards. The final rule also includes monitoring, recordkeeping, and reporting requirements.

Standards apply to publicly and privately owned treatment works that generate or treat domestic sewage sludge, as well as to any person who uses or disposes of sewage sludge from such treatment works. The rule requires compliance with these standards as expeditiously as possible but not later than 12 months after the date the rule is published, or within 24 months of publication if construction of new pollution control facilities is required to comply with the regulations.

New Initiatives in Point Source Control

Combined Sewer Overflow Control

Currently about 1,100 communities nationwide use combined sewer systems, which are designed to carry sanitary and industrial wastewater and storm water. These facilities are mainly located in older cities in the Northeast, the midwest, and along the west coast. Combined sewer overflows occur when the capacity of the combined sewer system is exceeded during a storm event. During these storm events, part of the combined flow in the collection system is discharged untreated into receiving waters. The overflows may contain high levels of suspended solids, floatables, heavy metals, nutrients, bacteria, and other pollutants. Pollution from CSOs can pose health risks, degrade

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the ecology of receiving waters, and impair the designated use of water resources.

EPA published the first National Combined Sewer Overflow Control Strategy in the *Federal Register* on September 8, 1989, at 54 FR 37370. Although implementation of the 1989 strategy resulted in some progress toward controlling CSOs, EPA determined, in August 1991, that implementation of the 1989 strategy was not proceeding rapidly enough.

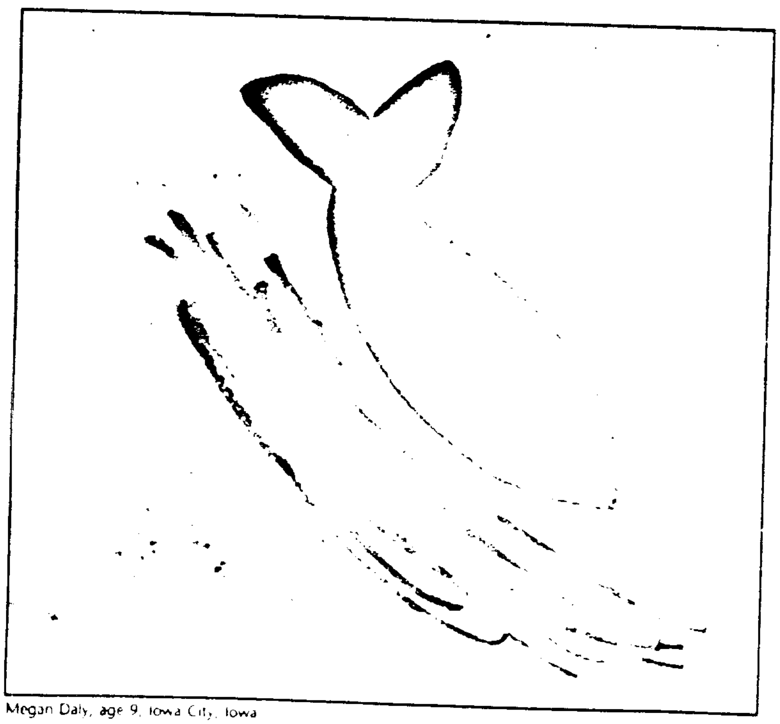
During the summer of 1992, EPA conducted a negotiated policy dialogue with key stakeholders. Based on the negotiated policy dialogue and subsequent negotiations between municipal and environmental groups and States, a CSO Framework Document was submitted to EPA's Office of Water for consideration as part of the development of a draft CSO policy. Although the framework was not the result of consensus among the negotiating parties, significant agreement was reached, allowing OW to use the framework as the basis to develop a draft CSO policy.

On December 22, 1992, the Assistant Administrator for Water and the Assistant Administrator for Enforcement issued a draft CSO Control Policy (dated December 18, 1992) for comment. The final CSO Control Policy was published in the *Federal Register* on April 19, 1994 (59 FR 18688).

The main purposes of the Policy are to elaborate on the 1989 National CSO Control Strategy and to expedite compliance with the requirements of the Clean Water Act.

The Policy is being developed to provide guidance to permittees with CSOs, NPDES authorities, and State water quality standards authorities on coordinating the planning, selection, sizing, and construction of CSO controls that meet the requirements of the CWA and to allow for public involvement during the decisionmaking process.

The CSO Policy represents a comprehensive national strategy to ensure that municipalities, NPDES permitting authorities, water quality standards authorities, and the public engage in a comprehensive and coordinated planning effort to achieve cost-effective CSO controls that ultimately meet appropriate health and environmental objectives, including compliance with water quality standards. The Policy recognizes the site-specific nature of



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CSOs and their impacts and provides the flexibility necessary to tailor controls to local situations.

Contained in the Policy are provisions for developing appropriate site-specific NPDES permit requirements for all combined sewer systems that overflow as a result of wet weather events and enforcement initiatives to require the immediate elimination of overflows that occur during dry weather and to ensure that the remaining CWA requirements are complied with as soon as practicable. The 1992 Needs Survey modeled the cost of compliance with the draft 1992 CSO Policy. The Needs Survey estimated that the national capital cost of CSO corrections will be $41.2 billion. The modeled estimate compares to the State-documented costs of $22.4 billion for 375 of the approximately 1,300 CSOs needing correction.

EPA is preparing a number of guidance documents to assist in the implementation of the final policy. Specific programmatic areas that this guidance will address are implementing minimum CSO control measures by all communities with CSOs; monitoring and modeling of combined sewer systems, CSO discharges, and receiving water impacts; preparing long-term CSO control plans by CSO communities; and drafting NPDES permit requirements for CSO discharges by EPA and State NPDES permit writers.

NPDES Stormwater Controls

Since 1972, State and EPA efforts under the NPDES program have traditionally focused on controlling pollutant discharges from POTWs and industrial process wastewaters. As these sources of pollution came increasingly under control, the need for controlling pollutants in stormwater point source discharges became more critical to efforts to achieve the goals of the CWA. As reflected in this report, stormwater discharges from a variety of sources, including storm sewers discharging urban runoff, construction site runoff, runoff from resource extraction activities, and runoff from land disposal sites, are major sources of use impairment.

Section 402(p) of the CWA amendments of 1987 established a timetable and framework for EPA to address stormwater discharges under the NPDES program. Section 402(p) required EPA to develop a two-phase program to control point source discharges of storm water. On November 16, 1990, EPA promulgated permit application requirements for the first phase for discharges from municipal separate storm sewer systems serving populations of 100,000 or more and for stormwater discharges associated with industrial activity including:

- Manufacturing facilities
- Construction operations or activities disturbing 5 or more acres
- Hazardous waste treatment, storage, and disposal facilities
- Landfills
- POTWs with approved pretreatment programs and/or discharging over 1 million gallons per day

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- Recycling facilities
- Power plants
- Mining operations
- Some oil and gas operations
- Airport facilities
- Certain transportation facilities (such as vehicle maintenance areas).

Permits were required to be issued for these sources, for the most part, by October 1, 1993.

For the second phase, EPA prepared a study that identified potential stormwater discharges, not regulated under Phase I, to be controlled to protect water quality. The study, entitled "Storm Water Discharges Potentially Addressed by Phase II of the National Pollutant Discharge Elimination System Storm Water Program," was submitted to Congress in March 1995. The study identifies the nature and extent of pollutants in these discharges and proposes one possible option for controlling these discharges.

To explore additional options for a Phase II stormwater program, EPA convened a Federal Advisory Committee subcommittee comprised of a broad spectrum of stakeholders. The subcommittee will provide EPA with recommendations for a Phase II stormwater program by December 1996. EPA is required under a consent decree to propose regulations by September 1, 1997, and finalize regulations by March 1, 1999.

Pollution Prevention

EPA has established an Office of Pollution Prevention that works with other program offices to improve pollution prevention activities within the Agency. For example, an Agency pollution prevention policy has been developed, and a strategy to address pollution prevention in manufacturing and chemical use has been drafted. Future strategies will focus on the municipal water and wastewater, agricultural, energy, and transportation sectors. A subcommittee comprising representatives from EPA Headquarters and Regions has been formed to develop an Agency-wide training strategy to ensure that pollution prevention concepts are integrated into all Agency activities.

In terms of the point source control program, the Agency's draft pollution prevention strategy recognizes the importance of permitting and enforcement activities and will continue support for a strong program in these areas. Training is being provided to familiarize NPDES permit writers with pollution prevention opportunities, how their permit decisions can affect other media, and how to effectively communicate the concept of pollution prevention to industrial managers.

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Nonpoint Source Control Program

Background

Nonpoint source pollution generally results from land runoff, atmospheric deposition, drainage, or seepage of contaminants. Major sources of nonpoint pollution include agricultural runoff, runoff from urban areas, and runoff from silvicultural operations. Siltation and nutrients are the pollutants responsible for most of the nonpoint source impacts to the Nation's surface waters. These diffuse sources are often harder to identify, isolate, and control than traditional point sources. As a result, from 1972 to 1987, EPA and the States placed primary focus on addressing the obvious problems due to municipal and industrial discharges: issuing permits for point source discharges, then inspecting, monitoring, and enforcing those permits to ensure that point sources met the Clean Water Act requirements.

Sections 208 and 303(e) of the Clean Water Act of 1972 established the initial framework for addressing nonpoint sources of pollution. States and local planning agencies analyzed the extent of NPS pollution and developed water quality management programs to control it with funds provided by EPA under Section 208. Best management practices were evaluated, assessment models and methods were developed, and other types of technical assistance were made available to State and local water quality managers.

The National Section 319 Program

In 1987, Congress enacted Section 319 of the Clean Water Act, which established a national program to control nonpoint sources of water pollution. Section 319 created a three-stage national program to be implemented by the States with Federal approval and assistance. States were to address nonpoint source pollution by (1) developing nonpoint source assessment reports, (2) adopting nonpoint source management programs, and (3) implementing the management programs over a multiyear timeframe.

All States and Territories now have EPA-approved nonpoint source assessments. EPA has also fully approved 55 State nonpoint source management programs and has approved the high-priority portions of all remaining State management programs.

Section 319 also authorizes EPA to issue annual grants to States to assist them in implementing their EPA-approved programs. From FY90 through FY95, Congress appropriated approximately $372 million for Section 319 assistance. EPA first issued guidance on the award and management of Section 319 funds in February 1991 following extensive public comment. In June 1993 the guidance was updated to incorporate suggestions from EPA Regions and a workgroup of State program managers and lessons learned during 3 years of awarding and managing Section 319 grants. The guidance encourages States to focus Section 319 funds on high-priority activities including:

- Controlling particularly difficult or serious nonpoint source problems, including, but not limited to, problems resulting from mining activities
- Implementing innovative methods or practices for controlling nonpoint sources of pollution, including regulatory (e.g., enforcement) programs
- Controlling interstate nonpoint source pollution problems
- Carrying out ground water quality protection activities that are part of a comprehensive nonpoint source pollution control program
- Addressing nationally significant, high-risk nonpoint source problems and focusing implementation activities in priority watershed or ground water areas
- Comprehensively integrating existing programs to control nonpoint source pollution
- Providing for monitoring and evaluation of program effectiveness, including using water quality monitoring protocols
- Demonstrating a long-term commitment to building the institutions necessary for effective nonpoint source management
- Emphasizing pollution prevention mechanisms
- Protecting particularly sensitive and ecologically significant waters (e.g., wetlands, estuaries, wild and scenic rivers, exceptional fisheries)
- Promoting comprehensive watershed management
- Providing for the use of antidegradation provisions and other measures necessary to ensure that population growth, new development, and new or expanded economic activity do not result in impairment of high-quality waters and waters currently meeting water quality standards
- Addressing urban storm water that is not subject to NPDES permit requirements
- Promoting implementation of coastal nonpoint source management measures developed pursuant to Section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990.

Roughly half of each State's annual award supports statewide program activity (staffing, public education and outreach, technical assistance) and half supports specific projects to prevent or reduce nonpoint source pollution at the watershed level.

EPA and the States have recently begun a process to examine and improve national and State nonpoint source programs to enhance program processes as well as substantially improve water quality. As a first step, EPA, in close cooperation with the States, developed additional guidance in April 1995 that provides greater flexibility to the States for strengthening and implementing their nonpoint source management programs.

Funding under Section 319 is also available to American Indian Tribes with approved nonpoint source assessment and management programs. In September 1994, EPA issued *A Tribal Guide to the Section 319(h) Nonpoint Source Grant Program* to provide Tribes with an overview of the Section 319(h) grant process and to assist Tribes in working with EPA Regions to meet the basic requirements for grant eligibility.

Section 319 National Monitoring Program

EPA developed the Section 319 National Monitoring Program to improve technical understanding of nonpoint pollution and the effectiveness of various nonpoint source control technologies. This program selects watershed projects that consistently monitor water quality and land management with standardized protocols for 6 to 10 years. As of June 1995, EPA had approved and funded 11 projects in the States of Vermont, Wisconsin, Pennsylvania, North Carolina, Michigan, Iowa, Nebraska, Arizona, Illinois, Washington, and California. EPA has also funded a pilot ground water demonstration project in Idaho. Several of these projects are summarized here.

The Lake Champlain, Vermont, project is a paired watershed study that will be carried out cooperatively by the University of Vermont and the Vermont Department of Environmental Conservation. The study is designed to examine the effectiveness of best management practices installed in two treatment watersheds to control sediment, nutrients, and bacteria contributions from livestock. The study calls for 2 years of pretreatment data collection, 1 year of monitoring during implementation of nonpoint controls, and 3 years of postimplementation monitoring. Data will be collected on a number of parameters, including total suspended solids, total phosphorus, total Kjeldahl nitrogen, fecal coliform, water temperature, dissolved oxygen, conductivity, fish, and macroinvertebrates. Land use and agricultural activity will also be monitored intensively in each watershed.

Otter Creek, Wisconsin, is a low-gradient warm water stream in the Sheboygan River watershed, which drains to Lake Michigan. Land use in the watershed is primarily agricultural. Data collected in 1992 indicated that the stream is highly degraded, impacted by nonpoint sources from barnyards, upland erosion, manure spreading, streambank erosion, and pastures along the creek. Habitat degradation—e.g., lack of cover, disturbed banks, and an absence of pools—also contributes to the stream's problems. The project, which includes a paired watershed and upstream-downstream studies, will encompass the monitoring of chemical, physical, and biological parameters and the implementation of nonpoint source controls. A number of State and Federal agencies are cooperating on this project. The Wisconsin Department of Natural Resources is providing technical assistance and has administrative and monitoring responsibilities; the USGS is carrying out chemical and physical monitoring; Sheboygan County is providing cost-share assistance and designing nonpoint source controls; and U.S. Department of Agriculture Soil Conservation Service (USDA-SCS), University of Wisconsin Extension, and USDA's Agricultural Stabilization and Conservation Service (ASCS) will also assist in implementation of the project.

The Sny Magill watershed project in Iowa incorporates paired watershed and upstream-downstream studies to monitor and assess improvements in water quality resulting from the implementation of nonpoint source controls. Land use in the Sny Magill watershed, the study site in the paired watershed study, is entirely agricultural with no industrial or urban areas. Land use consists predominantly of cropland (corn, oats, and alfalfa), pasture, and forest. Sediment is the major pollutant but nutrients, pesticides, and animal waste are also of concern. The USDA will provide technical assistance, cost sharing, and educational programs to assist agricultural producers in implementing nonpoint source control measures such as sediment control, stream corridor management improvements, and animal waste management systems. Land treatment application will be coordinated with water quality monitoring.

The Bloody Run watershed (a neighboring watershed of approximately the same size) serves as the paired comparison watershed, or control site. Primary monitoring sites were established on both watersheds to measure discharge and suspended sediment. Other sites on both creeks will be sampled for chemical and physical water quality variables on a weekly to monthly basis. A habitat assessment will be conducted along stretches of both stream corridors annually, fishing surveys will be conducted annually, and biomonitoring of macroinvertebrates will be performed bimonthly.

The Long Creek project is located in south-central North Carolina. The watershed contains mixed agricultural and urban/industrial land use. Long Creek serves as the primary water supply for Bessemer City (population 5,000). Sediment from eroding cropland is the major problem in the upper third of the watershed (above the water supply intake). Long Creek is impaired mainly by bacteria and nutrients from urban areas and animal holding facilities below the intake. Proposed nonpoint controls include implementing the land use restrictions of the State watershed protection law for areas above the water supply intake, erosion and sediment controls, animal waste management, and livestock exclusion. Water quality monitoring will include a single station before and after improved erosion control near the water intake, an upstream/downstream design on the Creek above and below the dairy farm, and a paired watershed design at a cropland runoff site on the dairy. Continuous and grab samples will be collected at various sites to provide the data needed to assess the effectiveness of the nonpoint controls.

The Morro Bay watershed, located on the central coast of California, is an important biological and economic resource. Morro Bay estuary is considered to be one of the least altered estuaries on the California coast. However, heavy development activities have resulted in an increase of nonpoint source pollutants entering the watershed. The nonpoint source pollutants of primary concern include sediment, bacteria, metals, nutrients, and organic chemicals. At present rates of sedimentation, Morro Bay could be lost as an open water estuary within 300 years. Not only has the accelerated sedimentation rate negatively impacted fish and macroinvertebrate species, it has also resulted in significant economic losses to the oyster industry. This project was developed to characterize the sedimentation rate and other water quality conditions in one of the Bay's tributaries, evaluate the effectiveness of several best management practices in improving water and habitat quality, and evaluate the overall water quality at selected sites within the watershed.

Reports on Section 319 Activities

As required by Congress, EPA published a report about Section 319, *Managing Nonpoint Source Pollution*, in 1992. This report described the Section 319 Program, summarized the State nonpoint source assessment reports submitted to EPA, and described Regional and State activities implemented to control nonpoint source pollution. In 1994, EPA published *Section 319(h) Success Stories*, which provided examples of successful solutions to nonpoint source pollution problems from States, Territories, and Tribes. The described projects include information and education programs, streambank stabilization projects, animal waste management projects, and urban runoff projects.

Nonpoint Source Management Programs and Implementation

The States, local governments, community groups, and EPA Regions have initiated many innovative projects across the Nation to manage nonpoint source pollution problems. The projects described in this section exemplify the diversity of approaches that have been applied to NPS pollution prevention and control. In some cases, prevention or control is only beginning. In other situations, prevention and/or control measures have been in place long enough to show significant results. For additional information about the following projects, please contact Steve Dressing at (202) 260-7110.

North and South Rivers Watershed, Massachusetts

The closing of shellfish beds contaminated from bacterial pollution concerned many citizens in the North and South Rivers watershed, located south of Boston above Plymouth. This concern propelled the North and South Rivers Watershed Association into action, assembling volunteers to sample water quality before, during, and after rainstorms to determine the extent and sources of bacterial contamination. The volunteer monitors found that bacterial pollution, which was particularly widespread after rainfalls, was caused primarily by failing septic systems, stormwater discharges, illegal septic tie-ins, and roosting birds.

Funding for the monitoring was provided by a Section 319 grant of approximately $35,000 and other private funding sources. As part of their project, the group worked with individual polluters to correct situations and with the local boards of health to enforce local ordinances. As a result, the volunteers made great progress in cleaning up both the North and South Rivers. In addition, the data gathered throughout the project will supplement that of the Massachusetts Division of Marine Fisheries, the agency that determines the schedule for additional shellfish harvesting days.

Statewide Stormwater Runoff Control, New York

Although many waterbodies in New York suffer from stormwater runoff in developed areas, New York chose to focus on preventing new development from causing further problems. With approximately $285,000 in Section 319 funds over several years, the State has established an extensive information and education program to address stormwater runoff from new development.

The 319 grants have provided funding for a number of projects. These projects include reprinting an urban erosion and sediment control manual, which contains standards and specifications for erosion and sediment control measures common to construction sites; production of a State Department of Environmental Conservation document on reducing the impacts of stormwater runoff from new development; enabling Department of Conservation staff to work directly with local governments and assisting them in developing local ordinances; conducting a variety of training courses on erosion and sediment control; development of a cooperative agreement that created the Sea Grant Extension storm drain stenciling program; and development of a video entitled *Luck Isn't Enough: The Fight for Clean Water.*

Mammoth Cave National Park, Kentucky

The Mammoth Cave National Park is a major tourist site, attracting over 2 million visitors annually. However, the unusual geology that attracts visitors to the park also makes it particularly vulnerable to poor water quality. Instead of flowing into surface streams, rain falling within the karst (limestone formation) sinkhole plain in and around the park flows into some 15,000 active sinkholes. The water travels through underground streams and caves, including Mammoth Cave, before emerging as spring water in the Green River. In the past several years, the State has become concerned that water quality degradation from intensive agriculture (due to excessive nutrients and bacterial contamination) could seriously affect the area.

The Mammoth Cave/Karst Area Water Quality Project was designed to reduce pollution in the park area and the surrounding karst sinkhole plain. The Kentucky Division of Water used part of its Section 319 grant to support the project's water quality monitoring, technical assistance, and installation of nonpoint source controls on demonstration farms in fiscal years 1991 through 1993. Activities were coordinated by a technical advisory committee formed with representatives from a number of State government agencies, citizens, and land users. Other agencies involved with the project include ASCS, SCS, National Park Service, and Tennessee Valley Authority.

Nolichucky River Watershed, Tennessee

Concern over nonpoint source water pollution from livestock production prompted Tennessee to target five subwatersheds in the Nolichucky River watershed. Animal waste systems were installed to store animal wastes and manure, which farmers later use to fertilize crops. A Section 319 grant of $58,000 provided assistance for installing best management practices in the watershed and also allowed project staff to monitor the water quality to measure the effectiveness of management practices. A year after installation, the Tennessee Department of Health found statistically valid improvements in benthic habitat in two watersheds.

Nanticoke Watershed, Delaware

Trap Pond in the Nanticoke watershed is the recreational focus for Trap Pond State Park. Increasing bacterial contamination and symptoms of accelerated eutrophication and algal blooms were evident as water quality in the lake became degraded. Two probable causes were identified: a direct discharge from an underground septic system and livestock with direct access to the stream. The problem with the leaking septic system was corrected and a Section 319 grant of $84,000 was awarded to implement animal waste management systems and nutrient management plans on farms throughout the watershed. All of the producers fenced livestock out of streams and some 98% of the producers installed manure storage facilities, buffer strips, and other best management practices.

West Lake Reservoir, Iowa

West Lake is the surface reservoir for Osceola and Woodburn, cities located in south-central Iowa. The lake was impaired by sediment, pesticides, and nutrients primarily from row crop agriculture. A Section 319 grant of nearly $170,000 was awarded for program staffing and implementing best management practices. Best management practices such as no-till and integrated crop management reduced sediment delivery and herbicide levels to the lake. In addition, a voluntary atrazine ban assisted in the lake's recovery.

Big Sioux Aquifer, South Dakota

The Big Sioux Aquifer and other smaller surface aquifers lie under approximately 1,000 square miles of eastern South Dakota. The aquifers supply drinking water to about one-third of the State's population. Although no widespread pollution problem existed, studies had uncovered isolated cases of nitrate contamination in the aquifer. With a grant from Section 319 funds and contributions from citizens and other organizations, the East Dakota Water Development District (EDWDD) began the Big Sioux Aquifer Protection Project. The goal of the project was to protect the Big Sioux Aquifer and other sensitive aquifers from contamination through information and education efforts and the development of local zoning ordinances.

As part of the project, the EDWDD also identified shallow aquifers vulnerable to contamination; located 30 public water supply wells within the project area; gathered information about the public water supply wells to help delineate a wellhead protection area for each one; installed 48 monitoring wells within nine wellhead protection areas to provide an early detection system; and used the Farm*A*Syst Program to inform landowners in rural areas about threats to their domestic wells. The group also developed a model ground water protection ordinance; as of August 1993, two cities and nine counties had adopted similar ordinances.

Pearl Harbor Bay Watershed, Hawaii

Soil erosion and heavy siltation in the East Loch of Pearl Harbor prompted the U.S. Navy to request that the South Oahu Soil and Water Conservation District hold an interagency meeting to explore ways to prevent soil erosion from all land uses in Hawaii. As a result of the meeting, the Pearl Harbor Estuary Program Interagency Committee (PHEPIC) was formed; its membership consisted of 17 agencies and groups.

Through the use of Section 319 funds in concert with other monies, PHEPIC began a public education and information campaign. As part of these efforts, a storm drain stenciling project was undertaken to raise public awareness about how storm drains are connected directly to streams and the ocean. Section 319 funds were also used in cooperation with Hawaii's Department of Transportation and Department of Highways in a demonstration project to restore a severely eroded site adjacent to the Pearl Country Club. This project involved revegetation of eroding roadside cuts with drought-tolerant, low-maintenance vegetation.

Funding for Nonpoint Source Control

In addition to Section 319 funds, several States have taken advantage of State Revolving Funds to provide loans to finance nonpoint source and other water pollution control programs. SRFs were originally established to assist States in upgrading their sewage treatment systems, but the 1987 amendments to the Clean Water Act provide States with the opportunity to use these funds for nonpoint source control. SRF loans are particularly suitable for funding structural BMP construction, such as stormwater detention ponds and manure storage structures.

Numerous States, including Washington, California, Delaware, and Ohio, are using SRF loans to fund a wide variety of nonpoint programs. Approved projects will retrofit failed septic tanks, construct stormwater management structures, remediate leaking underground storage tanks, and build poultry composting facilities. As States meet sewage treatment system upgrade requirements, SRF funds will become increasingly available to address nonpoint source problems.

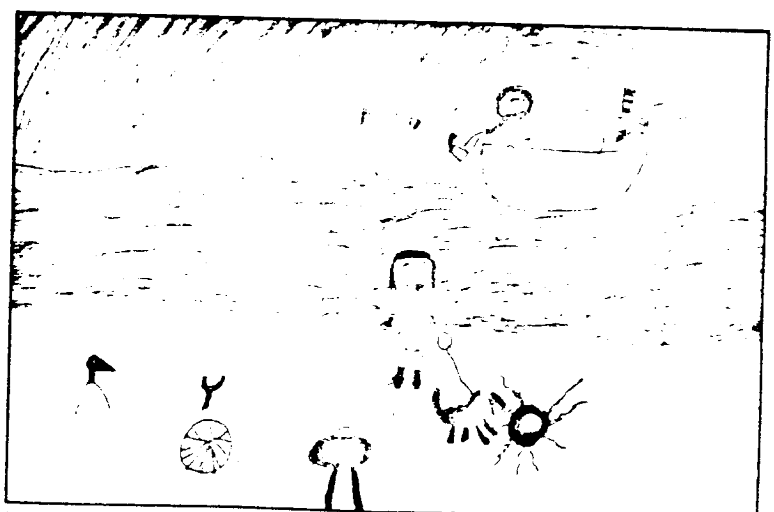
Coastal Nonpoint Pollution Control Program

As this report shows, serious water quality problems associated with nonpoint pollution still remain. The shift in population toward the coasts and associated development pressures moved Congress to provide States with new information and tools to achieve more effective protection of coastal waters from nonpoint pollutants. Congress enacted the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, which established under Section 6217 a new coastal nonpoint source pollution control program to be incorporated into both State Section 319 (CWA) programs and State Coastal Zone Management Act (CZMA) programs. NOAA administers the CZMA and EPA administers Section 319, and the two agencies have worked cooperatively toward implementing Section 6217.

Section 6217 requires that States with federally approved coastal zone management programs develop and implement Coastal Nonpoint Pollution Control Programs to ensure protection and restoration of coastal waters. Twenty-nine States and Territories, including several Great Lakes States, currently have approved coastal zone management programs.

Under CZARA, State Coastal Nonpoint Pollution Control Programs must provide for implementation of (1) management measures specified by EPA in the national technical guidance, and (2) additional, more stringent measures developed by each State as necessary to attain and maintain water quality standards where the baseline measures do not accomplish this

CZARA integrates State Nonpoint Pollution Control Programs with State Coastal Zone Management Programs.



Kings Park Elementary, 3rd Grade, Springfield, VA

objective. The CZARA further provides that States' Coastal Zone Management Programs must contain enforceable policies and mechanisms to ensure implementation of the baseline and additional management measures.

EPA issued final technical guidance in January 1993 titled *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. This guidance specifies management measures for five major categories of nonpoint pollution: agricultural runoff, urban runoff, silvicultural runoff, hydromodification, and marinas and recreational boating. The guidance also describes specific practices that may be used to achieve the level of prevention or control specified in the management measures.

EPA and NOAA have also issued joint program guidance to assist the States in developing coastal nonpoint pollution control programs. Final program guidance was issued in January 1993. The program guidance addresses issues related to development by the States of coastal nonpoint programs for joint approval by NOAA and EPA. In addition, NOAA and EPA have recently taken steps to provide States and Territories significant additional time and flexibility in developing and implementing their coastal nonpoint programs. The States must submit coastal nonpoint control programs to NOAA and EPA within 30 months of issuance of the management measures guidelines (July 1995). NOAA and EPA then have 6 months to complete their review of the coastal nonpoint programs.

Between November 1993 and June 1995, NOAA and EPA met with over 20 coastal States and Territories to review their progress in developing coastal nonpoint programs. These "threshold reviews" have assisted States in identifying where additional work may be necessary for meeting the requirements of Section 6217 and have enhanced NOAA's and EPA's understanding of the variety of State programs and approaches for controlling nonpoint pollution.

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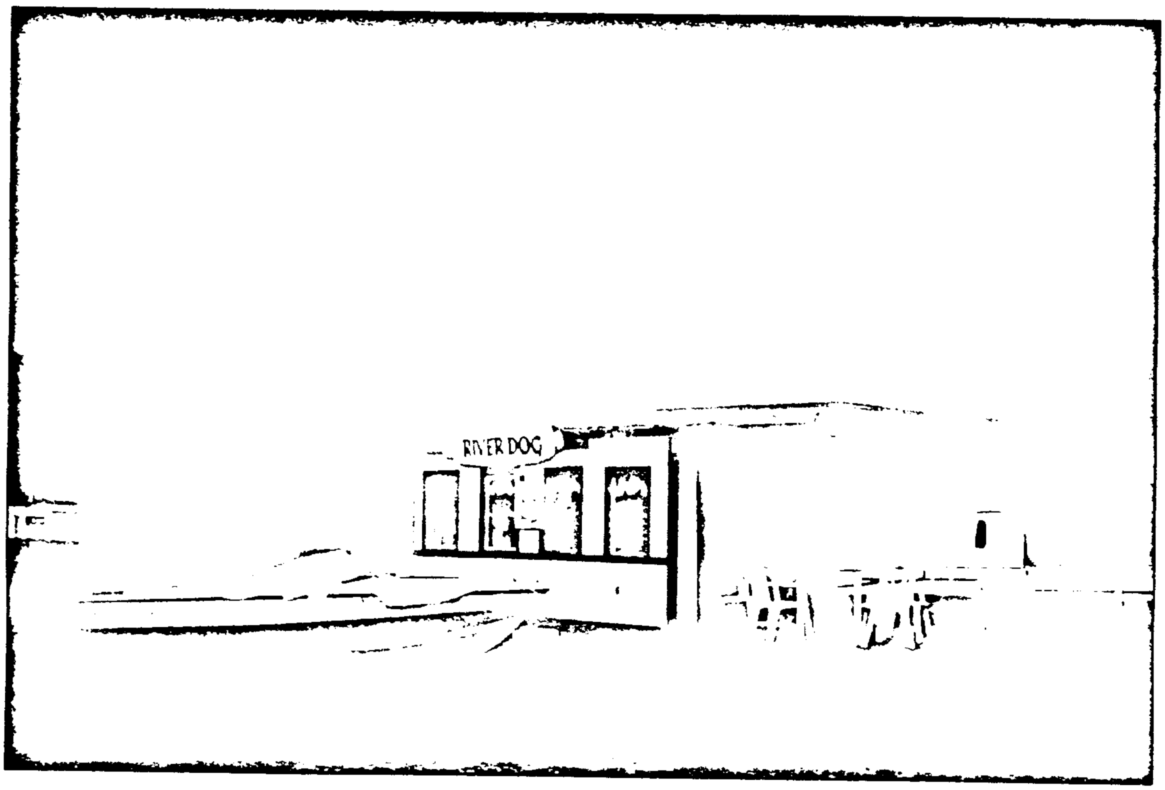

Jimmy Crawford, Raleigh, NC

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Protecting Lakes

Background

Since the early 1980s, and especially with the 1987 CWA reauthorization, nonpoint source impacts and multimedia issues such as acid rain have received increased attention in Federal regulations. Addressing these more holistic concerns has led to lake programs and projects that are closely coordinated with other Federal, State, Tribal, or local initiatives.

EPA encouraged States to develop and implement lake projects on a watershed basis. This ensures that restoration activities are long term and comprehensive. Under this approach, nonpoint source control, ground water protection, water quality permitting, estuarine protection and cleanup, and wetlands protection issues can be addressed in a holistic manner.

Biennial Lake Assessment

Under the 1987 CWA reauthorization, several new provisions were added to the original provisions encouraging States to identify their publicly owned lakes and classify them according to their eutrophic condition. Lake assessment information was to be updated in a fashion analogous to other State water quality assessments and reported biennially following the same timelines as the Section 305(b) reports. Most States now include their Section 314 lake assessments in their 305(b) reports. Recent procedural changes to the regulations governing the Water Quality Planning and Management Program (FRL-3979-8, *Federal Register*, Vol. 57, No. 143, Friday, July 24, 1992) now clearly specify that lake assessment materials should be part of the 305(b) report submittals.

Publicly Owned Lakes

Section 314 requires that States report on their "significant publicly owned lakes"–leaving the definition of "significant" up to the individual State. States have defined significant publicly owned lakes with varied physical and legal criteria, but most States have included minimum size criteria and recreational use caveats in their definitions. For example, New Hampshire's definition of significant publicly owned lakes is "any freshwater lake or pond that has a surface area of 10 or more acres, is not private, and does not prohibit recreational activity." As a general rule of thumb, most States settle on a set of significant lakes ranging in number from less than a hundred (for smaller States) to a few hundred lakes in larger western or midwestern States. However, some States classify all of their lakes as significant publicly owned lakes.

The States typically focus on highly utilized lakes because local

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Many citizen and lake associations monitor lakes.

Choiakarn Punovirivarat, age 8, Bruner Elementary, North Las Vegas, NV

citizens and governments are more likely to assist in control and restoration projects and assume ongoing stewardship for these lakes and their watersheds. High-value lakes attract a diverse group of local stakeholders to anchor the activities associated with lake projects.

Lake Beneficial Use Impairments and Trends

The 1987 CWA Amendments contain many provisions encouraging a water-quality-based approach to pollution assessment, planning, and management activities. Biennial lake assessments are now expected to make use of available information to document publicly owned lakes where uses are known to be impaired as well as lakes where there is evidence of water quality deterioration. Many States use EPA's Waterbody System to produce summary tables that categorize lake acreages by use attainment (e.g., fully supporting, threatened, partially supporting, or not supporting). Summary tables are also generally provided that categorize the major causes and sources of pollution. However, many States still lack water quality standards specific to lakes, thereby complicating the process of lake water quality assessment.

Under the 305(b) reporting process of the Clean Water Act, States are encouraged to provide waterbody-specific summaries of various public health and aquatic life concerns. This can include information on fishing advisories, fish kills, sites with sediment contamination, restrictions on surface water drinking supplies, bathing area restrictions, and incidents of waterborne diseases. This information is reported for all waterbody types, including lakes. Perhaps the most common concern reported is the contamination of fish tissue by toxicants, leading to fish consumption warnings or advisories. Although this information is certainly valuable, many States have difficulty relating fish consumption advisory data clearly to provisions in their own water quality standards. For instance, a public health agency may declare a fish consumption advisory for a lake based on trigger values for some toxicant (for instance, mercury) that are not tied to numeric standards criteria for any particular beneficial use. States are making progress in achieving consistency in their reporting of concerns such as fish consumption advisories in relation to their reporting State beneficial use attainment status. However, results for these two types of assessment information may require careful scrutiny to avoid misinterpretation.

Continued Importance of Trophic Status Classifications

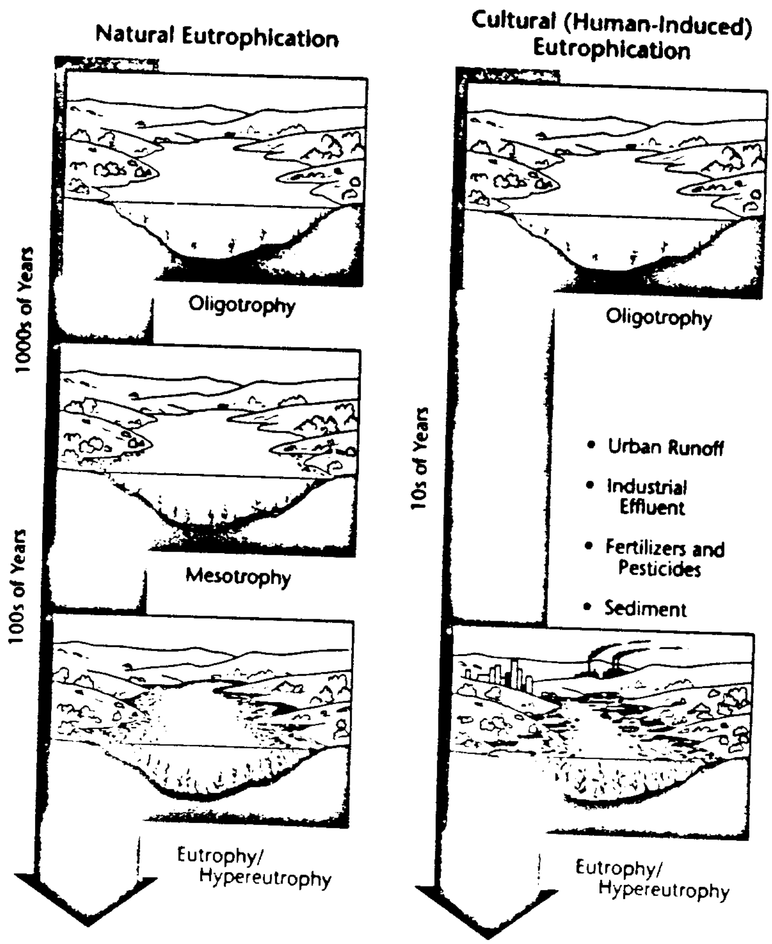
Reporting on trophic conditions is still a central feature under the 1987 CWA reauthorization, and most States still use ranking systems based primarily on trophic status information as the foundation for protecting lakes.

Trophic condition is a characterization of a lake's biological productivity based on the availability of plant nutrients. Commonly accepted systems for describing trophic status recognize a range of conditions, with oligotrophic indicating the least biologically productive lakes and eutrophic indicating significantly higher levels of productivity. For national reporting purposes, the following categories are recommended: oligotrophic, mesotrophic, eutrophic, and hypereutrophic. For those lakes showing exceptionally high levels of organic materials and associated reduced pH levels, humic substances, and natural color, the term dystrophic is used.

Both natural lakes and manmade reservoirs usually show shifts in their trophic condition over time (Figure 16-1). It is important, however, to distinguish between natural eutrophication, the process by which lakes gradually evolve and age, and cultural eutrophication, which can be defined as the culturally induced rapid acceleration of the natural eutrophication process. The natural eutrophication process ordinarily may take centuries, as lakes naturally shift from an oligotrophic to a more eutrophic status. Sedimentation processes will eventually lead to trophic shifts in manmade impoundments, generally in a much shorter time period than for natural lakes. Reservoirs, therefore, have effective lives ranging from a few decades to perhaps a few hundred years. Newly impounded reservoirs may initially be characterized as eutrophic because of the decay of woody debris but may shift to a less eutrophic status for most of the impoundment's useful life. The cultural eutrophication process, for either natural lakes or reservoirs, involves the rapid (over a matter of

Figure 16-1

The Progression of Eutrophication



(left column) The progression of natural lake aging or eutrophication through nutrient-poor (oligotrophy) to nutrient-rich (eutrophy) sites. Hypereutrophy represents extreme productivity characterized by algal blooms or dense macrophyte populations (or both) plus a high level of sedimentation. The diagram depicts the natural process of gradual nutrient enrichment and basin filling over a long period of time (e.g., thousands of years).
(right column) Cultural eutrophication in which lake aging is greatly accelerated (e.g., tens of years) by increased inputs of nutrients and sediments into a lake, as a result of watershed disturbance by humans.

Source: *NC Lake Assessment Report*. NCDEHNR, DEM. Report No. 92-02. June 1992

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years or a few decades) eutrophying of the waterbody because of human-induced external nutrient and sediment inputs.

Because there is an inherent dynamic aspect to the trophic balances in lakes, caution must be exercised in characterizing anything other than an oligotrophic condition as undesirable. On the other hand, many types of anthropogenic stresses may result in rapid trophic status shifts. If a lake shows rapid progression toward a state exhibiting excessive algae growth, rapid organic and inorganic sedimentation, and seasonal or diurnal dissolved oxygen deficiencies leading to obnoxious odors, fish kills, or a shift in the composition of aquatic life forms to less desirable forms, then an advanced stage of cultural eutrophication is very likely. Most commonly, large external inputs of nutrients from point and/or nonpoint sources leads to an undesirable stage of cultural eutrophication. Restoring a lake to a more desirable trophic condition will then require reductions in the external nutrient loading and possibly in-lake restoration activities to mitigate the impacts of previous pollution inputs.

When evidence suggests that pollution factors are driving the lake to a more eutrophic state, a State will likely rate that waterbody as a relatively high priority candidate for management attention. Other types of information are helpful in prioritizing a public lake's management needs (e.g., documentation of trends and consideration of factors such as acidity or toxics), but trophic status assessments are still the backbone of the classification systems used in most States.

At least half the States make use of a trophic classification methodology developed by R.E. Carlson in the 1970s. Carlson worked primarily with natural lakes in the Midwest. He developed a series of indices involving simple logarithmic transformations of monitoring records based on total phosphorus, chlorophyll *a*, and Secchi depth. For many lakes, these parameters provide a measure of the principal cause of cultural eutrophication (the nutrient phosphorus), a reasonable indicator of the standing crop of algae associated with nutrients (chlorophyll *a* is the major photosynthetic pigment in algal phytoplankton), and a measure of unwanted reduction in water transparency due to elevated levels of algal biomass.

The formulas for these trophic status indexes (TSIs) were calibrated to conditions in the Midwest so that an increase of 10 index units would match a change in lake eutrophic condition to the next highest status (e.g., from oligotrophic to mesotrophic). For many lakes studied by Carlson, there was a strong correlation among the predictions provided by the TSIs. Because it is generally much less expensive to gather total phosphorus data than chlorophyll *a* data and much easier to measure a light transparency from a Secchi disk than to develop actual water chemistry data, there has been a tendency to rely heavily on Secchi disk measurements when using a Carlson TSI to characterize trophic state.

Well over half the States use one or more of the Carlson TSIs or indices very similar to Carlson's. For the 1994 305(b) reporting cycle, there is a noticeable tendency on the part of the States to use greater discretion when the only measurement for a TSI comes from Secchi disk readings. Without other information about a lake, and especially reservoirs where reductions in transparency may be due more to suspended inorganic particles than to blooms of algae or due to location of the sampling site or other factors, a Secchi measurement may give false signals as to the degree of biological productivity.

States are increasingly using TSIs based on phosphorus or, where possible, chlorophyll *a* measurements. However, light transparency data may still be useful, especially when correlated with visual observations of color. Even if loss of transparency is due more to turbidity and suspended solids than to algae, it may indicate unwanted sedimentation problems affecting trophic balances and a lake's recreation value. When available, long time series of Secchi depth readings are often a good tool for trend analysis. Secchi readings, often collected by volunteer monitoring groups, can therefore still play an important role in a State's lake monitoring programs; but, for the highest quality characterization of lake trophic status, measurements more closely related to biological process and food chain dynamics are preferred.

Many States are evaluating different ways to supplement methods such as Carlson TSIs to make cost-effective characterizations of trophic status. For instance, using a broader range of parameters, there are other standard indexes that may prove helpful; many of these indexes were originally developed in the 1970s as part of EPA's pioneering National Eutrophication Survey. Whatever the general form in a TSI formula, it is highly desirable to regionalize the system to conditions found in a specific State or ecoregion. States such as North Carolina have developed regional indices, and Oregon, Minnesota, and Arkansas have applied ecoregion concepts in interpreting their lake monitoring data. Oklahoma and Texas are also evaluating different methods to assess trophic status in reservoirs.

Many States are now exploring ways to develop biologically based (bioassessment) techniques. For instance, the presence or absence of certain types of zooplankton is often strongly correlated with a well-balanced biological community. Diverse and healthy populations of algae-consuming zooplanktons such as *Daphnia pulex* can help prevent the buildup of objectionable algal biomass even in lakes showing appreciable nutrient inputs. Shifts in the populations of game fish or plankton-eating forage fish can sometimes lead to a decimation of the zooplankton, allowing algae to flourish. Biomanipulation techniques aimed at increasing the populations of top predator fishes or reducing the populations of forage fishes can often correct the trophic imbalances. Bioassessments of the plankton communities or the fish populations can therefore indicate overall trophic status. Other techniques being explored look at benthos or macrophytes in lake littoral areas. These techniques can be valuable supplements to the more traditional Carlson TSIs that focus on algal standing crop, nutrients, or transparency parameters.

In 1994, 41 States reported that 18% of the 9,735 lakes they assessed for trophic status were oligotrophic, 37% were

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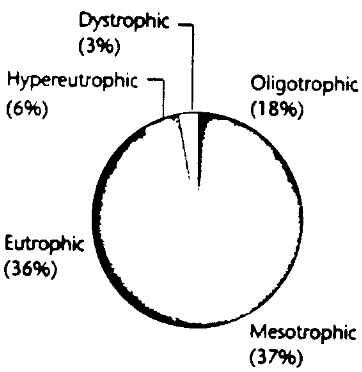
Figure 16-2

Trophic Status of Assessed Lakes



Based on data contained in Appendix H, Table H-1.

mesotrophic, 36% were eutrophic, 6% were hypereutrophic, and 3% were dystrophic (Figure 16-2). This information may be somewhat biased, as States often assess lakes in response to a problem or public complaint or because of their easy accessibility. It is likely that more remote lakes–which are probably less impaired–are underrepresented in these assessments.

Lake Acidity Impacts

During the 1980s, considerable national attention focused on how pollution can lower the pH of receiving waters, especially lakes. Acidity can pose a direct threat to aquatic life and lake recreational amenities. Major potential sources include atmospheric deposition and acid mine drainage. EPA coordinated a major multi-agency study called the National Acid Precipitation Assessment Program (NAPAP) to study acid deposition. A wealth of data were collected on many lakes and stream systems under NAPAP. NAPAP also provided insights into promising monitoring designs to document receiving waters with actual acidity problems or sensitivities to potential acid impacts.

NAPAP concluded that the incidence of serious acidification problems was far more limited than originally feared, and this Federal hypothesis seems to be reflected in evidence reported by the States in their lake water quality assessments. At least for significant publicly owned lakes, the Adirondacks area of New York emerges as the only region showing appreciable numbers of public lakes with significant acidification damage.

In addition to impacts from acidity per se, low pH conditions can accentuate impacts from a variety of toxicants. For instance, many metals show increased availability as the pH drops and, where acid mine drainage is involved, the pollutant source for the acidity may also be a source of toxicants. Acidity may also accentuate the impacts on aquatic organisms of a variety of toxics and may often increase bioaccumulation or biomagnification processes that move toxicants into the tissues of fish and thus into the food chain. Toxic accumulations in sediment also complicate the use of lake restoration techniques such as dredging.

Acidic lakes are generally found in areas where watershed soils have limited buffering capabilities. Acid rain or acid mine drainage can then depress a lake's pH levels to a point at which many forms of aquatic life are stressed or eliminated. Table 16-1 summarizes some of the common biological effects at progressively lower pH ranges.

In the eastern United States, such areas as southern New Jersey have been shown to have limited natural buffering capacity, making many lakes potentially vulnerable to acid deposition impacts. In addition to lakes, some States are concerned about acidity impacts on high-gradient trout streams. Where the acidity concerns affect whole watersheds, this encourages a search for mitigation techniques that could benefit both lakes and streams. New York has undertaken some innovative demonstration projects aimed at liming whole watershed areas instead of the more traditional strategy of liming just the lakes.

States have documented areas where local geological and soil factors may render lakes deficient in natural buffering capacity and therefore vulnerable to acidity stress. Such sensitive areas seem quite prevalent in high-altitude glacial lakes in mountainous areas in the Rockies and several western States. A major concern here is low pH water introduced from snowpack meltwater. Many of these high-altitude lakes may show a seasonal pulse of low pH inflows, usually during the Spring. The ecological consequences are not entirely clear, and States such as Colorado and Washington will continue to study this episodic phenomenon.

Serious impacts from acid mine drainage also seem relatively rare. No State has found clear documentation of acidity impacts related to active mining activities. However, there is some concern about abandoned mine workings. At least one State, Oklahoma, is undertaking a study on a portion of the Eufaula Reservoir that lies in a region with a long history of surface and hard rock coal mining activities.

In light of these concerns, Congress added provisions for State lake assessment reporting to document known instances of acidity or toxics impact to public lakes in the 1987 CWA reauthorization. If such issues are related to actual impairments or pose real degradation threats, States are encouraged to document methods and procedures that could mitigate the harmful effects of high acidity or toxic metals and other toxic substances.

In 1994, 26 States reported that, of the 5,933 lakes assessed for acidity, 9% exhibited acidity and 16% were threatened by acidity. Over half of these lakes exhibiting acidity and roughly one-quarter of the lakes threatened by acidity were in New York. Very little information was provided by States regarding the sources of acidity to impacted or threatened lakes.

Table 16-1. Effects of pH on Aquatic Life

pH Range	General Biological Effects
6.5 to 6.0	Some adverse effects for highly acid-sensitive species
6.0 to 5.5	Loss of sensitive minnows and forage fish; decreased reproductive success for trout and walleye
5.5 to 5.0	Loss of many common sports fish and additional nongame species
5.0 to 4.5	Loss of most sports fish; very few fishes able to survive and reproduce where pH levels commonly below 4.5

Toxic Effects on Lakes

In the 1987 CWA reauthorization, there was an expectation that if toxics concerns were encountered in lakes, they might be tied to an anticipated widespread incidence of acidity problems. As discussed above, evidence submitted by the States and from the Federal NAPAP investigations suggests that lake acidity problems are much rarer than anticipated. Toxics concerns States have submitted, therefore, are generally not related to depressed pH levels.

[illegible] concerns in lakes.

Many States do report serious toxics concerns, with the most common centering on fish consumption advisories. Most States maintain programs to sample fish tissues from their major public lakes. These collections also generally involve sampling of ambient water and sediments. Rarely do ambient water levels exceed detection limits for heavy metals or common pesticides. For sediments and fish flesh, however, virtually all States have at least one public lake at which elevated levels of some toxicant have been documented. Any exceedances of

FDA alert levels or other Federal or State threshold levels will be noted in the 305(b) reporting process. Especially for contaminants in fish flesh, State health authorities will issue consumption advisories so that the public can make appropriate fish consumption decisions.

If a State has established provisions in its water quality standards regarding these public health issues, lakes may be reported as showing beneficial use impairments. Where such standards are not well-defined, the information may show up only in the 305(b) sections dealing with public health/aquatic life concerns. If it is carried over into the use attainment portion of the 305(b) documents, States may choose to characterize the concern as a 305(b) "assessment" issue. This is a rapidly evolving field, with many States attempting to add public health features to their water quality standards or expanded standards' provisions for wildlife protection.

Because many of the toxicants in question are persistent substances (e.g., chlordane or PCBs), it is often likely that there are no active pollutant sources; rather the problems are related to in-place contaminants. This situation is compounded by the fact that many of the organic or heavy metal toxicants are multimedia problems, with any ongoing pollutant loading coming from atmospheric deposition. The sources for such "air pollution" inputs are generally not well known; in some cases the ultimate sources may even lie outside the United States, reflecting pollution processes on a hemispheric or global scale. Faced with these uncertainties, most States are continuing to gather monitoring data and are adopting risk management strategies.

In 1994, 39 States and Territories reported that they found elevated concentrations of toxic contaminants in fish, sediment, or water column samples representing over 2 million lake acres. These States surveyed more than 7.5 million lake acres for toxic contaminants, many of which had known or suspected toxicity problems. This information is difficult to interpret because States do concentrate their monitoring efforts on lakes with problems, and each State uses its own criteria for defining "elevated" concentrations of contaminants.

Trends in Significant Public Lakes

A final provision in the 1987 CWA reauthorization encourages States to make use of available information to identify trends in water quality for public lakes. With the possible exception of bog-like dystrophic lakes, lakes do naturally display shifts in trophic status over time, as well as pollution-induced trends. Trend analysis can therefore be extremely valuable in documenting the eutrophication rate. Where possible, trend assessments should look not only at shifts in trophic status but at all water quality issues, including trends involving toxic contaminants.

The majority of States do attempt some sort of trend determination. Frequently, determinations are made based on best professional judgment (BPJ) rather than more quantitative tests. Virtually every State that presents such BPJ trends

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assessments notes that confidence limits or other measures of reliability or precision are not available.

While the desirability of trend assessments is widely recognized, States still face challenges in gathering adequate information to statistically document trend signals. Although States continue to explore ways to detect empirically significant trends, virtually every State expressed the need to acquire additional data, a common estimate being that at least 10 years of observations would be needed to apply more rigorous statistical methods. Another common theme is that the patterns displayed in many lakes do not seem to be linear. Most available statistical tests are geared to spotting simple, linear trends. Where the underlying physical patterns are nonlinear or cyclical, more complex analyses are needed.

Some States do apply quantitative analysis techniques for lake assessments. Illinois used linear regressions combined with examination of scatter plots of the raw data and residuals. From 213 lakes, over half (56%) of the lakes had complicated fluctuating patterns suggesting cyclical or nonlinear patterns, perhaps related to weather variability. Illinois, therefore, felt that additional data and further analysis would be worthwhile. Wisconsin and Minnesota used the Seasonal Kendall tau test to look at trends in water clarity. This is a nonparametric test considered by many to be generally preferable to parametric tests for use with water quality data. Wisconsin looked at 40 lakes, with the test suggesting increasing trends (clearer water) for 16 lakes and decreasing trends for 6 lakes. Minnesota reported trends in Secchi transparency for the 16 lakes with 8 or more years of data. At a 10% detection level, 13 lakes were considered to have a significant decline in transparency and 44 lakes were considered to have a significant increase in transparency.

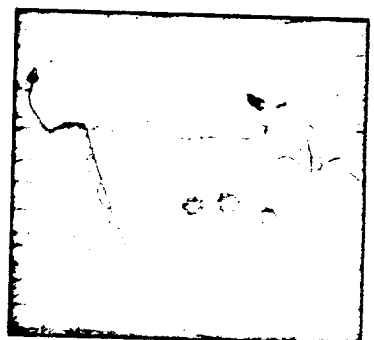
In 1994, 24 States reported that of the 1,828 lakes assessed for trends, 14% were improving, 68% were stable, and 18% were degrading. This information may be somewhat biased, as States often assess trends in lakes that are part of a management study or because of their easy accessibility. It is likely that more remote lakes are underrepresented in these assessments.

Pollution Control and Restoration Techniques

Managing lake quality often requires a combination of in-lake restoration measures and pollution controls, including watershed management measures:

Restoration measures are implemented to reduce existing pollution problems. Examples of in-lake restoration measures include harvesting aquatic weeds, dredging sediment, and adding chemicals to precipitate nutrients out of the water column. Restoration measures may not address the source of the pollution.

Pollution controls deal with the sources of pollutants degrading lake water quality or threatening to impair lake water quality. Control measures include planning activities, regulatory actions, and implementation of best management practices



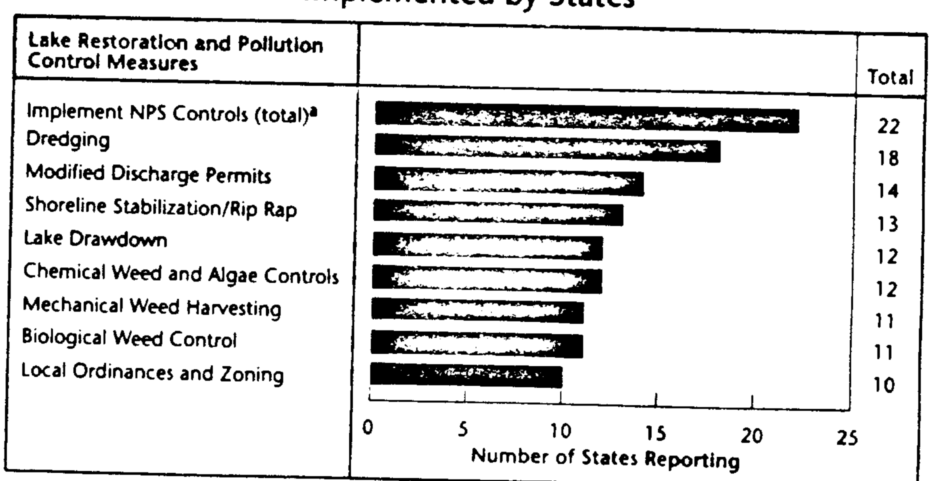
Case Kepner, age 8, Bruner Elementary, North Las Vegas, NV to reduce nonpoint sources of pollutants. Watershed management plans and lake management plans are examples of planning measures. Watershed management plans simultaneously address multiple sources of pollutants, such as runoff from urbanized areas, agricultural activities, and failing septic systems along the lake shore. Regulatory measures include point source discharge prohibitions and phosphate detergent bans.

States are asked to provide materials on their lake restoration techniques. For example, States may provide specific restoration techniques from which they will draw to develop lake-specific management plans. Where possible, States are encouraged to document specific techniques recommended for individual publicly owned lakes.

During the 1980s, most States implemented chemical and mechanical in-lake restoration measures to control aquatic weeds and algae. In 1994, the States reported that they still implement in-lake treatments, but they most frequently implement best management practices (BMPs) to control nonpoint sources of nutrients and siltation (Figure 16-3). Twenty-two States reported that they implemented BMPs to control NPS pollution entering more than 171 lakes. The States reported that they implemented agricultural practices to reduce soil erosion, managed animal waste, constructed retention and detention basins to cleanse

Figure 16-3

Lake Restoration and Pollution Control Measures Implemented by States



[a]Includes best management practices, such as conservation tillage, sediment detention basins, vegetated buffers, and animal waste management.

urban stormwater, revegetated shorelines, and constructed or restored wetlands to remove pollutants before they entered lake waters.

Clean Lakes Demonstrations

The 1987 amendments to Clean Water Act Section 314 established the Demonstration Program for lakes. The Act requires that the EPA Administrator give priority consideration to the following 10 lakes for inclusion in the Demonstration Program: Lake Worth, Texas; Lake Houston, Texas; Beaver Lake, Arkansas; Greenwood Lake, New Jersey; Deal Lake, New Jersey; Alcyon Lake, New Jersey; Gorton's Pond, Rhode Island; Lake Washington, Rhode Island; Lake Bomoseen, Vermont; and Sauk Lake, Minnesota.

These 10 lakes have water quality problems common to many lakes throughout the United States. Most of the water quality problems fall into two categories: (1) excessive siltation and sediment influx and (2) high levels of nutrient loading.

These water quality problems have many sources, but most can be linked to the development of the lakes' watersheds. Urbanization can increase runoff from lawns, highways, stormwater outfalls, and other surfaces. Shoreline development can result in increased nutrient loading from inadequate septic systems and the use of fertilizers on lawns. Rural development can lead to water quality problems as well. Farms and animal production facilities on or near lakes use and generate large quantities of nitrogen and phosphorus from animal feed, fertilizers, pesticides, and animal waste. Runoff from these facilities or fields can significantly increase the nutrient load to a lake. Soil erosion that occurs during construction or from poorly maintained commercial, residential, or agricultural lands can cause a significant influx of silt and sediment to a lake.

Demonstration Lakes

Lake Worth. Lake Worth is the primary source of drinking water for the City of Fort Worth, Texas. It is also a major recreational resource and is surrounded by almost 4,000 acres of public parks. In recent years, however, uses of the lake have been impaired by siltation and the unchecked growth of aquatic plants in the shallow areas of the lake. Studies conducted over the past 30 years have given project principals a clear understanding of the history and present condition of the lake and its watershed as well as a coherent restoration plan. This project enjoys very active public participation, cooperation with the U.S. Army Corps of Engineers, and coordination through an interagency planning committee composed of Federal, State, and local entities. With the workplan approved and engineering designs prepared, the restoration project is well under way and active. The project involves installation of an innovative pressurized wastewater collection system, enhancement of existing wetlands for nutrient uptake, dam operation adjustments to raise the water level, and removal of stumps and abandoned dock pilings.

Lake Houston. This 12,350-acre impoundment serves as a water supply and recreational lake for the City of Houston, Texas. Originally, the lake had a storage capacity of more than 160,000 acre-feet, but over the years the capacity of the lake has decreased by more than 18%. Studies indicate that the diminished capacity results from constant sedimentation and that uses of the lake are impaired by the excessive growth of aquatic plants. The current water quality problems are caused by runoff, primarily from urbanized areas around the lake, and point source discharges. Feasibility studies are under way to examine several restoration and pollution prevention methods for the lake, and the City of Houston is independently conducting a comprehensive lake and watershed study.

Beaver Lake. Located near Fayetteville, Arkansas, Beaver Lake is a 28,190-acre reservoir that serves as a drinking water supply and recreational facility for the surrounding population of more than 200,000 people. Although the lake has escaped any significant impairment to date, the State of Arkansas is concerned that rapid commercial, agricultural, and residential development threatens the water quality of the lake. Over the years, the Beaver Lake watershed has been studied extensively through the cooperative efforts of several Federal agencies. All recognize that runoff from the growing number of chicken and swine farms in the watershed could eventually affect the quality of the drinking water supply. Studies indicate that water clarity in the upper reservoir has been decreasing as a result of siltation and algal blooms. The source of the silt and nutrients is believed to be the increased number of confined animal production facilities and the spreading of the waste from the facilities on nearby pastures. EPA and the State of Arkansas are encouraging farmers to use best management practices voluntarily to reduce the potential for nutrient loading to the lake. The Army Corps of Engineers undertook an extensive effort to characterize the water quality of the lake and to determine the impacts of the surrounding watershed. Monitoring data indicate that the trophic status of the lake has not changed significantly since 1970. Although point sources of pollution to the lake have decreased, nonpoint sources have increased, resulting in no net change in nutrient input. No specific restoration measures have been recommended.

Greenwood Lake. Historic Greenwood Lake is unique among the Demonstration Program lakes because it is located in two States, New Jersey and New York. The lake, divided almost in half by the New York/New Jersey State line, is part of the headwaters for the Wanaque Reservoir, which is a major water source for northern New Jersey and a popular recreational area. Although Greenwood Lake is still a

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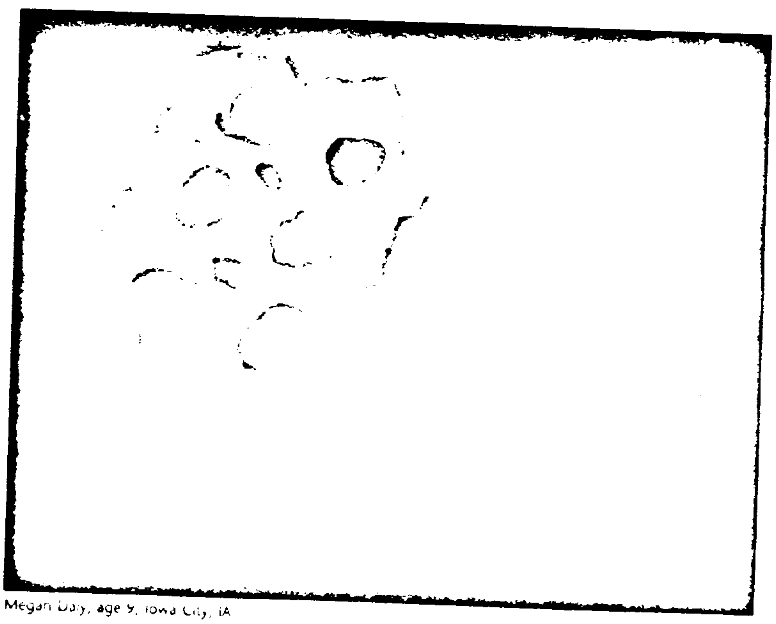
thriving water resource, it shows signs of water quality degradation: adverse changes in fishery populations, excessive growth of aquatic plants, and unpleasant odors and taste. This degradation is caused by increased nutrient and sediment loadings, which are the result of development in the watershed, stormwater runoff, septic discharges, and point source discharges into tributaries of the lake. Sources of lake pollution have been identified and a 10-part restoration plan was developed in the 1980s. Some portions of the plan—specifically lake drawdown and aquatic plant harvesting—were implemented as early as 1985. In addition, sewage treatment facilities have been upgraded, stormwater control measures have been implemented for new developments, and runoff conveyances have been maintained. Ongoing efforts include lake level drawdown, weed harvesting, development of a stormwater management plan prioritizing sites, construction of stormwater detention basins, and a public education program. Preliminary results indicate that the recurrence of excessive aquatic plants has decreased. In addition to the efforts of the States and EPA, the COE has developed a dredging plan for the lake.

Deal Lake. Deal Lake is the largest freshwater body in Monmouth County, New Jersey. By 1950, sedimentation, algal blooms, and bacteria concentrations had become so excessive that recreational uses were impeded or prohibited. State and local interest in restoring the lake culminated in 1983 in a State-sponsored comprehensive diagnostic/feasibility study. This study determined the primary source of sediment to be an old landfill located upstream of the lake. The source of nutrients and bacteria appears to be excrement from the abundant waterfowl that inhabit the lake. This study also defined a remediation plan that included in-lake work such as dredging and drawdown, as well as watershed management elements such as stabilization of the upstream landfill, stormwater management, erosion control, and the protection of sensitive habitats. The remediation plan was initiated in 1988 with $1 million of State funds. After the landfill was stabilized, a heavily sedimented portion of the lake was restored by dredging, construction of a sediment trap, wetland enhancement, and reclamation of



Megan Daly, age 9, Iowa City, IA

surface water habitat. Further activities completed or ongoing include (1) construction of stormwater detention basins, (2) dredging to create a new retention site, (3) development of watershed and "sensitive lands" management plans, and (4) public education and consultation with area schools.

Alcyon Lake. Alcyon Lake is a small manmade lake located in Pitman, New Jersey. The lake has been a center of community activity since the 1890s when Alcyon Park was built on the lakeshore. In 1951, Alcyon Park was sold and essentially abandoned. By 1980, three sources of pollution had been identified: (1) the LiPari Landfill, an abandoned chemical waste dump; (2) urban stormwater runoff; and (3) agricultural runoff. This pollution had been ongoing for over 20 years. In 1980, it was determined that the major problem at the lake was the discharge of approximately 150,000 gallons of chemical waste from the LiPari Landfill. The LiPari Landfill was designated as a Superfund project and the landfill is now contained. The Superfund Program is now dredging contaminated sediments from the lake and area streams and wetlands. Under the Clean Water Act, the Lake Demonstration Programs focused on the urban and agricultural sources of pollution to the lake. This effort is in progress and includes (1) examination of the stormwater drainage system to identify problem areas, (2) a volunteer monitoring program, (3) public participation meetings and an education program, (4) streambank stabilization, and (5) a joint effort with the Soil Conservation Service (recently renamed the Natural Resources Conservation Service) to implement watershed erosion control measures.

Gorton's Pond. Located near Warwick, Gorton's Pond is in a heavily urbanized area of Rhode Island. Consequently, it has many of the pollution problems associated with residential and commercial development. These include surface runoff that contains oil, grease, bacteria, fertilizers (nutrients), and sediment. Resulting problems are algal blooms, overgrowth of aquatic vegetation, and a decline in the fishery. Recommendations from an initial study stressed that the restoration plan must deal with the causes of the water pollution—land use practices in the watershed—as well as in-lake work. Land use management recommendations included erosion and sediment control, particularly during construction and at stormwater outfalls; stormwater treatment and/or diversion; and elimination of point and nonpoint source discharges such as onsite sewage disposal systems. In-lake methods proposed included limited dredging, nutrient inactivation, and aquatic plant harvesting. The design phase of a stormwater infiltration basin has been completed but the basin has not been constructed.

Lake Washington. Located in upper northwestern Rhode Island, Lake Washington is a shallow basin constructed more than 80 years ago. In recent years, excessive growth of aquatic vegetation, algal blooms, and increased sedimentation have occurred. The decomposition of the aquatic plants and algae has decreased the dissolved oxygen content in the water, threatening the survival of the fish population. Part of the water quality problems stem from the fact that the lake has a naturally low inflow of water, primarily ground water, and consequently has poor flushing. In addition, many lakeshore residents are on septic systems that have exceeded their useful life. A further source of pollution is runoff from a highway that abuts the lakeshore. Failing septic systems have been identified as the primary source of nutrients to the lake, and a centralized wastewater treatment system has been recommended. In-lake work such as drawdown, harvesting, and algicides may also be needed, as well as watershed management activities such as revision of local land ordinances, rip rap and vegetative swells, land acquisition, and better maintenance of stormwater drainage systems.

Lake Bomoseen. Lake Bomoseen is the largest lake located entirely within Vermont. It covers 2,364 acres and has an average depth of 27 feet. As a result, the lake is a major recreational resource and contributes to the economy of the region. Since 1982, the aquatic plant Eurasian water milfoil has spread rapidly in some areas of the lake. It is estimated that the plant occupies more than 600 acres of the lake out to a depth of 20 feet. The Eurasian milfoil coverage is very dense and has severely restricted use of the lake. In the 1980s mechanical harvesters were used to remove the plants from the lake's surface, but this method proved to be ineffective and uneconomical in controlling the plant growth. In 1989, staff of the Vermont Department of Environmental Conservation (DEC) discovered a dramatic decline in milfoil growth in Brownington Pond in northeastern Vermont. The decline appeared to be associated with the presence of a particular native herbivorous (plant-eating) aquatic weevil that feeds on Eurasian milfoil. In 1990, DEC began a 5-year research project on the use of the native insect as a biological control for milfoil in Lake Bomoseen as well as the other 25 lakes in Vermont that have a milfoil problem. The goal of the project is to determine the extent to which the aquatic weevil might contribute to milfoil reduction and the suitability of Lake Bomoseen and other lakes for weevil introduction. The project has involved determining the distribution and abundance of the native weevil in Vermont lakes, field collection of adult weevils for rearing stock, weevil rearing in a laboratory greenhouse, introduction of weevils into specific lake sites, and monitoring to determine survival of the weevils and feeding damage to milfoil plants. Results from the quantitative sampling effort done at the three weevil introduction sites on Lake Bomoseen are not yet available. However, visual observations indicate that the weevils have damaged the milfoil at all three sites and that some milfoil populations in shallow water are starting to collapse. Norton Brook Reservoir also received weevil introductions; however, introductions at this site were discontinued due to a lack of positive results. Unlike the observations at Bomoseen, little evidence of

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surviving weevils and weevil feeding damage was seen at this site. Therefore, at this point it is difficult to predict how successful the weevils will be at reducing Eurasian milfoil.

Sauk Lake. Sauk Lake covers 2,111 acres in central Minnesota and has a predominantly agricultural watershed encompassing 5 counties, 49 townships, and 28 cities. The overgrowth of aquatic plants and algae has severely curtailed or entirely discontinued the recreational uses of the lake. The sources of nutrient and sediment pollution are agricultural and urban runoff within the watershed and upstream of Sauk Lake. The State has begun to control these sources and prevent pollution in the upstream Lake Osakis watershed area. Measures include agricultural best management practices such as no-till farming and feedlot runoff diversion, streambank and shoreline erosion control, urban stormwater diversion, and a community education program. Meanwhile, the Army Corps of Engineers has been implementing a harvesting effort to reduce the aquatic plants in Sauk Lake.

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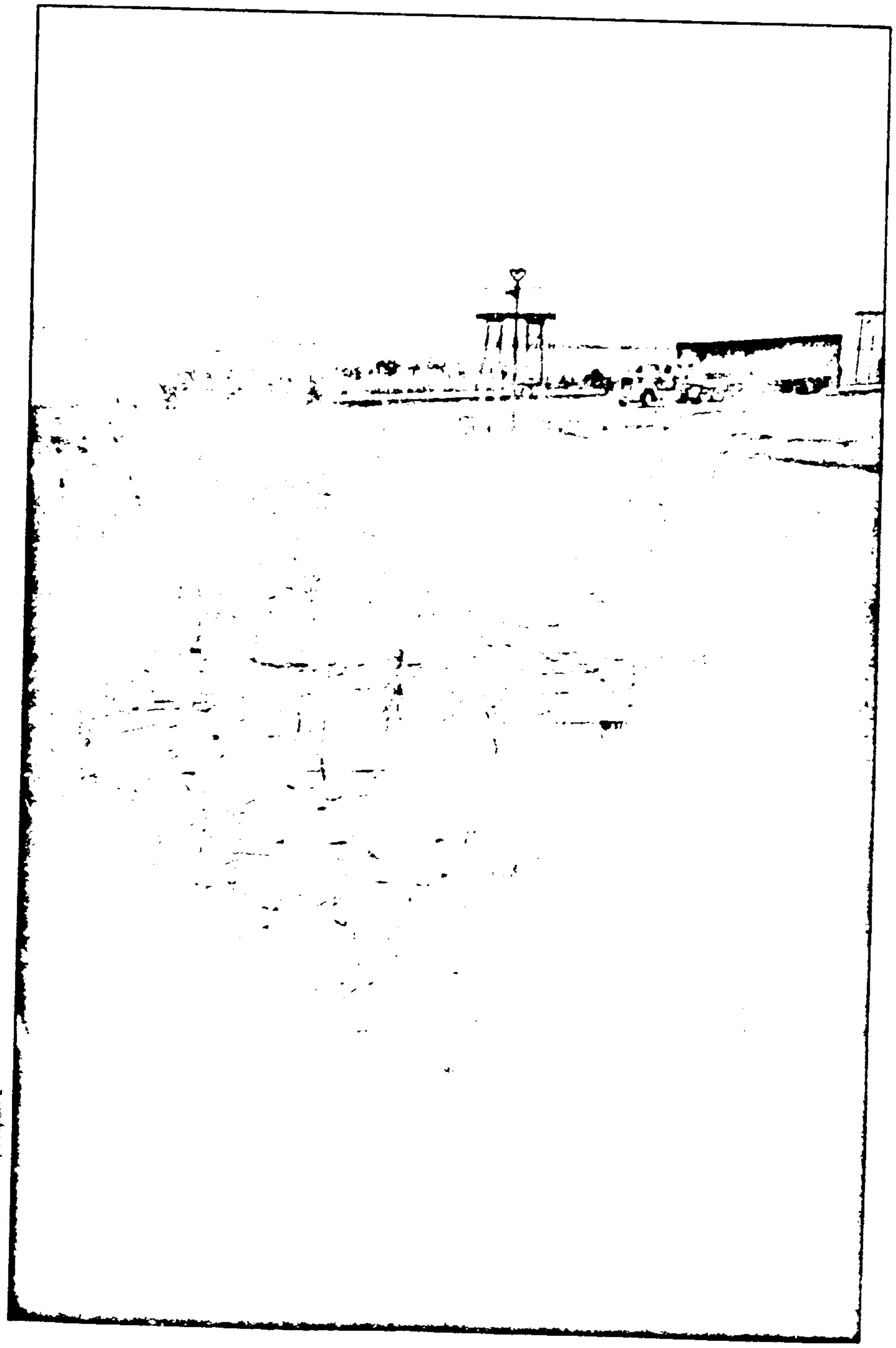

Audrey Moore, U.S. EPA, Region 2

Wetlands Protection Programs

A variety of public and private programs protect wetlands. The Conservation Foundation organized the bipartisan National Wetlands Policy Forum in 1987 to coordinate these disparate efforts and develop a national, coordinated vision for wetlands protection. The Forum issued a report in November 1988 containing over 100 recommended actions for all levels of government and the private sector. It established an interim goal to achieve no overall net loss of the Nation's wetlands base and a long-term goal to increase the quantity and quality of the Nation's wetlands resource base. Shortly after coming into office, the Clinton Administration convened an interagency working group to address concerns with Federal wetlands policy. After hearing from States, developers, farmers, environmental interests, members of Congress, and scientists, the working group developed a comprehensive 40-point plan for wetlands protection to make wetlands programs more fair, flexible, and effective. This plan was issued on August 24, 1993.

Section 404

Section 404 of the Clean Water Act continues to provide the primary Federal vehicle for regulating certain activities in wetlands. Section 404 establishes a permit program for discharges of dredged or fill material into waters of the United States, including wetlands.

The U.S. Army Corps of Engineers and EPA jointly implement the Section 404 program. The COE is responsible for reviewing permit applications and making permit decisions. EPA establishes the environmental criteria for making permit decisions and has the authority to review and veto Section 404 permits proposed for issuance by the COE. EPA is also responsible for determining geographic jurisdiction of the Section 404 permit program, interpreting statutory exemptions, and overseeing Section 404 permit programs assumed by individual States. To date, only two States (Michigan and New Jersey) have assumed the Section 404 permit program from the COE. The COE and EPA share responsibility for enforcing Section 404 requirements.

The COE issues individual Section 404 permits for specific projects or general permits (Table 17-1). Applications for individual permits go through a review process that includes opportunities for EPA, other Federal agencies (such as the U.S. Fish and Wildlife Service and the National Marine Fisheries Service), State agencies, and the public to comment. However, the vast majority of activities proposed in wetlands are covered by Section 404 general permits. For example, in FY94, over 48,000 people applied to the COE for a Section 404 permit. Eighty-two percent of these applications were covered by general permits and were processed in an average of 16 days. It is estimated that another 50,000 activities are covered by

The Administration's Wetlands Plan emphasizes improving Federal wetlands policy by

- *Streamlining wetlands permitting programs*
- *Increasing cooperation with private landowners to protect and restore wetlands*
- *Basing wetlands protection on good science and sound judgment*
- *Increasing participation by States, Tribes, local governments, and the public in wetlands protection*

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general permits that do not require notification of the COE at all.

General permits allow the COE to permit certain activities without performing a separate individual permit review. Some general permits require notification of the COE before an activity begins. There are three types of general permits:

- Nationwide permits (NWPs) authorize specific activities across the entire Nation. NWPs cover categories of activities that the COE determines will have only minimal individual and cumulative impacts on the environment. Currently, 36 NWPs authorize activities including construction of minor road crossings and farm buildings, bank stabilization activities, some cranberry operations, and the filling of up to 10 acres of isolated or headwater wetlands.

- Regional permits authorize types of activities within a geographic area defined by a COE District Office. Regional permits may authorize activities in a specific waterbody, a county, a State, a COE district, or multiple States within a COE district.

- Programmatic general permits are issued to an entity that the COE determines may regulate activities within its jurisdictional wetlands. Under a programmatic general permit, the COE defers its permit decision to the regulating entity but reserves its authority to require an individual permit. Under State programmatic general permits (SPGPs), the COE defers permit decisions to a State program for specific activities throughout the State or in a significant portion of the State.

Currently, the COE and EPA are promoting the development of SPGPs to increase State involvement in wetlands protection and minimize duplicative State and Federal review of activities proposed in wetlands. Each SPGP is a unique arrangement developed by a State and the COE to take advantage of the strengths of the individual State wetlands program. SPGPs may cover all

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Table 17.[illegible] Federal Section 404 Permits

General Permits (streamlined permit review procedures)				Individual Permits
Nationwide Permits	Regional Permits	Programmatic Permits		
		State Programmatic Permits	Others	
• Cover 36 types of activities that the COE determines to have minimal adverse impacts on the environment	• Developed by COE District Offices to cover activities in a specified region	• COE defers permit decisions to State agency while reserving authority to require an individual permit	• Special Management Agencies • Watershed Planning Commissions	• Required for major projects that have the potential to cause significant adverse impacts • Project must undergo interagency review • Opportunity for public comment • Opportunity for 401 certification review

regulated activities in a State or a select set of activities in a portion of the State. Several States have adopted comprehensive SPGPs that replace many or all COE-issued nationwide general permits (see highlight on page 442).

SPGPs simplify the regulatory process and increase State control over their wetlands resources. Carefully developed SPGPs can improve wetlands protection while reducing regulatory demands on landowners.

Wetlands Water Quality Standards

Water quality standards for wetlands ensure that the provisions of CWA Section 303 that apply to other surface waters are also applied to wetlands. In July 1990, EPA issued guidance to States for the development of wetlands water quality standards. Figure 17-1 indicates the State's progress in developing these standards (see Appendix D, Table D-5, for individual State data).

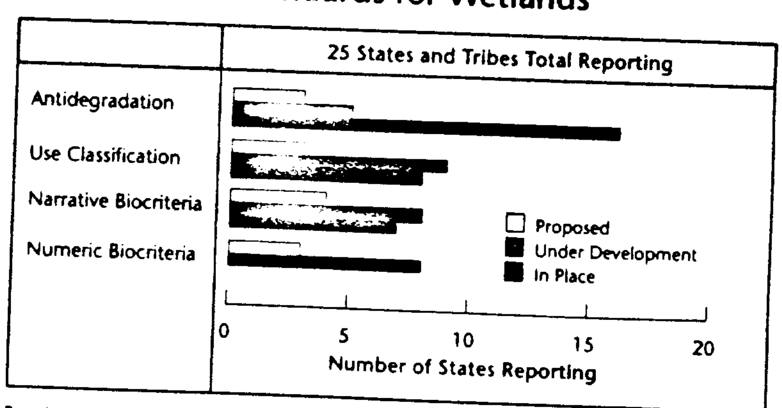
Water quality standards have three major components: designated uses, criteria to protect those uses, and an antidegradation policy. States designate uses that must, at a minimum, meet the goals of the CWA by providing for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water. States may choose to designate additional uses for their wetlands, such as flood water attenuation or ground water recharge where appropriate. Once uses are designated, States are required to adopt criteria sufficient to protect their designated uses.

Criteria are general narrative statements or specific numerical values such as concentrations of contaminants and water quality characteristics. Narrative criteria can be particularly appropriate for wetlands when quantitative data do not exist. An example of a narrative criterion is "natural hydrological conditions necessary to support the biological and physical characteristics naturally present in wetlands shall be protected."

Standards provide the foundation for a broad range of water quality management activities under the CWA including, but not limited to, monitoring for the Section 305(b) report, permitting under Sections 402 and 404, water quality certification under Section 401, and the control of nonpoint source pollution under Section 319.

Figure 17-1

Development of State Water Quality Standards for Wetlands



Based on data contained in Appendix D, Table D-5.

Water Quality Certification of Federal Permits and Licenses

Section 401 of the CWA gives States and eligible American Indian Tribes the authority to grant, condition, or deny certification of federally permitted or licensed activities that may result in a discharge to U.S. waters, including wetlands. Such activities include discharge of dredged or fill material permits under Section 404 of the Clean Water Act, point source discharge permits under Section 402 of the Clean Water Act, and Federal Energy Regulatory Commission's hydropower licenses. States review these permits to ensure that they meet State water quality standards.

In 1989, EPA issued guidance to States and American Indian Tribes on how to use 401 certification authority to protect wetlands. Section 401 certification can be a powerful tool for protecting wetlands from unacceptable degradation or destruction, especially when implemented in conjunction with wetlands-specific water quality standards. Section 401 grants States and Tribes the authority to deny certification or require conditions for certification if the State or Tribe determines that an applicant has failed to demonstrate that a project will comply with State or Tribal water quality standards. If a State or eligible Tribe denies Section 401 certification, the Federal permitting or licensing agency cannot issue the permit or license.

Most States now use their Section 401 certification programs to review activities requiring both Section 404 individual permits and selected general permits. Until recently, many States waived their right to review and certify individual and general Section 404 permits because these States had not defined water quality standards for wetlands or codified regulations for implementing their 401 certification program into State law. Now, most States report that they use the Section 401 certification process to review Section 404 projects and to require mitigation if there is no alternative to degradation of wetlands.

Ideally, 401 certification should be used to augment State programs because it applies only to projects requiring Federal permits or licenses. Activities that do not require permits, such as some ground water withdrawals, are not covered.

State Wetlands Conservation Plans

State Wetlands Conservation Plans (SWCPs) are strategies that integrate regulatory and cooperative approaches to achieve State wetlands management goals, such as no overall net loss of wetlands. SWCPs are not meant to create a new level of bureaucracy. Instead, SWCPs improve government and private-sector effectiveness and efficiency by identifying gaps in wetlands protection programs and identifying opportunities to improve wetlands programs.

A large number of land- and water-based activities impact wetlands. These activities are not addressed by a single Federal, State,

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or local agency program. Although many public and private programs and activities protect wetlands, these programs are often limited in scope and are not well coordinated. Also, these programs often do not address all of the problems affecting wetlands.

States, Territories, and Tribes are well positioned between Federal and local government to take the lead in integrating and expanding wetlands protection and management programs. They are experienced in managing federally mandated environmental programs under the Clean Water Act and the Coastal Zone Management Act. They are uniquely equipped to help resolve local and regional conflicts and identify the local economic and geographic factors that may influence wetlands protection.

- Texas' SWCP will focus on nonregulatory and voluntary approaches to wetlands protection to complement its regulatory program. The plan will encourage development of economic incentives for private landowners to protect wetlands and educational outreach for State and local officials.

- Tennessee's plan focuses on a strategy to collect wetlands information for outreach and education to private owners of wetlands as well as to regional and local decision-makers. Current implementation efforts include identification of critical functions of major wetlands types, priority sites for acquisition and/or restoration, as well as maintenance and restoration of natural floodplain hydrology through digitization and use of remote sensing.

- Maine's SWCP will focus on ways to establish better coordination between State and Federal regulatory programs as well as new nonregulatory mechanisms to foster voluntary stewardship. In addition, the State expects to use an ecosystem framework to guide the prioritization of wetlands for comprehensive protection and to review and improve compensatory mitigation policies.

Wetlands Monitoring/ Biocriteria Programs

Historically, wetlands protection efforts have concentrated on regulating the widespread destruction of wetlands due to the discharge of dredged and fill material and on conservation of wetlands to maximize tangible benefits such as hunting and fishing. States have only recently begun to take steps toward control of other disturbances that can result in the degradation of wetlands. Such disturbances include hydrologic alteration, vegetation clearing, introduction of alien species, habitat fragmentation, chemical pollutants, sedimentation, and changes in pH, dissolved oxygen, and temperature. The use of water quality standards is an important tool for States to use to address these causes of wetlands degradation.

Assessment of the biological integrity of a wetland is crucial to characterizing water quality because aquatic life tends to reflect the ecological health of a waterbody (including physical and chemical conditions) and will reflect a range of diverse degrading impacts on a

For more information:

- *See the Statewide Wetlands Strategies guidebook, which is available from Island Press (1-800-828-1302).*
- *Ask for copies of the SWCP brochure "Why Develop a State Wetland Conservation Plan?" from the EPA Wetlands Information Hotline (1-800-832-7828) (contractor operated).*

system. Measuring and tracking biological integrity is the best way to ensure that numerous degrading impacts, however subtle or long term, are detected and monitored.

A biocriteria program seeks to characterize the biological integrity of relatively undegraded wetlands or "reference" wetlands and uses this information to set reasonable goals for wetlands within a given eco-region or area. These goals, or beneficial uses, when written as aquatic life use designations (ALUDs) and codified in a State's water quality standards, guide the restoration of degraded wetlands and maintenance of biological integrity in all wetlands.

Supporting biocriteria are developed for each aquatic life use to define biological and ecological characteristics that wetlands must possess to attain an ALUD. Biocriteria generally begin as narrative statements and are assigned numeric values as more data are gathered. It is through this system of biological goal-setting, monitoring, assessment, and updating of biocriteria and ALUDs that the water quality improvement and protection goals of the CWA are achieved.

The extent and importance of impacts to wetlands will become clear only with systematic biomonitoring of reference sites, comparison with degraded wetlands, and research on the links between the type of disturbance and the ecological integrity of wetlands. Without these data, and programs to protect the quality as well as quantity of wetlands resources, wetlands losses will continue.

Although State progress toward development of biocriteria programs is limited and varied, several States have begun systematic long-term regional monitoring and monitoring of reference sites necessary to support a wetlands biocriteria program. Currently, Kentucky, Minnesota, Montana, and New Mexico are developing such programs. Other States have initated projects, often limited to a specific region, wetlands type, or monitoring method, that will help them gain experience and acquire data needed for launching a statewide wetlands biomonitoring program.

Swampbuster

The Swampbuster provisions of the 1985 Food Security Act and the 1990 Food, Agriculture, Conservation and Trade Act ("Farm Bills") deny crop subsidy payments and all other agricultural benefits to farm operators who convert wetlands to cropland after December 23, 1985, or who modify wetlands to make cropping possible after November 28, 1990. The U.S. Department of Agriculture's Natural Resources Conservation Service (formerly the Soil Conservation Service) is responsible for determining compliance with Swampbuster provisions and for determining whether agricultural lands fall under the jurisdiction of Federal wetlands laws, including both the Swampbuster provisions and Clean Water Act Section 404.

State Programs to Protect Wetlands

States protect their wetlands with a variety of approaches, including use of CWA authorities (such as Sections 401 and 303), permitting programs, coastal management programs, wetlands acquisition programs, natural heritage programs, and integration with other programs. For this report, States described particularly innovative or effective approaches they use to protect wetlands.

State-Reported Information

The following trends emerged from individual State reporting:

- Most States have defined wetlands as waters of the State, which offers general protection through antidegradation clauses and designated uses that apply to all waters of a State. However, most States have not developed specific wetlands water quality standards and designated uses that protect wetlands' unique functions, such as flood attenuation and filtration.

- Without specific wetlands uses and standards, the Section 401 certification process relies heavily on antidegradation clauses to prevent significant degradation of wetlands.

- In many cases, the States use the Section 401 certification process to add conditions to Section 404 permits that minimize the size of wetlands destroyed or degraded by proposed activities to the extent practicable.

States often add conditions that require compensatory mitigation for destroyed wetlands, but the States do not have the resources to perform enforcement inspections or followup monitoring to ensure that the constructed wetlands are functioning properly.

- More States are monitoring selected, largely unimpacted wetlands to establish baseline conditions in healthy wetlands. The States will use this information to monitor the relative performance of constructed wetlands and to help establish biocriteria and water quality standards for wetlands.

Some highlights from individual State reports are as follows:

- The District of Columbia adopted narrative criteria for wetlands in their 1994 water quality standards. Wetlands are now classified for designated use categories of Class C (the protection and propagation of fish, shellfish, and wildlife) and Class D (the protection of human health related to consumption of fish and shellfish). Wetlands are now protected from significant adverse hydrologic modifications, excessive sedimentation, deposition of toxic substances in toxic amounts, nutrient imbalances, and other adverse impacts from human activities.

- Massachusetts made significant progress in establishing wetlands-specific criteria. The State defined wetlands as waters of the State, designated uses for wetlands, adopted aesthetic narrative criteria and very general numeric criteria for wetlands, and drafted an antidegradation policy. The State intends to complete and implement the antidegradation policy; draft narrative biological criteria; develop specific numeric criteria for appropriate parameters; develop criteria

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for designating wetlands and Outstanding Resource Waters; and incorporate these standards and criteria into the State 401 Water Quality Certification Program. The State also drafted regulations for implementing the 401 program during the 1994 reporting cycle.

■ During 1992 and 1993, Minnesota completed rules to implement the 1991 Minnesota Wetlands Conservation Act. These rules require local governments to regulate the draining and filling of wetlands not classified as "public waters wetlands." Twenty-five exemptions are included in the Wetlands Conservation Act and Rules. Minnesota also began comprehensive wetlands conservation planning in 1993. An interagency task force staffed through the Minnesota Department of Natural Resources will develop statewide wetlands goals and guidance for coordinating local, State, and Federal wetlands programs.

Minnesota added specific definitions of wetlands to their water quality standards, assigned water use classifications to wetlands, adopted narrative nondegradation standards to protect wetlands, and implemented a wetlands mitigation process. The Minnesota Pollution Control Agency began surveying reference wetlands sites to develop biological and chemical criteria for the wetlands use classifications and to assess the biological and chemical health of wetlands throughout the State.

■ Nebraska adopted specific wetlands water quality standards in November 1993. The standards classify wetlands into two categories: isolated wetlands and surface water overflow wetlands that are adjacent to lakes or streams. The beneficial uses of aquatic life, wildlife habitat, agricultural use, and aesthetics are assigned to all wetlands. In addition, surface water overflow wetlands are protected for the assigned beneficial uses of the adjacent lake or stream. The State assigned narrative water quality criteria to protect the beneficial uses and numeric criteria to protect uses from toxic pollutants.

■ Ohio is in the process of drafting standards to protect the functional values of wetlands, including designated uses, narrative criteria, and an antidegradation policy specifically for wetlands. The State is also developing performance goals for wetlands mitigation projects and designing a monitoring program to support both wetlands water quality standards and the mitigation performance goals.

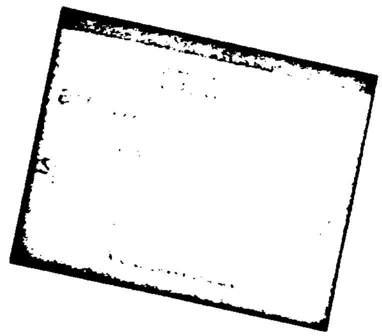
■ Wisconsin Administrative Code NR 103 established wetlands water quality standards in 1991 that include narrative criteria to protect specific wetlands values and functions, such as storm and flood water storage, water cycle functions, filtration of pollutants, shoreline protection, wildlife habitat, and recreational and scientific values.

The standards have greatly enhanced the effectiveness of Wisconsin's Section 401 Water Quality Certification Program by providing legal criteria for denying or adding conditions to proposed activities that will have a significant adverse impact on wetlands values and functions. The standards have controlled impacts to wetlands without halting all activities in wetlands—the State granted 401 Certification to more than half of the wetlands permit applications reviewed between 1991 and 1994.

Summary

There are a variety of public and private programs to protect wetlands. A forum was held in 1987 to coordinate these and provide national direction in the area of wetlands. Section 404 of the Clean Water Act is the major Federal program for regulating activities in wetlands. Other important tools to protect wetlands include voluntary stewardship, wetlands water quality standards, State water quality certification, State wetlands conservation plans, emergency wetlands reserve and conservation reserve programs, and Swampbuster provisions of the Farm bills, as well as incorporating wetlands considerations into other programs such as the Section 319 Nonpoint Source Program.

States reported that they are making progress in developing their programs to protect wetlands, especially in the areas of application of 401 certification, development of water quality standards for wetlands, State programmatic general permits, and formation of more efficient joint application procedures for permits. Despite these efforts, States reported that they continue to lose wetlands and the pressure to develop in wetlands remains high. In addition, there is little known about the quality of the remaining wetlands. States put forward a variety of recommendations on how to improve protection of wetlands, including consideration of wetlands on a landscape or ecosystem basis, development of scientific tools for States to assess and monitor ecological and water quality functions of wetlands, greater sensitivity for arid climates, and regulation of additional activities that impact wetlands.



More information on wetlands can be obtained from EPA's W[illegible] Hotline at 1-[illegible]32-7828 (9 a.m. to 5 p.m., eastern standard time).

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The New Hampshire State Programmatic General Permit

On June 1, 1992, the U.S. Army Corps of Engineers (COE) issued a New Hampshire State Programmatic General Permit (NHSPGP) and simultaneously revoked most nationwide permits for use in the State of New Hampshire. These actions streamlined the wetlands permitting process by consolidating the Federal Section 404 permit review process with New Hampshire's own comprehensive permitting process for activities proposed in wetlands. The actions also eliminated much of the confusion surrounding nationwide general permits.

Under the NHSPGP, the New Hampshire Department of Environmental Services (DES) Wetlands Bureau and the New Hampshire Wetlands Board perform the initial review of all projects proposed in the State's wetlands. The Wetlands Board makes the initial permit decisions, based on information and recommendations provided by DES. The New Hampshire Wetlands Laws of 1967 and 1969 require permits from the Wetlands Board for all projects proposed in the State's wetlands, regardless of project size. There are no exemptions for agricultural or silvicultural activities or activities proposed by Federal, State, or local agencies. The Wetlands Board consists of representatives from eight State agencies and four members of the public.

The Wetlands Board issues three types of permits for activities proposed in wetlands:

- Minimum impact permits for projects that impact less than 3,000 square feet
- Minor impact permits for projects that impact less than 20,000 square feet (about half an acre)
- Major impact permits for projects that impact more than 20,000 square feet.

The NHSPGP establishes the following procedures for processing each of the New Hampshire permits.

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- All projects that receive a minimum impact permit from the Wetlands Board automatically fall under the NHSPGP, with no COE action required. The Wetlands Board notifies permit applicants that the permitted project may commence without COE action.

- The COE and other Federal agencies screen projects that receive a minor impact permit from the Wetlands Board to determine if the project meets conditions of the NHSPGP or requires an individual Section 404 permit. The COE notifies the applicant within 30 days if an individual Section 404 permit is required. Projects with minor impact permits are approved automatically if the COE does not intervene in 30 days and the project meets the conditions of the NHSPGP.

- The COE and other Federal agencies screen projects that receive a major impact permit from the Wetlands Board to determine if the project meets conditions of the NHSPGP or requires an individual Section 404 permit. The COE should notify the applicant within 30 days if an individual Section 404 permit is required, but lack of notification does not provide automatic approval for major projects. The applicant must receive affirmative notification before they initiate projects with major impact permits.

The following categories of projects and activities are excluded from the NHSPGP and automatically require an individual Federal Section 404 permit:

- Projects that will fill more than 3 acres of wetlands or other U.S. waters

- New boating facilities, including marinas, yacht clubs, boat clubs, and public docks

- Projects within the limits of a COE navigation project

- Discharge of spoils in the ocean

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- Improvement dredging in the lower Merrimack River, the Connecticut River, Lake Umbagog, and tidal waters

- Breakwaters extending more than 50 feet from the shoreline

- Projects adversely affecting a National Park, National Forest, National Wildlife Refuge, endangered species, or a National Wild and Scenic River

- Any project likely to jeopardize the continued existence of threatened or endangered species

- Projects of national concern (such as significant fill of wetlands or projects that could affect archeological sites).

During the first year of NHSPGP implementation, New Hampshire reported a 76% reduction in the number of Section 404 individual permits issued and a sevenfold increase in the number of projects receiving documented Federal compliance with Section 404. The NHSPGP process appears to benefit everyone. The NHSPGP relieves permit applicants of time-consuming parallel State and Federal permitting procedures, reduces the COE's average review period for general permits, and frees up limited Federal and State staff to review major projects.

The NHSPGP also eliminates confusion over nationwide general permits. Prior to implementation of the NHSPGP, permit applicants who received nationwide permits often did not realize that they also needed a State permit. Conversely, applicants who received State permits often assumed that they qualified for a nationwide general permit and failed to apply for a required Section 404 individual permit.

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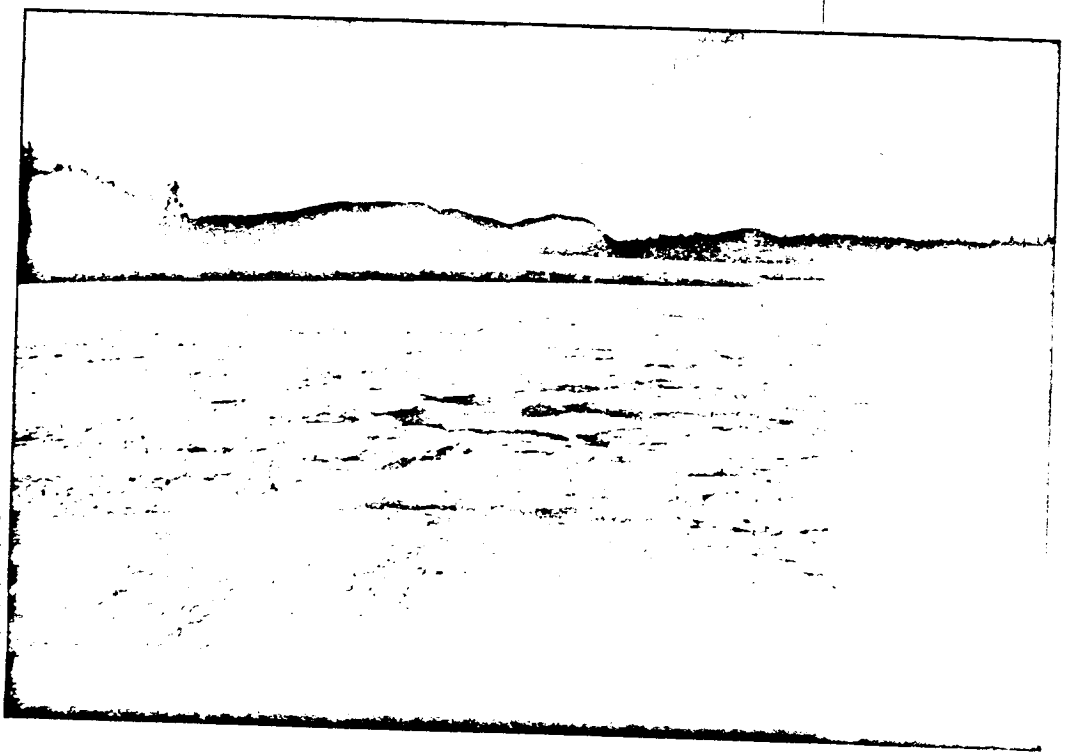

John Theilgard, Bynum, NC

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The Administration's Wetlands Plan

Shortly after coming into office, the Clinton Administration convened an interagency working group to address legitimate concerns with Federal wetlands policy. After hearing from States, developers, farmers, environmental interests, members of Congress, and scientists, the working group developed a comprehensive 40-point plan to enhance wetlands protection while making wetlands regulations more fair, flexible, and effective. The plan was issued on August 24, 1993.

The Administration Wetlands Plan emphasizes improving Federal wetlands policy by streamlining wetlands permitting programs; increasing cooperation with private landowners to protect and restore wetlands; basing wetlands protection on good science and sound judgment; and increasing participation by States, Tribes, local governments, and the public in wetlands protection. The Administration has already taken a number of actions to implement the Wetlands Plan, including the following steps:

- Proposed a nationwide general permit and created an administrative process to minimize the regulatory burden on small landowners for small projects on their land
- Clarified, by regulation, that prior converted croplands are not wetlands under both the Swampbuster and CWA programs
- Gave the U.S. Department of Agriculture the responsibility for identifying wetlands on agricultural lands for both Swampbuster and CWA programs
- Issued policies that have increased flexibility in wetlands permitting and reduced burdens on permit applicants
- Allowed for greater flexibility in permitting requirements in Alaska, due to the unique circumstances in that State
- Made it easier for permit applicants to use mitigation "banks"
- Requested increased funding for the Wetlands Reserve Program to assist farmers who want to restore wetlands

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- Increased funding to States, Tribes, and local governments for wetlands programs.

These efforts are only the first steps that the Administration is taking to reduce the burden of Federal wetlands regulations. Activities currently under development include

- Clarifying exemptions of man-made wetlands from Federal jurisdiction
- Establishing clear and firm deadlines for COE permit decisions
- Allowing administrative appeals of permit denials and wetlands jurisdictional determinations as an alternative to expensive and time-consuming litigation
- Establishing a wetlands delineator certification program to expedite regulatory decisions and improve the quality and consistency of wetlands delineations performed by private consultants
- Improving wetlands assessment techniques so that permit decisions better reflect the fact that all wetlands do not function in the same manner
- Developing guidance to promote the use of Section 404 programmatic general permits that reduce overlap between State and Federal wetlands permitting procedures and provide additional flexibility to State and local governments
- Expanding the Wetlands Reserve Program to all 50 States and allowing more types of land to qualify for the program.

Most of these actions ease the Federal wetlands permitting burden on small landowners and farmers. The Administration is committed to meeting our Nation's wetlands protection objectives without imposing unnecessary burdens on America's farmers and individuals who own property that happens to include wetlands.

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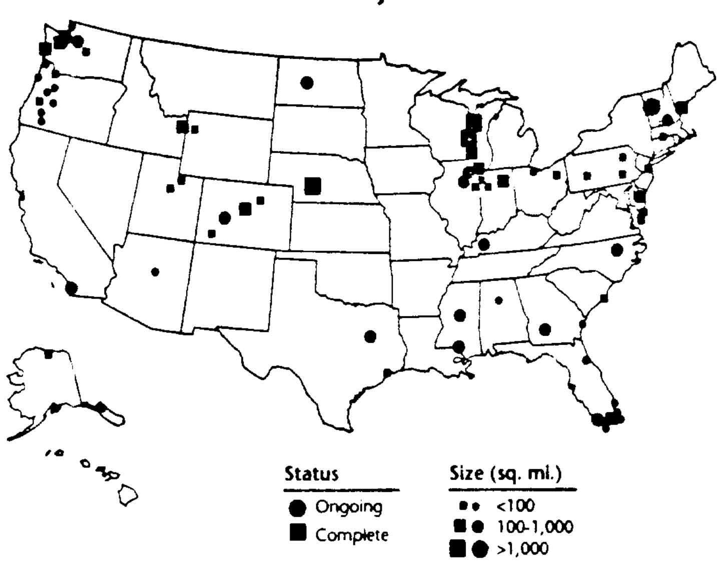
EPA Wetlands Advance Identification (ADID)

This highlight describes the advance identification of disposal areas (ADID), a planning process used to identify wetlands and other waters that are generally suitable or unsuitable for the discharge of dredged and fill material. It highlights how the ADID process works and the status of ongoing projects.

Status of EPA Wetlands ADID Projects – 1993



How the ADID Process Works

The ADID process involves collecting and distributing information on the values and functions of wetlands areas. EPA conducts the process in cooperation with the U.S. Army Corps of Engineers and in consultation with States or Tribes and local interests. Local communities can use this information to help them better understand the values and functions of wetlands in their areas. It also serves as a preliminary indication of factors likely to be considered during review of a Section 404 permit application.

The ADID process is intended to add predictability to the wetlands permitting process as well as better account for the impacts of losses from multiple projects within a geographic area.

Although an ADID study generally classifies wetland areas as suitable or unsuitable for the discharge of dredged or fill material, the classification does not constitute either a permit approval or denial and should be used only as a guide by community planners, landowners, and project proponents in planning future activities. The classification is strictly advisory.

Status of ADID Projects

As of February 1993, 38 ADID projects had been completed and 33 were ongoing. The projects range in size from less than 100 acres to more than 4,000 square miles and are located from Alaska to Florida, as shown in the map. ADID projects can be resource-intensive activities, although some have been completed in as little as 6 months.

Regional EPA experience indicates that the smaller or more local the ADID project boundaries, the more complete and effective the analysis and results. For example, ADID projects have been initiated by local entities to facilitate planning efforts such as the one undertaken in West Eugene, Oregon. In this particular study, local ADID efforts led to an abbreviated Section 404 permit process. Because the ADID was incorporated into the City of Eugene's general comprehensive plan and because Oregon land-use policies have the effect of local land-use law, the ADID effort streamlined the regulatory process. These local efforts have proven to be one of the more successful ways of generating support for wetlands protection. Local cooperation and support are vital to the success of ADID projects.

The number of ADID projects has increased over time, and EPA expects more States, Tribes, localities, and private organizations to become involved in providing funds and otherwise supporting ADID or other comprehensive planning efforts. Because ADID efforts are usually based on watershed planning, they are extremely compatible with geographic and ecosystem initiatives such as EPA's Watershed Protection Approach.

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Wetlands Mitigation Banking

Mitigation banking has the potential to play a significant role in the Section 404 regulatory program by reducing uncertainty and delays as well as improving the success of wetlands mitigation efforts. Landowners needing to mitigate or compensate for authorized impacts to wetlands associated with development activities may have the option of purchasing credits from an approved mitigation bank rather than restoring or creating wetlands on or near the development site.

A wetlands mitigation bank is a wetlands area that has been restored, created, enhanced, or (in exceptional circumstances) preserved, which is then set aside to compensate for future conversions of wetlands for development activities. A wetlands bank may be created when a government agency, a corporation, or a nonprofit organization undertakes such activities under a formal agreement with a regulatory agency. The value of a bank is determined by quantifying the wetlands values restored or created in terms of "credits."

Benefits of Mitigation Banking

- Banking can provide more cost-effective mitigation and reduce uncertainty and delays for qualified projects, especially when the project is associated with a comprehensive planning effort.
- Opportunities for successful mitigation are increased since the wetlands can be functional in advance of project impacts.
- Banking can eliminate or reduce the temporal losses of wetlands values that typically occur when mitigation is initiated during or after the development impacts occur.
- Consolidation of numerous small, isolated, or fragmented mitigation projects into a single large parcel may result in increased ecological benefits.
- A mitigation bank can bring scientific and planning expertise and financial resources together, thereby increasing the likelihood of success in a way not practical for individual mitigation efforts.

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Status

The Administration supports mitigation banking and is developing interagency guidance for the establishment and use of mitigation banks. Approximately 100 mitigation banks are in operation or are proposed for construction in 34 States across the country, including the first private entrepreneurial banks.

Jeff Reynolds, Raleigh, NC

Ground Water Protection Programs

Fifty-one percent of the Nation's population depended upon ground water as a source of drinking water in 1990 (U.S. Geological Survey Circular 1081, 1993). In addition to providing much of our Nation with drinking water, ground water is used for agricultural, industrial, commercial, and mining purposes.

The importance of our Nation's ground water resources is evident. Unfortunately, ground water is vulnerable to human contamination, and, in the 1994 305(b) reports, States identified 66 contaminant sources that threaten the integrity of ground water resources. Because it is expensive and technologically complex to remediate ground water resources that have been adversely impacted by human activities, ground water protection has become the focus of numerous State and Federal programs.

This chapter presents an overview of ground water protection programs and activities that have been described by the States in their 1994 305(b) reports and the laws and programs instituted by the Federal Government to provide a framework for ground water protection for the States.

State Programs

In their 1994 State 305(b) reports, States provided narratives detailing legislation, statutes, rules, and/or regulations dedicated to ground water protection that are in place, pending, or under development. The narratives also highlighted major studies undertaken by the States in the interest of ground water protection, issues related to ground water quality that are currently of concern or may be in the future, and progress in developing and implementing ground water protection programs. The purpose of these narratives was to provide an indication of the comprehensive nature of ground water protection activities among the States.

Clearly, States are committed to a number of activities to address existing ground water contamination problems and to prevent future impairments of the resource. These activities include enacting legislation aimed at the development of comprehensive ground water protection programs and promulgating protection regulations; adopting and implementing ground water protection strategies; adopting ground water classification and mapping programs; and establishing

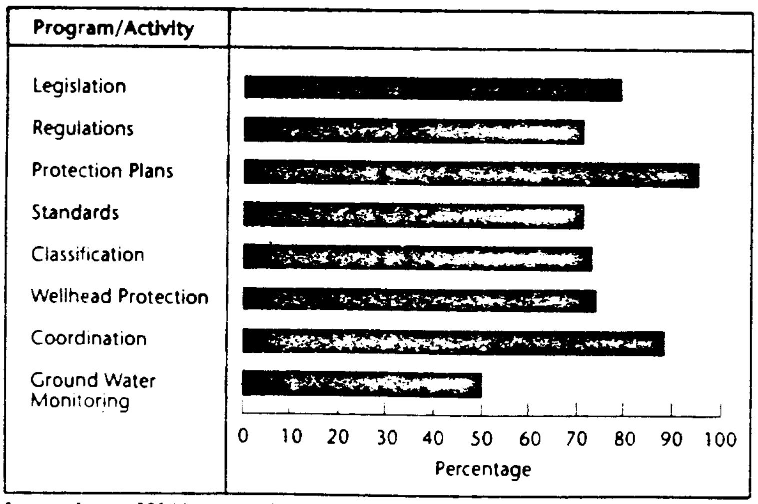
Wellhead Protection (WHP) Programs. Figure 18-1 presents the percentage of States, Territories, and Tribes reporting on each of these activities. As shown, States are making excellent progress in developing and implementing programs related to ground water protection.

Ground Water Protection Legislation

Forty-six of the 58 responding States, Territories, and Tribes report some form of current or pending legislation geared specifically to ground water protection. Generally, legislation focuses on the need for program development, increased data collection, and public education activities. In many States and Tribes, legislation also mandates strict technical controls such as discharge permits, underground storage tank registrations, and protection standards. Additionally, some States and Tribes have enacted legislation establishing a policy to restore and maintain ground water quality and remediate pollution that has occurred.

Figure 18-1

Percentage of Reporting States Having Implemented Programs or Activities



Source: Section 305(b) reports submitted by States, Tribes, and Territories.

Minnesota passed the Ground Water Protection Act (GWPA) of 1989 and continues to fund projects such as ground water monitoring and data management, increased control of pesticides and fertilizers, agricultural chemical cleanups, and local water plans. The law also states that ground water quality should be maintained so that it is continually free of human-induced pollutants.

The Michigan Legislature enacted the Environmental Response Act to identify, prioritize, and fund the cleanup of environmentally contaminated sites in cases where responsible parties do not provide relief. The Michigan Department of Natural Resources coordinates the State program with the Federal Superfund program. The two programs are complementary in their goals and objectives.

The primary legislation for Illinois ground water protection, the Illinois Groundwater Protection Act (IGPA), was enacted in 1987. The Act establishes the policy of the State to "restore, protect and enhance the ground waters of the State, as a natural and public resource."

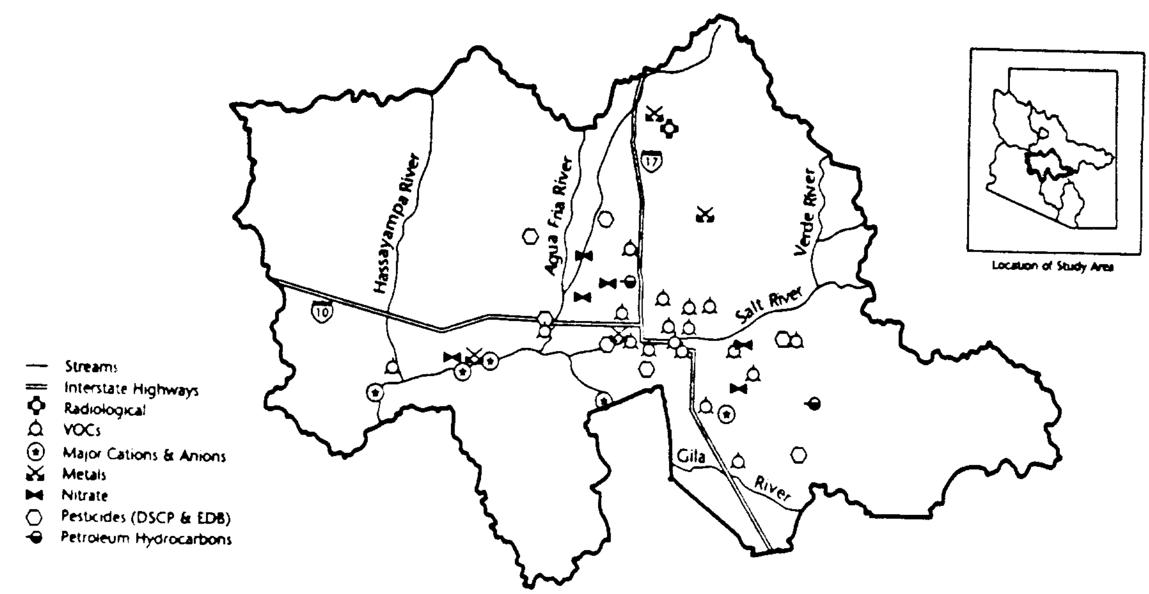
Discovery of extensive contamination in the State's ground water prompted Arizona to develop strong and comprehensive ground water legislation. The 1980 Ground Water Management Act promotes a strategy of preserving, enhancing, and protecting current water quality; remediating, minimizing, and preventing past, present, and future discharges to aquifers; and prohibiting discharges of toxic pollutants to aquifers. This Act defines several geographic areas in which ground water supplies are threatened. The State has designated these areas as Active Management Areas (AMAs). Figure 18-2 illustrates one AMA. Areas in which there is a possible or known threat to ground water resources are marked with the appropriate symbol. Management plans in these areas address the threats of both overdrafts and contaminants.

In Hawaii, problems with the quality and reliability of surface water supplies have led to concern over the protection of the State's ground water. The 1987 State Water Code protects ground water by authorizing the prohibition, control, and regulation of activities in areas vulnerable to ground water contamination. The State has adopted a policy of antidegradation and uses the authority established by this legislation to require proof that proposed activities will not degrade ground water before issuing a permit.

The Rhode Island legislature passed the Ground-Water Protection Act in 1985, establishing a

Figure 18-2

Ground Water Contamination in the Phoenix Active Management Area



Source: *Arizona Water Quality Assessment 1994*, Arizona Department of Environmental Quality.

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comprehensive ground water protection policy. Reenacted in 1991, it emphasized restoring, enhancing, and maintaining the chemical, physical, and biological integrity of Rhode Island's ground water. The legislature passed this law based on the belief that ground water is a critical renewable resource that must be protected to ensure the availability of drinking water.

Ground Water Regulations

Of the 58 responding States, Territories, and Tribes, 41 report that they have established regulations specifically geared toward protection of ground water quality. In general, State and Tribal ground water protection regulations stipulate controls for the management of specific sources of contamination and standards for ground water quality protection. These standards may be used to apply limits on the allowable discharges from contaminant sources and/or to set contaminant concentration targets or threshold levels for ground water cleanup.

Nevada has adopted statutory authority and promulgated associated regulations to implement a mining strategy that is widely considered to be a model for western States in terms of both controls placed upon the mining industry and the explicit considerations of impacts on ground water quality. Regulations include several requirements for the purpose of protecting ground water by minimizing or preventing discharges from mining facilities.

The Florida Department of Environmental Regulation (DER) has established both general and specific permitting provisions for permitting discharges to ground water. The regulations require that all discharges to ground water meet certain water quality conditions, such as Florida's water quality standards.

South Carolina's ground water regulations establish a ground water classification system to protect public health and maintain and enhance ground water quality. They include general rules and specific water quality criteria to protect classified and existing water uses. The regulations also set forth narrative standards for classification and specific numeric water quality standards for ground water that is classified as a source of drinking water.

Ground Water Protection Plans

Fifty-five of the 58 responding States, Territories, and Tribes have adopted, or are in the process of developing, ground water protection plans. The general content of these plans includes: selection of goals and objectives for ground water problems identified in the jurisdiction; development of a ground water classification system; program coordination mechanisms for local, State, and Federal ground water protection activities; public education and/or involvement; development of an interagency ground water data collection system; legislative recommendations pertaining to the regulation of contaminating sources; development of a ground water monitoring system; establishment of a WHP Program; improvement of existing ground water protection programs; and development of statewide

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standards for ground water quality. These plans provide the basis for their Comprehensive State Ground Water Protection Programs (CSGWPPs).

Texas outlines goals, needs, and recommendations in six important areas in its Ground Water Protection Plan: interagency coordination, hazardous and nonhazardous materials management, public water supply, rural water supply, research, and legislation. Within these areas, each of the following plan elements are discussed: status of existing programs, gaps or inadequacies in these programs, areas of currently unaddressed ground water issues, recommendations for changes or improvements in existing programs, and institution of new programs where needed.

The Indiana Plan is an agenda for State action to prevent, detect, and correct contamination and depletion of ground water resources. The implementation plan identifies key steps, schedules, responsibilities, resources, outputs, and contingencies to accomplish the objectives of the plan. This plan is to be adaptable to new Federal requirements, responsive to emerging issues and proprieties, and subject to revision based on experience.

As of January 1994, 8 of the 23 Nebraska Natural Resource Districts had developed local Ground Water Protection plans, including

- Stated goal to maintain ground water levels and quality at predevelopment levels forever

- Development of Ground Water Control areas with mandated permitting, spacing, and reporting requirements

- Development of Special Protection areas with required education, monitoring, and regulatory programs to reduce nonpoint source contamination

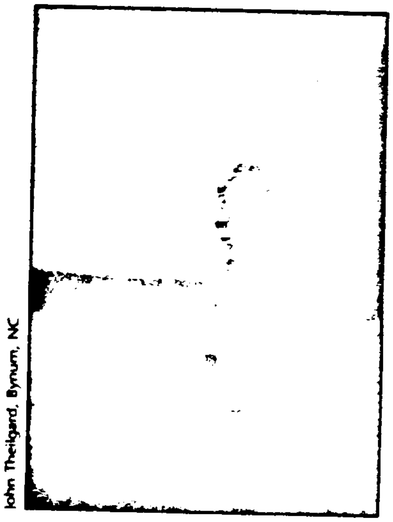
- Development of Ground Water Management Plans

- Development of Ground Water Quality Management Areas to manage nitrogen fertilizer application and irrigation practices.

Ground Water Protection Standards

Although many States and Tribes use Federal drinking water standards to direct their ground water protection activities, a number have tailored the standards to meet their specific conditions. State and Tribal ground water protection standards may be either narrative or numeric. Numeric standards set health-based maximum contaminant levels (MCLs) for specific compounds in ground water. Narrative standards are adopted for contaminants for which numeric standards have not been adopted. Forty-one States, Territories, and Tribes reported the development or implementation of ground water protection standards.

All ground water in South Carolina is classified as Class GB, which is ground water that meets the definition of an underground source of drinking water (USDW). All USDW supplies must have contaminant levels that are below MCLs set forth in the South Carolina *Primary Drinking Water Regulations*. Compounds for which standards or proposed MCLs do not exist are evaluated individually.



John Theilgard, Bynum, NC

Arizona's *Aquifer Water Quality Standards* are the cornerstone of the State's ground water protection program. All aquifers were initially classified and protected for drinking water use, and none has been reclassified. Numeric Aquifer Water Quality Standards were developed and adopted by Arizona as enforceable standards for the maximum permissible level of a parameter in a public water system. The Arizona Department of Environmental Quality has also adopted narrative aquifer water quality standards that allow regulation of pollutant discharges for which no numeric standards have been adopted.

Standards for ground water quality in Nebraska are intended to be the foundation for ground water point source programs in the State. Narrative standards deal primarily with beneficial uses of ground water. Beneficial uses of ground water, hydrologically connected ground waters, and surface waters are all protected. Numeric standards in the form of MCLs for various parameters are also provided. Some parameters listed are assigned "reserved status." This means that ground water standards have not been adopted for these parameters but will be in the future.

Ground Water Classification/Mapping Programs

Forty-two States, Territories, and Tribes have developed or are developing ground water classification systems to aid in the protection and management of their aquifers. Classification systems can be used as a basis for the maintenance and restoration of ground water quality, the development of ground water quality standards, and land use and pollution source management and regulation. Most ground water classification systems are based on the understanding that some human activities have the potential to degrade ground water. The systems are designed to restrict such activities to areas overlying aquifers containing lower quality waters while protecting the most vulnerable and ecologically important ground water systems. Most States and Tribes that have classification systems apply them to the permitting of discharges or potential discharges to ground water and the remediation of contaminated ground water. Some States may also use their systems to guide the development of new water supplies or to site certain types of industries.

The first tiers of a State's classification system are typically designed to identify and protect water that is currently used or has the potential to be used as a source of drinking water. The potential for drinking water use is generally based on water quality indicators, such as salinity and total dissolved solids, and potential yield. Some States and Tribes also place ecologically sensitive aquifers in the highest tiers of their classification systems.

Aquifers that do not meet these requirements or that are unsuitable for use because of poor ambient water quality or because of past contamination are generally classified for other types of uses, such as industrial processes or, in some cases, waste disposal.

The New Jersey Department of Environmental Protection and Energy has classified the State's ground water on a regional basis according to its hydrogeologic characteristics and designated uses. The State has applied a nondegradation policy to the most sensitive ecological area but allows minimal degradation in some other areas, recognizing that some human activities will adversely affect ground water.

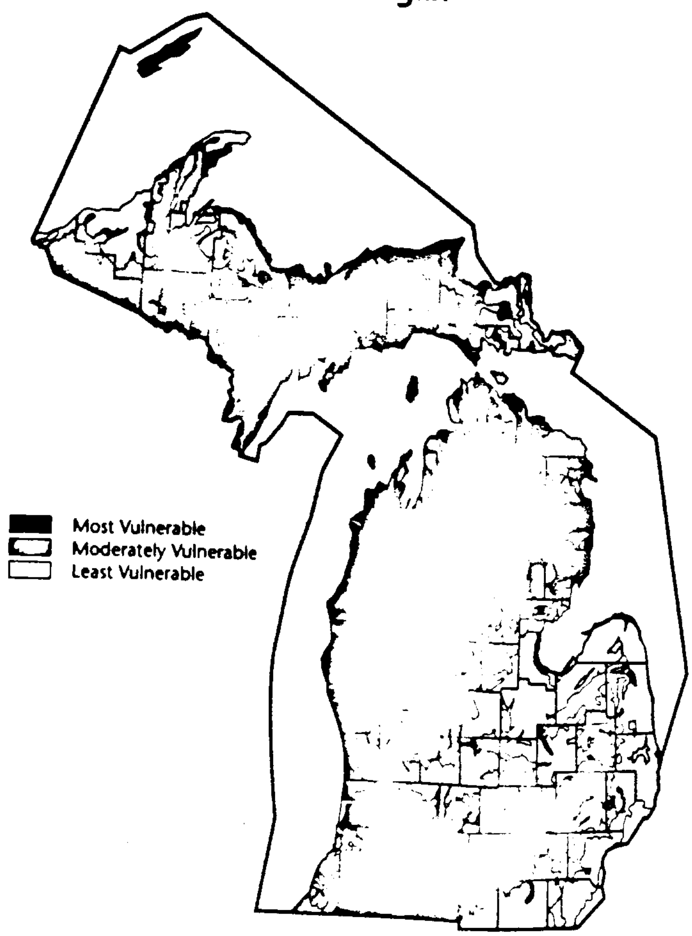
In 1992, Michigan State University Center for Remote Sensing mapped aquifer vulnerability to surface contamination for use in siting facilities or activities with a potential for ground water contamination. The most vulnerable areas constitute 31% of the State's land area and are composed of highly permeable soils over highly sensitive glacial drift, principally composed of sand and gravel (Figure 18-3). The moderately and least vulnerable areas make up 44% and 25% of the State, respectively.

As part of the development of a ground water classification system, the recharge areas for major aquifers in Rhode Island as well as approximately 450 sources of known and potential sources of ground water contamination have been mapped. The Rhode Island Department of Environmental Management (DEM) has made extensive use of the Rhode Island Geographic Information System (GIS) in this mapping. Maps can be produced with the GIS at different scales, in various formats, and with different layers of information. DEM encourages the use of these maps in local ground water protection efforts.

The lack of a classification system does not indicate a lower priority for ground water protection.

Figure 18-3

Aquifer Vulnerability to Surface Contamination in Michigan



Source: *Water Quality and Pollution Control*, Michigan 305(b) Report: Volume 13, Michigan Department of Natural Resources.

The majority of States, Territories, and Tribes that do not have explicit classification systems apply the same level of protection to all aquifers, with either a statewide antidegradation policy or the preservation of all ground water for drinking water use. For example, Minnesota does not employ a classification system. However, the State supports a nondegradation policy, promoting preventive measures to protect all ground water from degradation by human activities.

Wellhead Protection Programs

The 1986 Amendments to the Safe Drinking Water Act (SDWA) established the WHP Program. Under SDWA Section 1428, each State must prepare a WHP Plan and submit it to EPA for approval. By the end of April 1995, a total of 39 States had EPA-approved WHP Programs in place.

Six cases of benzene contamination were detected in public water supplies in Louisiana in 1992. Louisiana's WHP Program aided the communities in locating the sources of contamination and in the siting of new wells. Case studies of these communities prompted a coordinated effort between the WHP Program and the Louisiana Department of Environmental Quality Underground Storage Tank (UST) Division to see that all unregistered USTs are registered and all abandoned USTs within a 1,000-foot radius of public water supply wells are closed. This restrictive radius will increase with time.

Coordination of Protection Programs Among State Agencies

Historically, ground water protection programs have been overseen by many different agencies within the States, Territories, and Tribes, making coordination difficult for those programs. Coordinating the activities of these agencies to ensure an efficient ground water protection program has become a top priority in many jurisdictions. Fifty-one States, Territories, and Tribes report having developed a plan to coordinate ground water protection programs among their agencies.

The Illinois Ground Water Protection Act (IGPA) created the Interagency Coordinating Committee on Groundwater (ICCG) to direct efforts of State agencies and expedite implementation of ground water protection efforts. Ten State agencies actively participate in the ICCG. In order to direct overall comprehensive ground water protection efforts, the ICCG established the Governor-Appointed Groundwater Advisory Council (GAC), which is comprised of various interest groups, including business, industry, agriculture, regional planning, environmental, municipalities, water well drillers, and public water supplies.

Ground water protection in Colorado is a shared responsibility of many agencies at all levels of government. Colorado authorized four "implementing" agencies as partners in ground water protection: Mined Land Reclamation Board, The Oil and Gas Commission, the State Engineer (Division of Water Resources), and the Hazardous

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Materials and Waste Management Division of the Health Department. Each of the implementing agencies has developed regulations to protect ground water within the area of authority with which each agency is charged, and they annually report their progress to the Water Quality Control Division, the agency with final authority for protecting the resource.

Ground Water Monitoring Programs

Two types of ground water monitoring programs are used by States to collect data on ground water quality: ambient monitoring and compliance monitoring. Ambient monitoring programs measure background or existing water quality and are used to track long-term trends in contaminant concentrations. Compliance monitoring programs are required by Federal or State regulations (e.g., ground water monitoring at site cleanups under CERCLA, detection monitoring under RCRA, or community water supply monitoring under SDWA). Compliance monitoring activities measure for specific constituents to ensure that their concentrations in ground water are below regulated levels. In addition to ambient and compliance monitoring, States may also rely on monitoring data collected by Federal agencies, such as the USGS National Water Quality Assessment program, to assess basin ground water quality.

Chemical or constituent-based indicators are generally used as part of a monitoring program to define trends in ground water quality. The constituent-based indicators used in each State are typically selected based on local or regional water quality, contaminant use characteristics, or previously observed contamination patterns. By identifying changes in the concentrations of these constituents in ground water, land uses affecting vulnerable aquifers can be identified and corrected.

Administrative indicators are another form of indicator parameter that may be used by States. Administrative indicators assess the status of potential sources of contamination, such as the number of hazardous waste sites, the amount of leachable pesticides applied to land, the amount of toxic chemicals released annually, the number of abandoned water wells, or other changes in regional land use practices. These administrative indicators allow States to target their ground water protection and monitoring activities.

Table 18-1 summarizes the types of indicators and monitoring programs that States and Territories currently use to measure ground water quality. Appendix I, Table I-2, presents this information in greater detail. Data were obtained from review of 305(b) reports, monitoring program documentation, and contact with State officials. For conflicting sources, the most recent information is presented and the source is cited.

Virtually all of these States engage in some type of ground water quality monitoring program. Specifically, 23 States report active ambient monitoring programs. In addition, Colorado and Nevada have proposed ambient monitoring programs. Sixteen of these States

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Table 18-1 Summary of Current State Ground Water Monitoring Programs

State	Constituent-Based Indicators	Administrative Indicators	Monitoring
Alabama	Not applicable	Not applicable	Compliance; Ambient
Alaska	Not applicable	Administrative[a]	Compliance
Arizona	(pesticides, VOCs, ions, metals, hydrocarbons, radionuclides, bacteria)	Not applicable	Ambient; Federal
Arkansas		Administrative[a]	Compliance; Ambient; Federal
California	Not applicable	(pesticide residues)	Compliance; background monitoring for pesticides
Colorado	Not applicable	Not applicable	Compliance; Ambient proposed
Connecticut	Not applicable	Not applicable	Compliance; past monitoring for pesticides
Delaware	Not applicable	Not applicable	Compliance; periodic ambient studies; Federal
Florida[b]	Not applicable	(pesticides, VOCs, metals, nitrates, trihalomethanes)	Compliance; Ambient; Federal
Georgia	(pH, nitrate, specific conductivity, inorganics)	(land use)	Ambient
Hawaii	(organics, chlorides)	Not applicable	Not applicable; Federal
Idaho	(radionuclides, pesticides, ions, bacteria, VOCs)	Administrative[a]	Ambient
Illinois	Not applicable	Not applicable	Ambient
Indiana	(bacteria)	Not applicable	Not applicable; periodic ambient studies
Iowa	Not applicable	Not applicable	Compliance; Federal
Kansas	Not applicable	Not applicable	Ambient
Kentucky	Not applicable	Administrative[a]	Compliance
Louisiana	Not applicable	Administrative[a]	Compliance; Federal
Maine	Not applicable	Not applicable	Not applicable
Maryland	(pH, alkalinity, ion-specific conductance)	Not applicable	Ambient; Federal
Massachusetts	(specific conductance, TOC, COD, ionic balance)	Not applicable	Compliance
Michigan	Not applicable	Administrative[a]	Compliance
Minnesota	Not applicable	Administrative[a]	Ambient; Federal; Compliance
Mississippi	Not applicable	Not applicable	Compliance; Federal

Table 18-3 Summary of Current State Ground Water Monitoring Programs (continued)

State	Constituent-Based Indicators	Administrative Indicators	Monitoring
Missouri	(nitrate)	Not applicable	Not applicable; Federal
Montana	Not applicable	Not applicable	Compliance
Nebraska	(pesticides, nitrate)	Not applicable	Compliance; periodic ambient studies; Federal
Nevada	Not applicable	Not applicable	Not applicable; proposed Ambient
New Hampshire	Not applicable	Not applicable	Not applicable
New Jersey	Not applicable	Administrative[a]	Compliance
New Mexico	Not applicable	Not applicable	Compliance
New York	(alpha particle activity)	(public supply vulnerability)	Compliance; Federal
North Carolina	Not applicable	Not applicable	Compliance
North Dakota	Not applicable	Not applicable	Ambient
Ohio	Not applicable	Not applicable	Ambient
Oklahoma	Not applicable	(maximum allowable limit [MAL] violations)	Compliance; Ambient
Oregon	Not applicable	Not applicable	Compliance
Pennsylvania	Not applicable	Not applicable	Ambient
Rhode Island	Not applicable	Not applicable	Compliance; Federal
South Carolina	Constituent	Not applicable	Compliance; Ambient
South Dakota	(bacteria)	Administrative[a]	Compliance; Federal
Tennessee	Not applicable	Not applicable	Not applicable; Federal
Texas[b]	Not applicable	Not applicable	Compliance; Ambient
Utah	Not applicable	Not applicable	Compliance
Vermont	(many)	Administrative[a]	Compliance
Virginia	Not applicable	Administrative[a]	Ambient
Washington	(specific conductivity, gross alpha, nitrate, pesticides)	Administrative[a]	Compliance; periodic ambient studies for agricultural chemicals; Federal; proposed Ambient
West Virginia	(many)	Not applicable	Ambient; Federal
Wisconsin	Not applicable	Administrative[a]	Compliance; Ambient
Wyoming	Not applicable	Not applicable	Compliance

[a] Indicators suggested by EPA in the guidance document for the 305(b) report.
[b] State relies on programs below State level for ground water data.

NOTE: Although all States have federally mandated compliance monitoring programs, this table reports those States that use their compliance monitoring data to evaluate ground water quality.

report using specific constituent-based indicators to track trends in ground water quality statewide. Florida has focused the set of parameters monitored under their ambient program based on their understanding of local water quality patterns and contaminant sources. In regions of high agricultural land use, Florida focuses on nitrate and chloride levels in ground water. Similarly, Florida analyzes for certain trace metals (e.g., arsenic, barium, cadmium, chromium, copper, mercury, nickel, silver, and zinc) in regions of industrial land use. South Carolina has established a network of 114 public and private water supply wells that draw water from a single aquifer and are known not to be impacted by contaminants in order to assess ambient ground water quality statewide. South Carolina tests for 39 individual parameters once every 5 years on a rotating basis. Several States are also pursuing the use of indicators to screen for certain sets of water quality parameters in their monitoring programs. For example, Idaho is developing the use of immunoassays to assess the presence of pesticides in ground water. Idaho uses the immunoassay methods to analyze specifically for 2,4-D, alachlor, carbamate, carbofuran, cyanazine, metalachlor, and triazines.

In addition to ambient monitoring, 31 States report that they also use data from compliance monitoring activities to assess trends in ground water quality, and 18 use Federal monitoring data.

A total of 18 States use administrative indicators to track potential sources of contamination. Of these 18 States, 13 use indicators that were suggested by EPA in its guidance document for the 305(b) Water Quality Report to Congress. These indicators include MCL violations, point sources of pollution (e.g., underground storage tanks, military bases, RCRA, CERCLA, and other hazardous waste sites), nitrate contamination, and pesticide use.

Federal Programs

The Federal Government has instituted laws and programs to provide a framework to States, Territories, and Tribes for protection of our Nation's ground water resources. These include Federal statutes that mandate certain ground water protection activities and EPA programs that deal specifically with the control of contaminant source activities conducted under the authority of Federal statutes. Federal statutes include the Safe Drinking Water Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation, and Liability Act, the Toxic Substances Control Act, the Federal Insecticide, Fungicide, and Rotenticide Act, and the Pollution Prevention Act.

Under these Acts, the EPA is responsible for 20 programs related to ground water protection. Most of these are regulatory programs that restrict or prevent specific activities from introducing contaminants onto the land, into the subsurface, or into ground water resources. The rest are nonregulatory and provide national guidance and technical assistance to jurisdictions to identify and protect their vulnerable ground water resources and integrate existing ground water protection

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programs. Both types of programs are key components of EPA's successful ground water protection strategy when building partnerships with other EPA programs, Federal agencies, State and local governments, industry, environmental groups, and the regulated community. Several concepts fundamental to this approach to ground water protection are based on EPA's guiding principles: ecosystem protection, environmental justice, pollution prevention, strong science and data, partnerships, and compliance. They are:

- Review regulations for opportunities to get better environmental results at less cost; improve new rules through increased coordination.
- Actively promote pollution prevention as a standard business practice and a central ethic of environmental protection.
- Make it easier to provide, use, and publicly disseminate relevant pollution and environmental information.
- Assist companies that seek to obey but exceed legal requirements and consistently enforce the law against those that do not.
- Change permitting so that it works more efficiently, encourages innovation, and creates more opportunities for public participation.
- Give industry the incentives and flexibility to develop innovative technologies that meet and exceed environmental standards while cutting costs.

Highlights of a number of Federal ground water protection programs are presented according to the following protection categories: resource protection, pollutant source control, and pollution prevention.

Resource Protection

The protection of the Nation's ground water resources is addressed under the Clean Water Act and the Safe Drinking Water Act. The CWA encourages ground water protection, recognizing that ground water provides a significant proportion of the base flow to streams and lakes. Ground water protection afforded by the SDWA is focused on waters that supply public water systems (PWSs), and through implementation of the Wellhead Protection and Underground Injection Control Programs.

Clean Water Act

In the CWA (Public Law 92-500) of 1972 and in the CWA Amendments of 1977 (Public Law 95-217), Congress provided for the regulation of discharges into all navigable waters of the United States. Ground water protection is addressed in Section 102, providing for the development of Federal, State, and local comprehensive programs for reduction, elimination, and prevention of ground water contamination.

As part of the CWA, a process is established that allows for the generation of information concerning the quality of our Nation's ground water resources and the reporting of this information to EPA and the U.S. Congress. The requirements for this process are found in Sections 106(e)

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and 305(b) of the CWA. Section 305(b) mandates that States develop a program to monitor the quality of their waters and report the status in this biennial National Water Quality Inventory Report to Congress. This process, referred to as the 305(b) process, is the principal means by which the EPA, Congress, and the public evaluate water quality, the progress made in maintaining and restoring water quality, and the extent to which problems remain.

Unfortunately, information reported on the quality of our Nation's ground water resources has not always provided a complete and accurate picture of overall ground water quality. This is due, in part, to the expense involved in collecting ground water monitoring data, the complex spatial variations of aquifer systems across the Nation, and the differing levels of sophistication among State programs. Recognizing this problem, EPA worked with States to develop guidelines for the comprehensive evaluation and reporting of ground water quality.

Appreciating that data collection and organization vary among the States and that a single data source for evaluating ground water quality does not exist, EPA suggested several different sources of data that may be used by States to evaluate their ground water quality. EPA then encouraged States to use available data that they believe reflects the quality of the resource. EPA also focused on allowing States to report information for aquifers or hydrogeologic settings that are a State priority due to high ground water demand or vulnerability. Using these guidelines, States will be able to provide a more meaningful interpretation of ground water quality.

Comprehensive State Ground Water Protection Program

Under the authority of the CWA Section 102, many States are developing Comprehensive State Ground Water Protection Programs tailored to their goals and priorities for the ground water resource. CSGWPPs will guide the future implementation of all State and Federal ground water programs and provide a framework for States to coordinate and set priorities for all ground-water-related activities. Each CSGWPP consists of six strategic components: a goal, a priority-setting mechanism, roles and responsibilities, management measures, information collection and management, and public participation.

The EPA is committed to working with States in developing and carrying out the CSGWPP approach. A State with an EPA-endorsed CSGWPP works in partnership with the EPA to further improve State ground water protection activities, develop a vision of integrated, resource-focused ground water protection, and identify ways that the Federal Government can support State ground water protection efforts.

Figure 18-4 shows the progress in implementing the CSGWPP approach. As of 1994, the EPA had approved four State CSGWPPs, and EPA endorsement is anticipated for an additional six States in 1995. Another 29 States are expected to submit CSGWPPs for EPA approval by the end of fiscal year 1996.

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Safe Drinking Water Act

The SDWA was passed by Congress in 1974 and amended in 1986. Under this Act, EPA sets national limits on contaminant levels in drinking water to ensure that the water is safe for human consumption. The principal ground water protection afforded by the SDWA comes through the enforcement of these limits through State and Federal supervision of public water systems. The SDWA also contains programs to implement the Wellhead Protection Program, the Sole Source Aquifer (SSA) Program, and the Underground Injection Control (UIC) Program, described below.

Approximately 93% of all PWSs (177,589 systems serving nearly 114 million people) obtain their water from a ground water source. These include systems that supply year-round water to households (46,880 Community Water Systems); systems that provide water to places such as schools, factories, and hospitals (23,221 Nontransient Noncommunity Water Systems); and systems that supply water to transitory customers such as campgrounds, motels, and gas stations (107,488 Transient Noncommunity Water Systems). Private, domestic wells are not regulated under the SDWA.

Drinking Water Standards

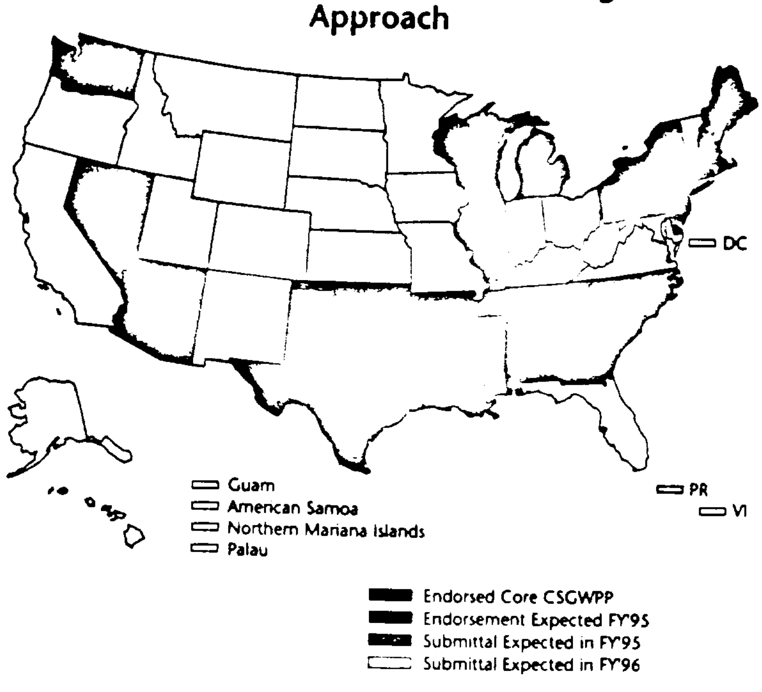
EPA, under the SDWA, seeks to ensure that public water supplies are free of contaminants that may cause health risks and to protect ground water resources by preventing the endangerment of underground sources of drinking water. EPA has pursued a twofold approach: (1) protecting drinking water at the tap, and (2) preventing contamination of ground water sources of drinking water supplies.

The 1986 Amendments to the SDWA provided for an expanded Federal role in protecting drinking water, mandating changes in nationwide safeguards, and new responsibilities to enforce them in the event of State inaction.

EPA has also focused on the prevention of contamination of

Figure 18.4

Progress in Implementing the Comprehensive State Ground Water Protection Program Approach



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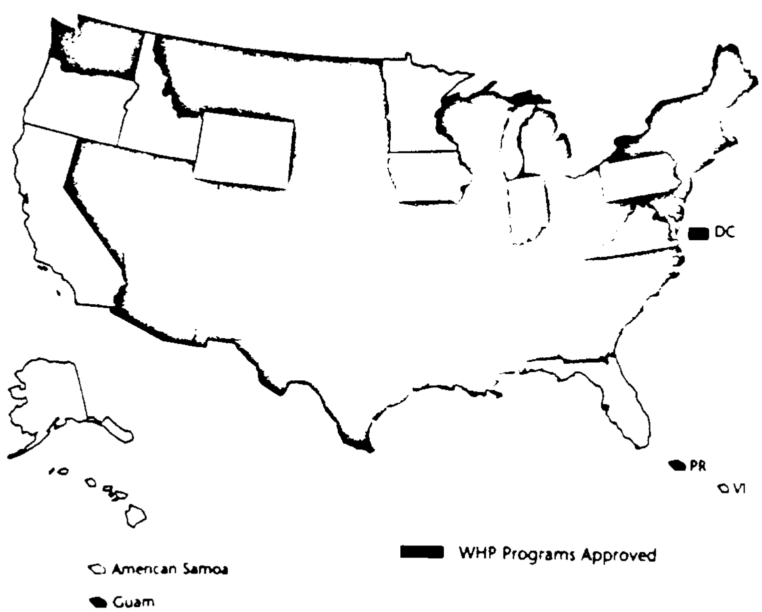
vulnerable ground water resources by assisting States in the development and implementation of comprehensive ground water protection plans. These plans address both the full range of actual and potential sources of ground water contamination and provide for local wellhead protection programs in the areas around public water wells. In addition, EPA has targeted specific activities to protect drinking water sources from the harmful effects of injection of wastes and other fluids. Utilizing authorities provided by the UIC, EPA is increasing emphasis on the vast number of diverse shallow (Class V) injection wells by developing technical industry guidance. EPA is also reviewing the permitting requirements for Class I hazardous waste wells and the imposition of more restrictive standards for all Class II oil and gas injection wells.

Figure 18-5

Status of Wellhead Protection Programs Across the U.S. and Territories



Wellhead Protection Program

The 1986 Amendments to the SDWA established the WHP Program. Under SDWA Section 1428, each State must prepare a WHP Plan and submit it to EPA for approval. The objective of this program is to protect public health through local action to prevent ground water contamination from reaching public wells by (1) identifying the areas around public water supply wells that contribute ground water to the well, and (2) managing potential sources of contamination in these areas to reduce threats to the resource.

By the end of April 1995, a total of 39 States and Territories had EPA-approved WHP Programs in place. Figure 18-5 illustrates the States and Territories having regulatory authority to implement WHP programs. EPA is working with the remaining States, Tribes, and Territories to help them develop WHP Programs. EPA's Office of Ground Water and Drinking Water is supporting the development and implementation of WHP at the local level through many efforts. For example, EPA-funded support is provided through the National Rural Water Association (NRWA) Ground Water/Wellhead Protection programs. These programs are currently being implemented voluntarily in 31 States. These States work to integrate their local programs with the WHP Program to meet State requirements. Figure 18-6 presents the States with active and pending NRWA Wellhead Protection programs.

EPA is also funding Wellhead Protection workshops for local decisionmakers. Eighty-eight of these workshops were held in 26 States. These workshops were attended by approximately 4,400 people.

In 1991, EPA funded a 2-year cooperative agreement with NRWA to promote ground water protection. This agreement was extended for an additional 2 years. At the conclusion of the first 4 years, over 2,000 communities in 26 States were actively involved in protecting their water supplies by implementing wellhead protection programs. These 2,000 communities represent 3,985,000 people in the rural areas of the United States who will have better-protected water supplies.

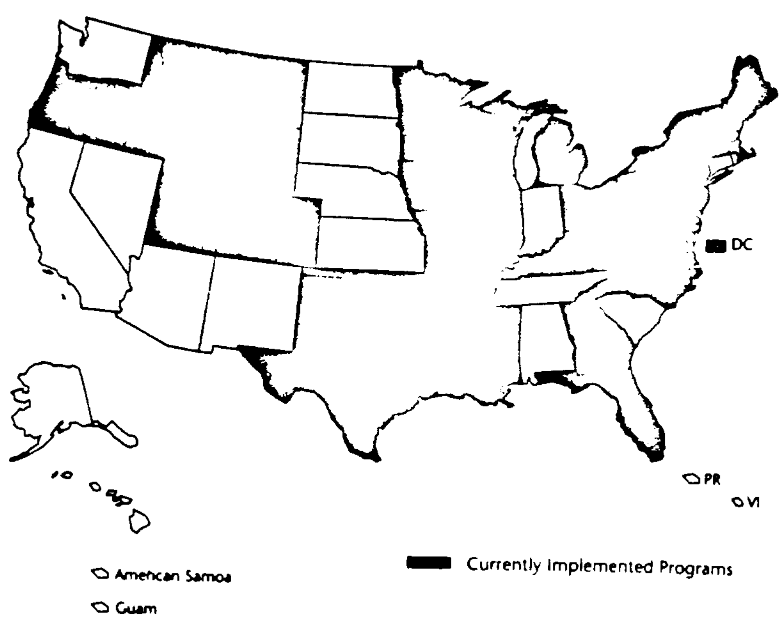
EPA also funded a 3-year cooperative agreement with the League of Woman Voters (LWV) to develop and test models of community outreach in 18 communities. Based on the experience in those communities, a guidebook entitled *Protect Your Groundwater: Educating for Action* was developed. The popularity of this guidebook led to a national videoconference of the same name. Broadcast in April 1994 to over 150 sites, the videoconference directly reached approximately 3,000 persons. Videotapes were made of the conference and distributed to LWV chapters across the country. The success of this videoconference has led to further cooperation with LWV to bring WHP to even more communities.

According to State 305(b) reports, WHP Programs have taken varying forms in the different States. Among the stages of WHP Program development reported by States are

- Grants to communities to explore and tailor WHP approaches to their needs
- Mapping of sensitive ground water protection areas
- Establishment of mandatory WHP programs to protect public water supply wells
- Establishment of public education and outreach programs
- Establishment of specific protection criteria for wells tapping confined aquifers and more stringent protection criteria for wells tapping unconfined aquifers.

Figure 18.6

States with National Rural Water Association Wellhead Protection Programs



Sole Source Aquifer Program

The Sole Source Aquifer protection program was established under Section 1424(e) of the SDWA of 1974. The program allows communities, individuals, and organizations to petition EPA to designate aquifers as the "sole or principal" source of drinking water for an area. Since the first SSA designation in 1975—the Edwards Aquifer in the area around San Antonio, Texas—64 designations have been made nationwide. Seven petitions were evaluated for possible designation at the end of 1994.

If the sole-source designation is approved for an aquifer, EPA is then authorized to review all Federal financially assisted projects to determine if, as a result of the project, the potential exists for adverse impacts to public health due to aquifer contamination. If the Federal financially assisted project is approved by EPA, the project may be implemented as planned with commitment of Federal financial assistance; however, if the potential exists for aquifer contamination, modifications to the project may be necessary prior to commitment of Federal financial assistance. Federal funds may be used to make these modifications to ensure that projects will not contaminate the aquifer.

Federal financially assisted projects undertaken in SSA areas may include a variety of activities involving several agencies. For instance, approximately 50% of the reported activities were initiated by Housing and Urban Development (HUD) through Community Development Block Grants. These include the construction of nursing homes, repair and construction of firehouses to avoid hydrocarbon runoff from equipment from entering the ground water, and installation of septic systems using proper non-polluting drainage construction. The Department of Agriculture Farmers Home Administration has invested in construction and preplanned siting programs for residential areas and ancillary facilities on a large scale.

The Department of Transportation assists in funding construction of roads, highways, mass transit, and certain railroad and airport facilities. This type of construction requires that the proper disposal of surface water runoff be dispersed rather than concentrated on the ground surface and avoid the flooding of local aquifers by runoff from salting stations, hydrocarbons from highway spills and general traffic use, including airports and hangar areas.

Designation helps project sponsors by providing a set of guidelines for aquifer quality review and ground water protection techniques. It also allows individuals, agencies, and States and Tribes the opportunity to develop strategies beyond the SSA program to protect drinking water aquifers, such as adopting Wellhead Protection Programs.

Figure 18-7 illustrates the number of projects reviewed, approved, and modifed for fiscal years 1990 through 1994. Only five projects were not approved during this same period: four projects in 1991 and one in 1992. There were no other unapproved projects after 1992. This curtailment is an indication that SSA project sponsors have adjusted to the ongoing SSA ground water protection program objectives.

Review of Figure 18-7 indicates the following:

- A total of 1,039 projects were reviewed over the 5-year period. Of these, 838 were approved and 74 were modified.

- Review of project modifications indicates that ground water protection was achieved through changes in drainage and spill containment, clear identification of SSA boundaries, more focused pre- and postconstruction activity monitoring, and review of initial project designs.

- For fiscal years 1992, 1993, and 1994, project modifications decreased by approximately 64% over previous years. This decrease reflects the maturing of the SSA program as a community ground water protection tool. Project sponsors and designers acknowledge that proper aquifer protection is required up front in the design phase and that incorporation of proper aquifer protection will expedite designations.

Pollutant Source Control

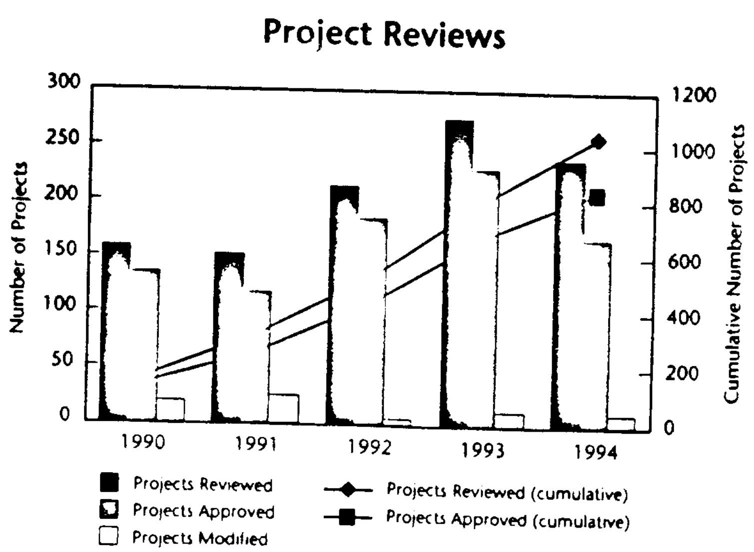
Four principal programs control pollutant sources under four different laws: underground storage tanks and solid and hazardous waste treatment, storage, and disposal are regulated under RCRA; underground injection of waste fluids is regulated under SDWA; abandoned waste is regulated under CERCLA; and nonpoint sources are controlled under CWA.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (Public Law 94-580) was passed by Congress in October 1976, amending the 1965 Solid Waste Disposal Act to address the problem of safe disposal of the huge volumes of solid and hazardous waste generated nationwide each year. This Act authorizes a regulatory program to identify and manage wastes that pose a substantial hazard to human health or the environment. RCRA is a part of EPA's comprehensive program to protect ground water resources. Protection is achieved through the development of regulations and methods for handling, storing, and disposing of hazardous material and through the regulation of underground storage tanks.

Poorly managed or poorly located municipal landfills rank high

Figure 18-7



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Kings Park Elementary, 3rd Grade, Springfield, VA

among State ground water contamination concerns. Of the quarter million solid waste disposal facilities in the United States, about 6,000 are municipal solid waste facilities. Approximately 25% of these municipal facilities have ground water monitoring capabilities.

As of September 1994, there were 418 land disposal facilities subject to ground water monitoring requirements under RCRA. Approximately 221 of these facilities are conducting detection monitoring, 42 are conducting compliance monitoring, and 155 are undertaking corrective action.

Solid and Hazardous Waste

RCRA has evolved from a relatively limited program dealing with nonhazardous solid waste to a far-reaching program that also encompasses the handling, storage, and disposal of hazardous waste. Hazardous waste generators, transporters, and owner/operators of treatment, storage and disposal facilities (TSDFs) constitute the RCRA-regulated community. On November 8, 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) to RCRA, thereby greatly expanding the nature and complexity of activities covered under RCRA.

The goals of RCRA, as set forth by Congress, are

- To protect human health and the environment
- To reduce waste and conserve energy and natural resources
- To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

RCRA also requires the promulgation of standards related to underground storage tank systems for both chemicals and petroleum products.

In 1990 and 1991, RCRA programs continued to emphasize the preparation of risk assessment documents and development and evaluation of tests and procedures for conducting risk assessments. Health and Environmental Effects Documents, Reference Doses, and technical evaluations are provided to support the RCRA waste listing, permitting, and land disposal restriction programs. The 1990 program emphasized the development of health and environmental effects documents for the listing/delisting programs and reference doses for the land disposal restriction program. In addition, techniques for determining soil gas concentrations and constituents and for determining ground water contamination potential were evaluated under field and laboratory conditions. Guidelines for monitoring ground water around RCRA Subtitle D landfill facilities are being developed.

Underground Storage Tank Program

One of the primary goals of this program is to protect the Nation's ground water resources from releases by underground storage tanks containing petroleum or certain hazardous substances. The EPA works with State and local governments to implement Federal requirements for proper management of USTs. The EPA estimates that about 1.2 million federally regulated USTs are buried at over 500,000 sites nationwide. Nearly all USTs contain petroleum; about 30,000 USTs hold hazardous substances covered by the Federal regulations.

In 1988, EPA issued regulations setting minimum standards for new tanks (those installed after December 22, 1988) and existing tanks (those installed before December 22, 1988). By December 1998, existing USTs must be upgraded to meet minimum standards or be replaced with new tanks or be closed properly. Since 1988, more than 900,000 old USTs have been closed, thus eliminating a significant number of potential sources of ground water contamination. Of the remaining 1.2 million USTs, about 400,000 have already been upgraded or replaced.

New and existing USTs complying with EPA's standards can prevent leaks caused by spills, overfills, corrosion, and faulty installation. USTs complying with the leak detection requirements can identify releases quickly, before contamination spreads. Corrective action requirements secure responsible and timely cleanup of contaminated sites.

As of January 1995, more than 278,000 UST releases had been confirmed. The EPA estimates that about half of these releases have reached ground water. Over 110,000 contaminated sites have been cleaned up, and cleanups are under way at 100,000 more sites. EPA estimates that the total number of confirmed releases could reach 400,000 in the next several years, primarily due to releases discovered during the closure or replacement of old USTs. After this peak, EPA expects fewer releases as USTs comply with leak prevention requirements.

Congress created the Leaking Underground Storage Tank (LUST) Trust Fund in 1986 to provide money for overseeing corrective action taken by a responsible party and to provide money for cleanups at UST sites where the owner or operator is unknown, unwilling, or unable to respond or that require emergency action. Since 1986, $469 million has been dispersed to State UST programs for State officials to use for administration, oversight, and cleanup work.

UST owners and operators must also meet financial responsibility requirements that ensure they will have the resources to pay for costs associated with cleaning up releases and compensating third parties. The amount of coverage required ranges from $500,000 to $1 million, according to the type and size of the UST business. Many States have provided financial assurance funds to help their UST owners meet the financial responsibility requirements. These State funds raise over $1 billion annually for use on UST cleanups.

The Agency recognizes that, because of the large size and great diversity of the regulated community, State and local governments are in the best position to oversee USTs. EPA encourages States to seek State program approval so they may operate in lieu of the Federal program. To date, 20 States have received State Program Approval. All States have UST regulations and programs in place. The Agency also has developed a data management system that many States use to track the status of UST facilities, including their impact on ground water resources. EPA also has negotiated UST grants with all States and provided technical assistance and guidance for implementation and enforcement of UST regulations.

Safe Drinking Water Act

Pollutant source control is addressed under the SDWA through the UIC program.

Underground Injection Control Program

EPA's UIC program was developed to regulate underground injection wells and thereby ensure that underground sources of drinking water are protected. Injection wells are classified as follows:

- Class I: Wells used to inject hazardous substances or industrial and municipal waste beneath the lowermost formation containing a source of drinking water. There are 159 hazardous waste wells at 61 facilities and 350 nonhazardous waste wells at 197 facilities controlled by stringent design, construction, and operating requirements. The hazardous waste management facilities inject 9 billion gallons of fluids each year. This volume represents 89% of all hazardous waste that is land disposed.

- Class II: Wells used to inject fluids in the process of oil or natural gas production. More than 160,000 disposal and enhanced recovery wells inject brines into geologic formations. These wells inject approximately 3 billion gallons of produced brine and enhanced recovery fluids every day.

Together Class I and II injection wells dispose of a larger volume of hazardous waste into deep bedrock formation than all the other RCRA hazardous waste disposal facilities by a factor of eight.

- Class III: Wells used to inject fluids for the purpose of in situ mineral extraction.

- Class IV: Wells used to dispose of hazardous or radioactive waste into or above an underground drinking water source. These wells are banned.

- Class V: Class V injection wells are generally shallow wastewater disposal wells, stormwater, and agriculture drainage systems or other devices that can release nutrient and toxic fluids into the ground and eventually into water table aquifers. EPA estimates that more than 1 million Class V wells currently exist in the United States. A majority of Class V wells may pose little or no risk to human health. Others, however, may inject fluids containing bacteria, viruses, nitrate-nitrogen, and toxic chemicals that can contaminate the habitat and food supply of fish and wildlife species, the base flow for surface waterbodies, and the public drinking water supply. These wells include more than

Wells as Conduits of Contamination

Although anecdotal cases abound of wells serving as conduits that allow contaminants to enter an aquifer, few occurrences are documented. However, the publication *Drinking Water: Safeguards Are Not Preventing Contamination From Injected Oil and Gas Wastes* (GAO, 1989) provides a table of 23 documented cases of contamination of an underground source of drinking water via Class II oil and gas injection wells. Fourteen of these cases resulted from wells that were improperly plugged or constructed and/or had leaky casings. Nine other cases were the result of deliberate injection into an aquifer before its designation as an underground source of drinking water. What is particularly noteworthy in these cases is the enormous cost of cleanup. In one of the cases, the State (Kansas) authorized $300 million to begin cleanup because the contamination threatened a major municipal well field. In 18 of the other cases, no cleanup is intended because it is either impractical or too costly.

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100,000 shallow injection wells such as those used to dispose of waste from automotive service bays.

Currently, all shallow injection wells that do not endanger underground sources of drinking water are allowed; however, because of the diversity in the risks posed by Class V wells and the size and nature of the regulated community, EPA encourages a nontraditional regulatory approach to addressing these wells. A large proportion of the Class V wells are owned by small businesses. To effectively address the unique challenges posed by the Class V universe, EPA is implementing a comprehensive strategy for the management of Class V injection wells. The strategy involves a carefully tailored combination of guidance, education, and outreach and enhancing the use of existing regulatory authorities through some minor changes to the UIC regulations. The goal of the strategy will be to speed up the closure of potentially endangering Class V wells using current authorities and to promote the use of best management practices to ensure that other Class V wells do not endanger USDWs.

Grants allotted under Sections 1443(b) and 1451 of the SDWA may be used to support UIC activities to protect ground water resources. State and Federal UIC programs include permitting and review of permits to ensure that wells meet requirements for well construction, operation, monitoring, plugging, and abandonment, and financial responsibility to ensure that underground sources of drinking water are not endangered. Section 1422 provides EPA with authority to grant primary enforcement authority (primacy) to States to administer a UIC program in their States. Section 1425 allows an alternative test for EPA to use to approve a State's UIC program for Class II brine disposal wells.

EPA and States currently administer 57 UIC programs to maintain regulatory coverage of the almost one-half million underground injection wells. The majority of these programs are State-administered, as depicted in Figure 18-8. State agencies with primary enforcement authority respond to UIC violations. If a response cannot be made in a timely manner, EPA takes enforcement action.

In 1992 and 1993, EPA continued to review "no migration" petitions for hazardous waste injection wells to ensure conformance with RCRA and UIC provisions. EPA has targeted specific enforcement, outreach, and regulatory activities to protect drinking water sources from the harmful effects of injections of wastes and other fluids through the vast number of diverse Class V injection wells. The Class V rule has significant implications for the disposal of industrial wastes. EPA also plans to propose "area of review" requirements for all Class II wells.

EPA Regional offices administering UIC programs in nonprimacy States continue to review permit applications for injection wells and continue oversight of State primacy programs to ensure that UIC permits issued meet program requirements. Regional offices also continue to review petitions from operators of hazardous waste injection wells seeking exemptions from the injection well ban.

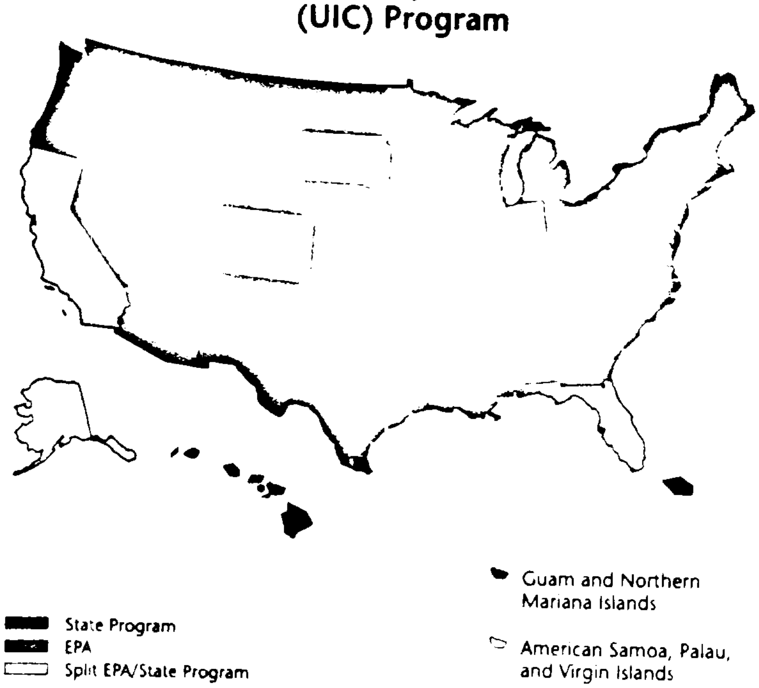
Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act and the Superfund Amendments and Reauthorization Act of 1986 created several programs operated by EPA, States, Territories, and Tribes that act to protect and restore contaminated ground water. Restoration of contaminated ground water is one of the primary goals of the Superfund program. As stated in the National Contingency Plan, EPA expects to return usable ground waters to their beneficial uses, wherever possible, within a time frame that is reasonable given the particular circumstances of the site. Following are statistics related to Superfund restorations:

- In the absence of Superfund, 11.9 million people could be exposed to carcinogenic risk greater than 1 in a million, and 9.9 million people could be exposed to noncarcinogenic effects above health-based standards at National Priority List (NPL) sites.
- At 94% of NPL sites where ground waters were classified (426 of 453), the ground water is currently used or potentially usable as a source of drinking water. This suggests that only 6% of NPL sites involving ground water contamination are classified as nonusable aquifers (e.g., saline or nonpotable).
- Of the 622 NPL sites reporting ground water contamination near the site, the ground water is currently used for private water supplies at 42% of the sites and for public supplies at 27% of the sites.
- At the 67% of NPL sites where ground water is currently used for drinking water purposes, the ground water is potentially threatened by a migrating contaminant plume.
- Organic compounds are the predominant ground water contaminants for 89% of the sites for which remedies for ground water contamination have been selected. Table 18-2 lists the most frequently detected organic and inorganic constituents reported at NPL sites.
- Ground water contamination is associated with 63% of the sites for

Figure 18-8

Underground Injection Control (UIC) Program



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which remedies have been selected (702 of 1,121).

- Generally, ground waters that are currently used or are potentially usable for drinking water supply are being cleaned to MCLs authorized under the SWDA. However, in some cases, more stringent State standards are used. At least 12 States have promulgated cleanup standards for ground water, including Massachusetts, West Virginia, Illinois, Minnesota, Wisconsin, New Mexico, Texas, Iowa, Nevada, South Dakota, Wyoming, and Washington.

Pollution Prevention

The Pollution Prevention Act of 1990 was enacted by Congress to promote pollution prevention and environmental protection goals. Under this Act, the EPA Office of Pollution Prevention and Toxics and the U.S. Department of Agriculture Cooperative State Research Service have worked cooperatively to lead the Nation in the development of environmentally sound agricultural policies. The Agriculture in Concert with the Environment Program promotes the use of sustainable agriculture and the integrated management of nutrients, pesticides, resources, and wastes to reduce the risks of environmental pollution. Grants allotted under this Act may be used to fund outreach projects involving education, demonstration, and training in sustainable agricultural practices that emphasize ground water protection and reducing the excessive use of nutrients and pesticides.

Grants are also available under this Act to support State and local pollution prevention programs that address the reduction of pollutants across all environmental media: air, land, surface water, ground water, and wetlands. These grants may be used to promote and coordinate existing State pollution prevention activities that focus on specific media, to develop new multimedia pollution prevention programs, to develop mechanisms to measure progress in multimedia pollution prevention, and to conduct education and outreach programs.

Tab[illegible] List Sites

Rank	Contaminants	Number of Sites
Organic Compounds		
1	1,1,2-Trichloroethylene	336
2	Chloroform	167
3	Tetrachloroethene	167
4	Benzene	163
5	Toluene	160
6	1,1,1-Trichloroethane	155
7	Polychlorinated biphenyls	138
8	Trans-1,2-Dichloroethylene	107
9	1,1-Dichloroethane	103
10	1,1-Dichloroethene	94
11	Vinyl chloride	81
12	Xylene	76
13	Ethylbenzene	69
14	Carbon tetrachloride	68
15	Phenol	61
16	Methylene chloride	58
17	1,2-Dichloroethane	56
18	Pentachlorophenol	52
19	Chlorobenzene	46
20	DDT	35
Inorganic Constituents		
1	Lead	306
2	Chromium ion and related species	213
3	Arsenic	149
4	Cadmium	126
5	Copper ion and related species	83
6	Mercury	81
7	Zinc ion and related species	75
8	Nickel ion and related species	45
9	Barium	41
10	Cyanides and associated salts	38

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Grass Roots Ground Water Protection

As the impacts of ground water contamination become more widely known, volunteers and grass roots ground water protection initiatives are becoming common in communities across America. The programs range from volunteer-driven efforts to protect vital drinking water supplies through Wellhead Protection Programs, to volunteer-sponsored well water quality testing and public education on the sources of our drinking water.

The El Paso Experience

In late 1989, the Texas Water Commission targeted the city of El Paso, Texas, for a pilot project to protect the city's ground water. This pilot project marked the beginning of an innovative, volunteer-driven Wellhead Protection Program. A team of dedicated volunteers was coordinated through the El Paso Retired Senior Volunteer Program.

Over a 3½-day period, the 23 senior citizen volunteers surveyed possible sources of ground water contamination around all 138 public water wells that provide drinking water to the city of El Paso. They reviewed historical records, interviewed area residents, and conducted door-to-door surveys to catalog potential threats to their drinking water. The State estimated that the volunteer effort saved approximately $35,000, and resulted in the identification of approximately 20,000 potential sources of pollutants near the water wells.

The El Paso pollution source inventory formed the backbone of the El Paso Wellhead Protection Program and resulted in a city ordinance concerning the storage of hazardous materials within the vicinity of the public water wells. The effort has recently been expanded into Mexico, since the residents of the adjacent Mexican city of Ciudad Juarez also rely on drinking water from the same aquifers.

Oregon's Volunteer Well Water Nitrate Testing Project

The Oregon Department of Environmental Quality sponsored a project to encourage residents to test their well water for nitrate levels. The project was conducted from 1991 to 1993 and resulted in volunteers testing a total of 1,600 wells. The Oregon Ground Water Community Involvement Program was initiated to continue the nitrate testing program. The Program

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provides volunteer training, resource materials and nitrate test kits and promotes public education through nitrate testing events and ground water forums.

League of Women Voters Ground Water Education Programs

The League of Women Voters (LWV) has sponsored a number of volunteer-led ground water education programs. The LWV in Rockford, Illinois, surveyed residents concerning their knowledge of water supply and ground water contamination concerns. Similar surveys were conducted by the LWV in Red Wing, Minnesota, and Salt Lake City, Utah. The LWV of Enid, Oklahoma, organized volunteers to conduct pollution source inventories around the city's five water well fields. Other LWV chapters have developed videos, brochures, and other educational materials concerning ground water protection and potential threats to ground water quality.

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Protecting Our Drinking Water: The EPA's Source Water Protection Initiative

Americans have long enjoyed the luxury of safe, affordable drinking water. A rising awareness of water pollution incidents, however, has caused people to be concerned about drinking water quality. Many communities have recognized that preventing the pollution of lakes, rivers, streams, and ground water is the key to ensuring the long-term safety of drinking water. This common sense approach is known as **source water protection.**

The Safe Drinking Water Act emphasizes monitoring and treatment to protect drinking water safety. However, protection based on monitoring and treatment alone is not sufficient. Nearly all groups interested in drinking water safety see a need for stronger efforts to prevent pollution from entering drinking water sources rather than relying solely on water treatment to reduce health threats.

The EPA encourages this prevention-oriented approach and is actively promoting the development of grass roots source water protection activities. As part of the Source Water Protection Initiative, the EPA hopes to

- Restore the public's rights and responsibilities to protect their drinking water
- Raise public confidence in the safety and quality of their drinking water supply
- Reduce the costs of providing safe drinking water.

Wellhead Protection Programs

Many States and communities are currently promoting source water protection, in Wellhead Protection (WHP) programs. The 1986 Amendments to the Safe Drinking Water Act established the Wellhead Protection Program to aid communities in protecting their drinking water quality. Through wellhead protection, communities identify the land areas that contribute ground water to public water supply wells. They then develop plans to manage the potential sources of contamination in those vulnerable areas, thereby reducing the likelihood of polluting the drinking water source.

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By the end of December 1994, a total of 37 States and Territories had EPA-approved WHP Programs in place. In addition, thousands of local WHP initiatives have been undertaken in communities across the Nation. As of 1993, approximately 3,800 communities that are dependent on ground water for drinking water had complete WHP programs.

Expanded Source Water Protection Goals

The idea of wellhead protection can apply to surface water supplies as well. The EPA is encouraging stronger watershed protection programs, through approaches available under the Federal Clean Water Act, to protect surface waters used for drinking water supplies. Source water protection, for both ground water and surface water, may offer significant advantages to both drinking water purveyors and consumers.

The EPA is planning a National Source Water Protection Workshop in 1996. This workshop will provide communities with the tools and information needed to establish source water protection programs. The workshop will be televised and will target communities that have delineated their source water protection areas and carried out source identification. The workshop will also assist communities in moving toward source management.

The EPA has also set the following source water protection goals:

- By 1997, establish a core network of 10,000 communities with active and comprehensive local WHP programs in place.
- By 1997, incorporate source water protection and source management as priority objectives in projects requiring financial assistance from other Federal programs.
- By 1997, begin to expand source water protection approaches to communities reliant on surface water for drinking water.
- By 2005, have 50% of all community water supplies covered by active and comprehensive local source water protection programs.

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Costs of Not Preventing Contamination of the Ground Water Resource

The sage adage that "An ounce of prevention is worth a pound of cure" is being borne out in the field of ground water protection. Three separate efforts to look at the cost of prevention versus remediation have found that there can be real cost advantages to promoting prevention of ground water contamination in the public and private sectors.

The analysis of prevention in Maine found that, for six large municipal water systems with contamination from salt storage, gasoline, landfill leachate, and industrial solvents, costs for well replacement, emergency supplies, water treatment, and/or remediation ranged from $500,000 to $1,500,000. Of the 2,000 small water systems in the State, perhaps as many as 70 are contaminated. For six small systems, remedial costs ranged from $6,000 to $155,000. Costs for preventing contamination in these cases were estimated to be 1/10th to 1/100th of the costs of remediation for the large systems and 1/5th to 1/10th for the small systems. Although remediation is thus more costly than prevention, whether prevention is more cost-effective in any particular instance depends on the risk that a water system without a particular type of preventive measure would need remediation and when any costs of remediation would be incurred.

The State of Washington's Wellhead Protection Program found that, in a sample of small communities ranging in size from 300 to 5,000 people affected by such contaminants as ethylene dibromide (an agricultural fumigant), gasoline, and trichloroethylene (TCE, a solvent), costs for cleanup and/or a new water supply ranged from $40,000 to $1,800,000, with costs continuing to be incurred. For a larger city—Tacoma—where TCE and other contaminants were found in a wellfield in concentrations more than 10 times the health standard, costs over the expected 18-year cleanup period are estimated to be $25 million.

Washington's Wellhead Protection Program catalogued the types of costs associated with contaminated public water supplies and found that they included

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- Provision of emergency water supplies
- Construction and operation of water treatment facilities at the wellhead
- Well replacement
- Transmission line construction
- Hydrogeologic studies
- Remedial measures at or near the contamination source including soil removal, soil capping, and the installation and operation of "pump and treat" systems
- Additional administrative costs
- Public information and education
- Legal proceedings.

Intangible costs included

- Increased health risks
- Decreased ability to provide adequate volumes of water, especially in emergencies, such as fires
- Reduced consumer confidence
- Economic impairment
- Lost opportunity costs in spending funds for cleanup rather than other community needs
- Consumer hysteria and overreaction
- Disposal of wastewater from pump and treat facilities.

The Freshwater Foundation report, *Economic Implications of Groundwater Contamination to Companies and Cities* (1991), indicates that costs to 17 Minnesota cities for remediating ground water contamination was over $30 million, with seven cities reporting costs over $1 million and two reporting impacts in the $10 to $20 million range. Fourteen cases of ground water contamination involving corporations found that most businesses spent over $1 million, with five spending from $5 million to nearly $10 million. In addition to the technical and engineering remedial costs, a major corporate cost was legal fees.

Part V

Cost and Benefits of Water Pollution Control

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Costs and Benefits of Water Pollution Control

Introduction

Section 305(b) of the Clean Water Act calls for States to prepare estimates of the economic and social costs necessary to achieve the objectives of the Act. States are also requested to report on the economic and social benefits of these achievements. None of the States, Territories, and Tribes reporting on their water quality programs attempted to describe the full extent of the economic costs and benefits associated with water quality improvement. Thus, the costs shown in this chapter are from the U.S. Department of Commerce, Bureau of Census, *Pollution Abatement Costs and Expenditures, 1992.* Pennsylvania and the District of Columbia submitted expenditure information on municipal wastewater treatment, which is included in this report as well.

The benefits described in this chapter are from many sources. Information from the Sport Fishing Institute, State reports, and EPA and other Federal sources was used to help measure environmental benefits achieved. It is important to understand the impossibility of measuring the total environmental benefits of water quality improvement. First, benefits are local and to measure the benefits of cleaner water in each locality would be impossible. Second, the methodology does not exist to measure the value of biodiversity or the value of the oxygen produced by a healthy ecosystem. Although these intrinsic values are very important, they are not measurable quantitatively or monetarily. This chapter provides some insight into the benefits of water quality improvement found throughout our Nation. When economic benefits data are not available, biological indicators are used to show stream improvement. The assumption is that, if the insect life in the stream is improving, eventually the fish will return and so will recreation, which has an economic value.

Costs of Water Quality Improvement

Estimates of the costs and benefits of water pollution control are shown in Table 19-1 derived from President Clinton's *Clean Water Act Initiative: Analysis of Costs and Benefits* published in 1994. This table shows the current and planned expenditures associated with the current implementation of the Clean Water Act requirements. Private sources are estimated to spend roughly $30 billion per year on water pollution control, municipalities spend about $23 billion per

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year, agriculture spends approximately $500 million per year, State water programs spend $500 million per year, and Federal agencies spend approximately $10 billion per year. These total to a range of $63 billion to $65 billion per year spent on water pollution control.

Since 1972, EPA has invested over $64 billion in municipal wastewater treatment. State and local governments have contributed many more dollars. In 1972, only 42% of the population was served by secondary or better municipal wastewater treatment facilities. By 1992, this number had increased to more than 62% of the population. This achievement is impressive considering that, during this time, both the Nation's population and the volume of pollution flowing through our sewer systems increased by nearly 30%.

EPA has invested appproximately $1.4 billion since 1972 in maintaining State water quality programs through grants funded under Section 106 of the Clean Water Act. The goals of the Section 106 program are to assist States, Territories, and Tribes in establishing and maintaining adequate measures for preventing and controlling surface and ground water pollution. Other Federal agencies such as the Corps of Engineers, the U.S. Geological Survey, the Natural Resources Conservation Service, and the Fish and Wildlife Service have contributed substantially to the water pollution control efforts in this country.

Pennsylvania provided the most complete set of data. Pennsylvania reported that, during the past 5 years, new grants totaling more than $118.5 million in Federal funds were offered to Pennsylvania municipalities for construction of sewage treatment facilities. Actual dollar expenditures under this Federal grant program during this period amounted to $261.3 million,

Table 19.[illegible] Summary of Current and Planned Spending under the Existing CWA (millions $/year)

	Private Sources	Municipalities	Agriculture	State Water Programs*	Federal Agencies	Total (Quantified)
Pre-1987 Act	$25,286	$17,190	$191	$373	$9,564	$52,604
Nonpoint Source Controls/ Watershed		$389 - $591	$240 - $389	$125	$234	$988 - $1,339
Storm Water: Phase I	$3,990	$1,650 - $2,555				$5,640 - $6,545
CSOs		$3,450				$3,450
Other Costs	$943 - $1,073	$88				$1,031 - $1,161
Total	$30,219 - $30,349	$22,767 - $23,874	$431 - $580	$498	$9,798	$63,713 - $65,099

*Pre 1987 expenditures, estimated to be about $2.7 billion per year for administration and compliance, are not shown here because the cost of complying with the current and future water quality standards could not be estimated. The values shown here are only for administering the program.

Source: U.S. EPA 1994. *President Clinton's Clean Water Act Initiative: Analysis of Costs and Benefits.* EPA 800-S-94-001. Office of Water, Washington, DC.

which includes expenditures from grants made during prior years. Funding from other Federal agencies, including the Farmer's Home Administration and the Department of Commerce, has provided municipalities an additional $63.1 million for facilities planning and administration. State funds and grants issued by the Department of Environmental Resources (DER) and the Pennsylvania Department of Commerce have provided municipalities another $140.1 million for wastewater treatment facilities in the same 5-year period (Table 19-2). These facilities, as they begin operation, represent a significant effort in the cleanup of Pennsylvania's waters.

The District of Columbia estimates the capital cost for the Blue Plains wastewater treatment plant at about $600 million and operation and maintenance costs at about $110 million per year.

Benefits of Water Quality Improvement

Improvements in water quality are valuable to all Americans. Millions of people enjoy recreational activities like fishing, swimming, and boating on waters where these pursuits might not be possible without the control measures undertaken under the Clean Water Act. Cleaner water has reduced health risks to people who swim and fish. Cleaner water has contributed to more productive commercial and recreational fisheries in many parts of the country. It has lowered costs to agriculture and to industries that would otherwise have to treat contaminated water before using it. It has also lowered costs to drinking water systems that might otherwise have to install additional treatment technologies. Finally, cleaner water has

Tabl[illegible] Federal Expenditures for Water Pollution Control in Pennsylvania, 1989-1993 (thousands of dollars)

Year	EPA New Grants	EPA Grant Expds.	FHA Grant Expds.	Federal Dept. of Comm. Expds.	PA DER Act 443 Expds.	PA DER Act 339 Expds.	PA DER Act 537 Expds.	PA Dept. of Comm. Expds.	PENNVEST* Loan and Grant Obligat.	Total Expds.
1989	41,398	69,691	4,565	1,180	249	20,934	1,037	0	122,300	261,354
1990	34,116	83,987	5,533	950	8	23,778	2,097	5,146	104,600	260,215
1991	32,137	51,473	13,554	0	5	27,211	1,013	935	135,400	261,728
1992	1,237	26,155	18,444	300	55	28,787	3,132	3,402	67,300	148,812
1993	9,605	29,957	17,323	1,250	11	28,667	3,120	3,398	76,300	169,631
Total	118,493	261,263	59,419	3,680	328	129,377	10,399	12,881	505,900	1,101,740

*PENNVEST is a fund created in Pennsylvania to provide grants and loans for sewage treatment projects.

NOTE: EPA new grants column refers to EPA's delivery of grants to the State in that year. EPA grants expenditures column refers to the State's actual use of grant funds during that period and prior years. Thus, the grants and expenditures in any one year will not necessarily be equal.

Source: 1994 Pennsylvania 305(b) report, Table 47, page 156.

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provided important aesthetic benefits to Americans who derive value from knowing that waters are cleaner, even when they are unable to visit them.

Notwithstanding these important and substantial benefits of clean water, EPA has not quantified systematically all of the extraordinarily diverse improvements in water quality that have occurred since the Clean Water Act was passed, or that may be attributable to the Act. Moreover, such quantification must typically precede the valuation of improvements in dollar terms. Thus, the total magnitude of environmental, economic, and health-related benefits that result from improvements to water quality are not measurable given existing data and analytic methods. The following discussion describes, nonetheless, some of the benefits associated with water quality improvements.

Recreation

Outdoor recreation is a lucrative business in the United States. Much of our outdoor recreation activities depend on clean water. Sport fishing alone accounts for 1.3 million jobs and $19 billion in wages.* The Sport Fishing Institute (1994) estimates more than 50 million anglers spent more than $24 billion on fishing trips and equipment in 1991. The Institute claims that freshwater fishing "generates nearly 60% of the economic impacts within the sport fishing industry." Expenditures of this magnitude generated approximately $1 billion in State sales taxes and more than $2 billion in Federal income taxes.

The sport fishing industry is increasingly vocal about the need for clean water programs. Fifty million anglers, representing a significant portion of the U.S. population, receive direct benefits of improved water quality.

Eighty million Americans participate in outdoor (non-pool) swimming. Local and State economies are dependent on beach-related recreating, whether at ocean or lake beaches. In 1988, $1.3 to $5.4 billion was lost in the New York-New Jersey area due to beach closings resulting from water quality health standard violations.

Commercial Fishing

The value of U.S. commercial fish landings is about $3.5 billion annually and the industry's total contribution to the GNP is about $16.5 billion. Shellfish landings represent 45% of this total. Nearly 87% of the value of U.S. finfish landings are species-dependent on near-coastal waters for breeding and spawning.†

Good Water Quality Benefits the Economy

Good water quality is important for economic development. Companies that want to attract the best workers often locate in areas that are replete with parks and open spaces, where air and water quality

* Sport Fishing Institute. *Economic Impact of Sport Fishing in the United States*. Washington, DC: April 1994.

† U.S. EPA, Office of Water. *Financing Clean Water Background Materials for Hearing with House Marine and Fisheries Committee, Subcommittee on Environment and Natural Resources*. Washington, DC: February 1993.

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are good, and where recreational opportunities are abundant. These amenities are essential for the quality of life required by today's workforce.

The Institute for Southern Studies published a study in October 1994 illustrating the relationship between State economic growth and environmental quality. What this study shows is summed in a quote from Dr. Stephen Meyer of the Massachusetts Institute of Technology. Dr. Meyer concluded: "States with stronger environmental standards tended to have the higher growth in their gross state products, total employment, construction employment, and labor productivity than states that ranked lower environmentally." The study ranked Louisiana last for jobs and environmental quality. Eight other southern States (along with Indiana, Ohio, and Oklahoma) ranked among the 14 worst States in both categories. Hawaii, Vermont, and New Hampshire ranked among the top six States for both jobs and environmental quality. Six States ranked among the top 12 in both categories: Wisconsin, Minnesota, Colorado, Oregon, Massachusetts, and Maryland.*

There are industries that are dependent on a healthy, clean water supply. These industries range from the soft drink to the computer chip industry. For these industries, clean water is a valued economic input. The cleaner the source water, the less treatment the intake water requires. These savings are then passed on to their consumers.

The following discussion illustrates how various States and the District of Columbia benefit from improved water quality and describes some of the actions they are taking to rebuild the benefits lost two and three decades ago.

Water Quality Benefits Identified by States

Pennsylvania

Improved water quality conditions have enabled programs to be undertaken to reintroduce breeding populations of bald eagle, osprey, and river otter in Pennsylvania. The Pennsylvania Game Commission's Bald Eagle Recovery Project was carried out from 1983 to 1989. A total of 88 young eagles were released from hatching sites in the upper Delaware and lower Susquehanna River basins. In addition, eaglets were introduced to active nests in northwestern Pennsylvania to supplement populations in that area. As a result of this program, 13 bald eagle nests were found in 1992. All together, the nests produced 21 hatchlings. In 1993, a record 16 pairs of bald eagles attempted to nest in the Commonwealth. Even though some nests were abandoned due to the March blizzard, 15 eaglets were produced.

Through cooperative projects, over 100 osprey (fish hawks) were hatched in northeastern Pennsylvania in the early 1980s to form the nucleus of what has become a viable breeding population in the Poconos. In 1989, a hatching tower was constructed on the Hammond Dam in Tioga County, which can accommodate up to 16 ospreys. This project was initiated in 1990

* Hall, Bob. *Green and Gold.* Institute for Southern Studies. October 1994.

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with nine ospreys, the first of approximately 70 to be released over 5 years. Cooperating parties have included the Game Commission, the Fish and Boat Commission, the National Audubon Society, the U.S. Army Corps of Engineers, and researchers from East Stroudsburg University and the Dubois Campus of Penn State University. In 1992, as many as 14 active osprey nests were located in the State. Nine were in the Poconos, three were in Lancaster County, and one each was in York and Somerset Counties.

River otter reintroductions began in 1982. From 1982 through 1989, 39 otters were released in the Kettle, Pine, and Loyalsock Creek basins in north central Pennsylvania. These otters have expanded their range and reproduced. Otter reintroductions in northwestern Pennsylvania began with the release of four otters in the Tionesta Creek basin in 1990. More otters were scheduled to be released in this basin during 1991. An April 1992 otter release in the Youghiogheny River brought them back to the drainage for the first time in more than 100 years. Five otters were released near Confluence as part of a cooperative program. Additional releases are planned. In addition, Maryland stocked 18 otters on the Youghiogheny near Oakland in 1989 and 1990. The success of these programs is due, in part, to improved water quality and resulting improved fisheries.

The following are estimates of the economic value of fishing and boating to the Pennsylvania economy. In 1992, a total of 1,081,163 fishing licenses were sold in the State. In addition, 735,237 Trout Stamps were sold. These sales provided $17 million in revenue to the Pennsylvania Fish and Boat Commission. Over 2 million people participated in fishing (anglers under age 16 do not need a license) and spent between $750 and $800 million in direct trip and equipment expenditures. This translates to an average of $750 to $800 per angler per year. This is a significant contribution to the economy.

In addition, there are 311,893 registered boats in Pennsylvania that generated $4.2 million in fees for the Fish and Boat Commission in 1992. An estimated 3 million Pennsylvanians participated in boating activities and contributed $3.056 billion to the economy for equipment, supplies, food, lodging, fuel, etc.

Connecticut

Entire industries are based wholly, or in part, on having clean water resources. These include fishing, boating, swimming, and a variety of recreation or tourism-related industries. An extensive survey was conducted by the University of Connecticut College of Agriculture and Natural Resources for EPA Region 1. The final report titled, *The Economic Importance of Long Island Sound's Water Quality Dependent Activities*, released in January 1992, was based on survey data collected between June 29 and November 29, 1990.

The study estimates that the value of Long Island Sound to the economies of New York and Connecticut for water-quality-dependent activities was $5.5 billion in 1990. Three billion dollars of this was attributed to Connecticut's economy. The following discussion briefly summarizes use valuations for

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Connecticut's portion of Long Island Sound.

Commercial finfish and shellfish landings were estimated to be $53 million. Specific associated industries directly related to harvesting increases this value to $148.4 million. Additional industries relating to the processing, wholesaling, and retailing of fish and shellfish were not considered. Thus, the value this industry adds to the Connecticut economy is understated.

An estimated 7.5 million persons visited Connecticut's beaches in 1990. Studies conducted in Rhode Island and Florida indicate that this translates directly into $159.1 million for Connecticut's economy (on average, $21 per person per year). Related contributions to the State's tourism industry increase this estimate to $361.45 million.

Sportfishing constitutes another important industry in Long Island Sound. Roughly 330,000 people participated in the sport in 1991. Direct expenditures associated with sport fishing is estimated at $258.5 million (on average, $780 per angler per year). Related activities increase this estimate to $624.6 million contributed to Connecticut's economy (on average, $1,890 per angler per year).

Recreational boating represents the largest industry that depends on maintaining water quality. Direct expenditures for equipment and services were estimated at $836 million. This increased to $1.84 billion with the inclusion of related activities.

Finally, an attempt was made to estimate the value of salt marshes as a resource unto themselves and not as developable land. Many values, such as flood control and erosion buffers, were not assigned dollar values. A conservative estimate of the value of the marshes as spawning grounds and feeding areas for commercial and recreational fishes was calculated at $93.75 million. This value was equally divided between New York and Connecticut.

Connecticut's shellfish industry has grown from a harvest of 30,000 bushels in 1972 to 900,000 bushels in 1992 with a value exceeding $46 million. The shellfish industry contributes approximately $500,000 in goods and in-kind services to the Connecticut Department of Agriculture, which oversees the State's shellfish industry.

An estimated 392,419 acres are available for growing shellfish; of these, over 46,500 are currently cultivated. Eighty percent of all acreage available for shellfishing is currently approved or conditionally approved. The remaining 20% (78,009 acres) is closed. Four million bushels of oyster shells have been planted in an attempt to restore State public oyster beds. Management efforts of local shellfish commissions are increasing, and several towns, including Stamford, Norwalk, Guilford, and Madison, have begun "relay" programs to enhance recreational shellfishing.

Other fisheries, including lobsters, finfish, squid, hard clams, scallops, and conch, contribute significantly to Connecticut's fishery harvest. This harvest amounted to 19,200,000 pounds in 1992, combining live weight of fish, lobsters, and squid plus the meat of oysters, clams, scallops, and conch. At an off-vessel value of nearly $60 million, this makes Connecticut the

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largest aquaculture-producing State in the region.

District of Columbia

The stench of the Potomac River in the 1960s made recreation on or near the river undesirable. The change in the water quality today is readily discernible. Today residents and visitors recreate along its banks as well as partake in various boating activities on the river. Water sports such as rowing, wind surfing, and annual water vehicle competitions have become part of the Potomac River culture in the District. Increased development along the Georgetown and Alexandria water fronts are another symbol of the river's resurgence.

There has been a return of recreational fishing to District waters. Surveys conducted by fisheries management programs have clearly shown that fishing and the number of anglers have increased greatly. The sale of fishing licenses in the District provided the support for these surveys. The number of fishing licenses sold in 1993 (12,916) is more than two and one-half times the number sold in 1988 (4,900 licenses)—the first year fishing licenses were sold.

These benefits are real and it is important to note that they would not have been feasible without the leadership of the Federal Government, State government, local government, citizen groups, and industry all working together.

New York

New York State Department of Environmental Conservation published *20 Year Trends in Water Quality of Rivers and Streams in New York State* in 1993. The study reports trends in macroinvertebrates from 1972 to 1992. The increase in macroinvertebrates such as mayflies, caddisflies and stoneflies is a significant indicator of the improving health of a waterbody. The following describes 10 of New York's greatest success stories:

Canandaigua Outlet below Canandaigua – The stream in 1972 had 3 to 4 inches of black organic sludge downstream of the sewage discharge. Following the 1980 upgrading of the Canandaigua Sewage Treatment Plant, mayflies and caddisflies are now found at the downstream site.

Cattaraugus Creek, Gowanda – Water quality is now considered excellent in Cattaraugus Creek; the benthic fauna is dominated by intolerant species. Moderate to severe pollution from tannery and glue processing discharges was well documented in 1976. These discharges have since been eliminated.

Cayadutta Creek below Johnstown – Severe pollution was well documented at all sites downstream of the Gloversville-Johnstown wastewater treatment facility. Following the 1991 upgrade of the plant, species richness indicators increased from 8 to 23, and mayflies, stoneflies, and caddisflies were found, similar to the upstream site.

Lower Hudson River below Albany – All biological indices have improved below Albany since 1972 and may be attributed to many improvements in municipal and

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industrial sewage treatment. Several blue crabs were collected in this reach in 1992.

Mohawk River below Rome – From 1972 to 1989, species richness rose from 8 to 24 species, and mayflies, stoneflies, and caddisflies appeared. The change is attributed to improved treatment of both industrial and municipal wastes.

Mohawk River below Utica – Following the construction and upgrade of sewage treatment facilities, the macroinvertebrate fauna changed from a tolerant worm and midge fauna to a diverse fauna containing mayflies and caddisflies.

Oneida Creek below Oneida – The 1982 upgrade of the Oneida Sewage Treatment Plant changed the fauna from a severely impacted community of worms and midges to a diverse community of mayflies, stoneflies, and caddisflies.

Skaneateles Creek, entire length – Most sites were found to be severely impacted in 1972. In 1992, following improved treatment of most discharges, diverse communities were found, with numerous mayflies and caddisflies.

Tonawanda Creek below Batavia – The former fauna below the sewage discharge was a classic worm and midge sewage fauna. Following the 1990 completion of the new Batavia wastewater treatment facility, this formerly severely impacted site now harbors many mayflies and caddisflies.

Upper Hudson River below Glens Falls – Mayfly/caddisfly species increased from 1 to 7 from 1972 to 1986, following numerous improvements in treatment of municipal and industrial wastes. Biological changes were accompanied by improvements in water clarity.

Water Quality Benefits in the Nation's Waterbodies

Iowa's Swan Lake

In the early 1980s, Iowa's Swan Lake suffered from turbidity, sedimentation, nuisance algal blooms, and frequent fishkills. By 1990 conditions had changed:*

- In 1990, visits to Swan Lake State Park were up 170% from 1986 levels, and camping in the park more than doubled during the same period.
- Between 1982 and 1989, the number of anglers at the lake increased more than sevenfold.
- From 1987 through 1990, the value of fishing at Swan Lake exceeded $1.75 million.
- Between 1986 and 1990, concession income at the park quadrupled.
- Camping receipts in 1990 were 2.5 times higher than those of 1986.

Chesapeake Bay

A 1987 study estimated the value of the Chesapeake Bay to the commercial fishing industry, port

*U.S. EPA, *Clean Lakes Program Review*, 1992.

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and shipbuilding activities, and Bay-related tourism at $31.6 billion. Recreational activities, such as boating, fishing, hunting, sightseeing, and dining on the regional cuisine accounted for $8.4 billion per year.*

Gulf of Mexico†

There are almost 2 million registered motor boats in the five Gulf States and an estimated 4 million recreational anglers. In 1991 the National Marine Fisheries Service estimated there were 15.5 million marine recreational fishing trips in the Gulf of Mexico region. Private and rental boat anglers accounted for the highest percentage of the fishing effort.

The Gulf of Mexico is especially rich in fish and shellfish species. Three of the top 10 U.S. ports in terms of the value of fish landings are located in the Gulf States. Also, the Gulf had three of the top five States in terms of value in 1990: Louisiana, Texas, and Florida. Seventy percent of the 346 million pounds of shrimp landed in the U.S. in 1990 came from the Gulf States (250 million pounds) valued at $420 million. Other important shellfish include blue crabs and oysters. In 1989, Texas and Louisiana landed 11.7 million pounds of tuna valued at $22.5 million. The Gulf also accounted for 11.5 million pounds of shark valued at $7.9 million.

Great Lakes‡

The Great Lakes provide tremendous economic and ecological benefits to the area. One quarter of all U.S. industry and more than 70% of U.S. and 60% of Canadian steel mills are in the Great Lakes Basin. Over 23 million people depend on the Great Lakes for drinking water. The area affords habitat for a vast array of plant and animal species, many of which are native to the Great Lakes Basin.

Recreational benefits are also significant. Data from the mid-1980s indicate that recreational boating marinas employed almost 20,000 people. Boat sales and other boater spending (marina fees, licenses, repairs, etc.) amounted to almost $4 billion per year. Recreational fishing adds another $3 billion to $7 billion per year.

Water quality in the Great Lakes has improved significantly since the passage of the Clean Water Act in 1972. Although discharges from wastewater treatment plants have increased due to population growth and development pressures, levels of dissolved oxygen have steadily improved. Reductions in organic material, solids, and phosphorus are noteworthy as well. Phosphorus loadings to Green Bay from the Fox River decreased by 3.6 million pounds by 1982. Fish have returned to some harbors from which they had disappeared.

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* U.S. EPA, *Chesapeake Bay Program, A Work in Progress, A Retrospective on the First Decade of the Chesapeake Bay Restoration.* Washington, DC: September 1993.

† The Center for Marine Conservation and U.S. EPA. *Environmental Quality in the Gulf of Mexico: A Citizen's Guide.* 2nd Ed. Washington, D.C.: June 1992.

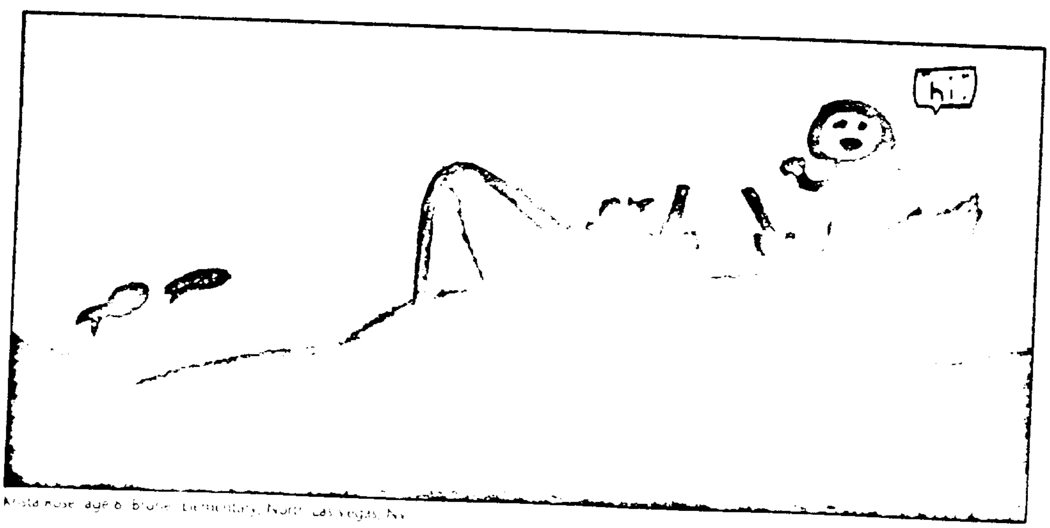
‡ U.S. EPA, Office of Water. *Clean Water: A Memorial Day Perspective.* Washington, DC: May 1994.

The number of double-crested cormorants, a water bird that all but vanished in the Great Lakes in the 1970s, has climbed to 12,000 nesting pairs. The number of bald eagles is nearing the highest level ever measured in Michigan.

Improvements in Great Lakes water quality have had a positive economic impact on the recreational fishing industry. Fishing licenses purchased in the county of Green Bay, Wisconsin, increased from 19,000 in 1970 to 51,000 in 1989. Boat registration more than doubled during the same period, leading to an increased demand for launch ramps and other boating facilities in the Green Bay area. The revitalization of the fishery resources in Lake Ontario has spurred the development of the charter boat fishing industry, boater and angler access sites, fishing derbies, and additional employment opportunities.

Water quality improvements and increased lakeside development have caused people to return to the shore of Lake Erie to enjoy boating, fishing, swimming, and other water-based activities. Algal blooms and bacteria counts in Ohio beach areas along Lake Erie have dropped more than 90% from 1968 to 1991. As a result, Ohio's waterfront has seen an increased number of boating, camping, and vacation resort facilities being constructed. From 1986 to 1993, there was a 30% increase in the number of marinas in the Lake Erie Basin. Ohio's Lake Erie tourism industry is now an $8.5 billion per year industry.

Lakeshore cities, such as Cleveland, Ohio, have begun to restore their shorelines, which were considered "dead" 25 years ago. A new harbor and festival park have already been completed. Several museums are completed or are under construction and an aquarium is planned.



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☐ **The National Water Quality Inventory: 1994 Report to Congress – Appendixes.** EPA841-R-95-006. December 1995. This document contains the data tables used to generate the information presented in the 1994 Report to Congress. (216 pages)

☐ **The Quality of Our Nation's Water: 1994. Executive Summary of the National Water Quality Inventory: 1994 Report to Congress.** EPA841-S-95-004. December 1995. A summary of the complete Report to Congress, including individual summaries of the Section 305(b) reports submitted by the States, Tribes, and other jurisdictions. (200 pages)

☐ **Fact Sheet: National Water Quality Inventory: 1994 Report to Congress.** EPA841-F-95-011. December 1995. Brief synopsis of the water quality data submitted by the States, Tribes, and other jurisdictions in their 1994 Section 305(b) reports. (12 pages)

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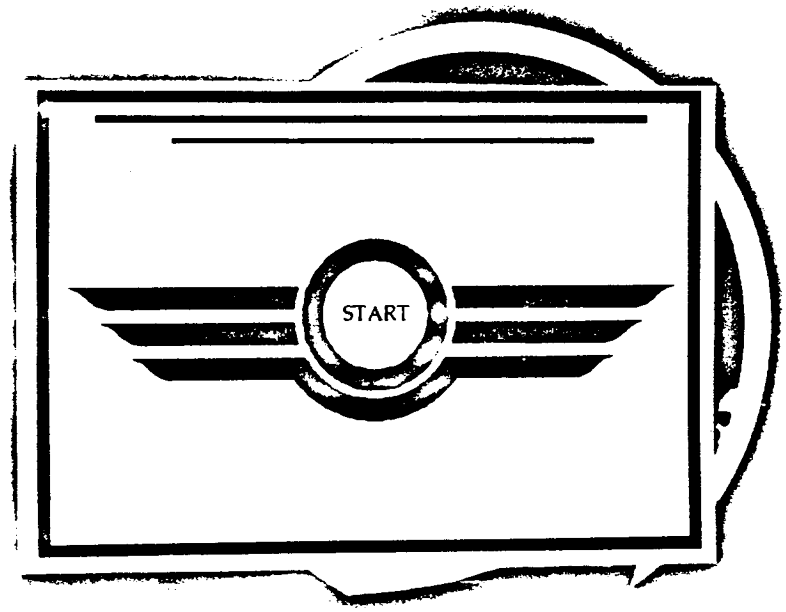

Guidelines for Urban Erosion and Sediment Control

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Guidelines for Urban
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SOIL AND WATER CONSERVATION SOCIETY

To advance the science and art of good land and water use worldwide

Empire State Chapter
100 S. Clinton Street, Room 771
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VOL 12

Dear Land Manager:

The Soil Conservation Society of America was organized in 1945 with the objective to "Advance the Art and Science of Wise Land Use." Although the organization changed its name to the Soil and Water Conservation Society (SWCS) in 1987, its mission remains to promote excellence in land and water management in local communities and throughout the world. The Empire State Chapter of SWCS is the local, New York State unit of the international organization.

In 1988, the Chapter accepted the challenge of publishing and distributing erosion and sediment control guidelines for urban areas as an appropriate project within the stated objective of the Society. The Chapter has also accepted publishing and distribution responsibility for stormwater management guidelines. A variety of training is available using one or both of these manuals as references.

These guidelines will benefit all citizens, both those who install practices and those who benefit from their installation. I would like you, the users of these guidelines, a person concerned with proper land use, to know more about the Soil and Water Conservation Society.

SWCS is a non-profit, international organization with more than 13,000 members. Members of the Society help promote land and water management excellence through personal involvement and collective action.

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The members of the Society receive bi-monthly, the Journal of Soil and Water Conservation one of the most respected magazines in land and water management in the world. It has been published for more than 40 years and is a major benefit of being a member. Society members have an outstanding annual meeting each year at different locations throughout the U.S.A. and Canada. There are also many special conferences and working groups throughout the year. The activities are too numerous to discuss here, but if you would like additional information, write me at the address on this letter or call me during business hours at (607) 776-9631 ext. 2542. (The address of the International Headquarters is: Soil and Water Conservation Society, 7515 N.E. Ankeny Road, Ankeny, Iowa 50021).

I commend you for using a sound approach to preventing sediment problems in your community. The Empire State Chapter is pleased to provide you with these guidelines.

John P. Wildeman

JOHN P. WILDEMAN
President, Empire State Chapter, SWCS

SOIL AND WATER CONSERVATION SOCIETY

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NEW YORK GUIDELINES FOR URBAN EROSION AND SEDIMENT CONTROL contains standards and specifications for erosion and sediment control measures commonly used on construction sites. Both vegetative and structural measures (permanent and temporary) are included in the manual. It also information on calculating storm water runoff and erosion rates as well as a sample soil erosion and sediment control ordinance. The manual is a valuable tool for planners, engineers, local officials, contractors and others involved in development activities.

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REDUCING THE IMPACTS OF STORMWATER RUNOFF FROM NEW DEVELOPMENTS contains guidance on reducing flooding and water quality impacts from new development through stormwater management and erosion and sediment control. This manual also contains information on stormwater management planning, performance standards and management practices. The manual is a valuable tool for planners, engineers, local officials, contractors and others involved in development activities.

This manual has been prepared by the New York State Department of Environmental Conservation and made available to the Empire State Chapter of the Soil and Water Conservation Society for distribution and reprinting.

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Copies of these documents may be purchased from some county Soil and Water Conservation Districts or directly from the Soil and Water Conservation Society, Empire State Chapter. Check with your local county Soil and Water Conservation District for availability before ordering direct.

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GUIDELINES FOR URBAN EROSION & SEDIMENT CONTROL

Third Printing - October 1991

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Agricultural Engineering Department, Cornell University
New York State Department of Environmental Conservation
New York State Department of Transportation
New York Chapter of Land Improvement Contractors of America
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PREFACE

The parent document "Guidelines for Erosion and Sediment Control in Urban Areas of New York State" was originally published by the USDA-Soil Conservation Service in 1972 to provide information on minimizing erosion and sediment problems on land undergoing urban development. These guidelines were used by soil and water conservation districts, planning boards, property owners, land developers, contractors and consultants.

Based upon the experience gained in the use of this document, a committee was formed in 1978 to update this guide. This committee contained specialists and representatives from:

New York State Soil & Water Conservation Committee

Agronomy Department, Cornell University

Agricultural Engineering Department, Cornell University

New York State Department of Environmental Conservation

New York State Department of Transportation

New York Chapter of Land Improvement Contractors of America

O'Brien and Gere Engineers, Inc.

USDA-Soil Conservation Service

This committee completed their draft document "Sediment and Erosion Control for Developing Areas" in May 1980. Before this document could be finalized, technological advances and increased demand for natural resource planning due to increased urban pressure on rural areas, caused an additional need for revision and expansion of the technical chapters.

In March 1985, work resumed on the guide to expand the standards and specifications to include temporary and permanent structural measures for erosion and water control, update the discipline vocabulary, incorporate the most recent methods and procedures available, and provide local planners and legislators examples of public administration. The guide was again revised in mid-1991 to incorporate general updates, a chapter on calculating runoff, a chapter on bio-engineering, the addition of temporary and permanent practices and a site specific example demonstrating the planning and design process.

Although the initial publication was written for internal Service and Soil and Water Conservation District use, the need and demand for this information has expanded throughout the State to other public service agencies and the general public. This document aims to help improve water quality, reduce sediment damage and associated maintenance costs of road ditches, storms sewers, streams, lakes, flood control structures, and improve the value of on-site detention basins for recreational use. It is distributed by the Empire State Chapter of the Soil and Water Conservation Society.

This guide can be used to assist local units of government in preparing and implementing their soil erosion and sediment control programs and in reviewing proposed site development plans; establish or encourage uniformity through standards in applying erosion control techniques; and help developers and planners to make maximum use of potential development sites by proper management of their natural resources. It is to this end the document was created.

Donald W. Lake, Jr., P.E.

State Conservation Engineer

USDA-Soil Conservation Service

Syracuse, New York

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The New York Guidelines for Urban Erosion and Sediment Control contains standards and specifications for erosion and sediment control measures commonly used on construction sites. Both vegetative and structural measures (permanent and temporary) are included in the manual. The manual is a valuable tool for planners, engineers, local officials, contractors, and others involved in development activities.

Copies can be purchased for $25.00 per copy from some county Soil and Water Conservation Districts or directly from the Soil and Water Conservation Society, Empire State Chapter. Check with your county Soil and Water Conservation District for availability before ordering direct.

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SECTION 1 - INTRODUCTION

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Section prepared by:

Donald W. Lake, Jr., P.E.,
State Conservation Engineer,
USDA-Soil Conservation Service, Syracuse, NY

INTRODUCTION

Purpose

These guidelines provide information on minimizing erosion and sediment problems on land undergoing urban development. They show how to use soil, water and plants to improve the quality of our environment. These guidelines were developed by the Soil Conservation Service (SCS) in cooperation with state and local agencies for use by soil and water conservation districts (hereafter referred to as districts). These guidelines also may be helpful to planning boards and other government bodies, property owners, land developers, contractors, consultants, and others.

Scope and Authority

The guidelines apply to urban lands where housing, industrial, institutional, recreational and highway developments are occurring or are imminent. They are statewide in scope and are somewhat generalized due to variations in climate, topography, geology, soils and plant requirements. Feasible ways to minimize erosion and sedimentation are varied and complex. Alternative methods can be used to solve a problem. Final decisions on measures to be used are made by local people.

The SCS, working through districts, has broad authority to help people solve problems of soil, water, and related resources. There may be times, however, when these problems or related conditions are referred to outside groups for advice or assistance. Any technical assistance given by SCS personnel must conform with local policies and procedures as well as standards established by the agency.

If authorized by districts, SCS can:

1. assist local groups or communities in reviewing and developing resource plans and evaluating benefits and costs of treatment measures;
2. provide technical assistance to install soil, water and plant conservation measures before or during construction;
3. give advice on maintenance programs for installed measures.

Erosion and Sediment Hazards Associated with Urban Developments

In the urbanizing process, many people may be adversely affected by development on relatively small areas of land. Uncontrolled erosion and sediment from these areas may cause considerable economic damage to individuals and society in general. Stream pollution and damages to public facilities and private homes are examples.

Hazards associated with urban developments include:

1. a large increase of soil exposed to erosion from wind and water;
2. increased water runoff, soil movement, sediment accumulation and peak flows caused by:
   - A. removal of plant cover;
   - B. a decrease in the area of soil which can absorb water because of construction of streets, buildings, sidewalks and parking lots;
   - C. changes in drainage areas caused by grading operations, diversions and streets;
   - D. changes in volume and duration of water concentrations caused by altering steepness, distance and surface roughness;
   - E. soil compaction by heavy equipment which can reduce the water intake of soils as much as 90 percent of the original rate;
   - F. prolonged exposure of unprotected sites and service areas to poor weather conditions.
3. altering the groundwater regime that may adversely affect drainage systems, slope stability, survival of existing vegetation and establishment of new plants;
4. exposing subsurface materials that are too rocky, too acid, or otherwise unfavorable for establishing plants;
5. obstructing streamflow with new buildings, dikes and landfills;
6. improper timing and sequence of construction and development activities;
7. abandonment of sites before completion of construction.

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BASIC PRINCIPLES OF EROSION AND SEDIMENT CONTROL

The Erosion and Sedimentation Processes

The standards, specifications and planning guidelines presented in this document are intended to be utilized when development activities change the natural topography and vegetative cover of an area. It is necessary to formulate and implement erosion and sediment control plans with urban land development because such development can increase erosion and sediment problems. To understand how erosion and sediment rates are increased requires an understanding of the processes themselves.

Soil erosion is the removal of soil by water, wind, ice, or gravity. This document deals primarily with the types of soil erosion caused by rainfall and surface runoff. Raindrops strike the soil surface at a velocity of approximately 25-30 feet per second and can cause splash erosion. Raindrop erosion causes particles of soil to be detached from the soil mass and splash into the air. After the soil particles are dislodged, they can be transported by surface runoff, which results when the soil becomes too saturated to absorb falling rain or when the rain falls at an intensity greater than the rate at which the water can enter the soil. Scouring of the exposed soil surface by runoff can cause further erosion. Runoff can become concentrated into rivulets or well defined channels up to several inches deep. This advanced stage is called rill erosion. If rills and grooves remain unrepaired, they may develop into gullies when more concentrated runoff flows downslope.

Sediment deposition occurs when the rate of surface flow is insufficient for the transport of soil particles. The heavier particles, such as sand and gravel, transport less readily than the lighter silt and clay particles. Previously deposited sediment may be suspended by runoff from another storm and transported farther downslope. In this way, sediment is carried intermittently downstream from its upland point of origin.

Factors That Influence Erosion

The erosion potential of a site is determined by five factors; soil erodibility, vegetative cover, topography, climate and season. Although the factors are interrelated as determinants of erosion potential, they are discussed separately for easy understanding.

1. **Soil Erodibility** - The vulnerability of a soil to erosion is known as erodibility. The soil structure, texture, and percentage of organic matter influence its erodibility. The most erodible soils generally contain high proportions of silt and very fine sand. The presence of clay or organic matter tends to decrease soil erodibility. Clays are sticky and tend to bind soil particles together. Organic matter helps to maintain stable soil structure (aggregates).

2. **Vegetative Cover** - Vegetation protects soil from the erosive forces of raindrop impact and runoff scour in several ways. Vegetation (top growth) shields the soil surface from raindrop impact while the root mass holds soil particles in place. Grass buffer strips can be used to filter sediment from the surface runoff. Grasses also slow the velocity of runoff, and help maintain the infiltration capacity of a soil. The establishment and maintenance of vegetation are the most important factors in minimizing erosion during development.

3. **Topography** - Slope length and steepness greatly influence both the volume and velocity of surface runoff. Long slopes deliver more runoff to the base of slopes and steep slopes increase runoff velocity. Both conditions enhance the potential for erosion to occur.

4. **Climate** - Climate also affects erosion potential in an area. Rainfall characteristics such as frequency, intensity, and duration directly influence the amount of runoff that is generated. As the frequency of rainfall increases, water has less chance to drain through the soil between storms. The soil will remain saturated for longer periods of time and stormwater runoff volume may be potentially greater. Therefore, erosion risks are high where rainfall is frequent, intense, or lengthy.

5. **Season** - Seasonal variation in temperature and rainfall defines periods of high erosion potential during the year. A high erosion potential may exist in the spring when the surface soil first thaws and the ground underneath remains frozen. A low intensity rainfall may cause substantial erosion because the frozen subsoil prevents water infiltration. In addition the erosion potential increases during the summer months due to more frequent, high intensity rainfall.

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SECTION 2 - RESOURCE PLANNING IN URBAN AREAS

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Section prepared by:

Donald W. Lake, Jr., P.E.,
State Conservation Engineer,
USDA-Soil Conservation Service, Syracuse, NY

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RESOURCE PLANNING IN URBAN AREAS

Resource Planning

Effective solutions to urban erosion and sediment problems begin with planning. Resource plans can guide and control urban growth preventing wasteful and haphazard developments.

Districts and the SCS have technical resource data and information that can serve as a basis for decision making by local authorities to fulfill the objectives established by plans. These objectives may include reserving best agricultural areas for cropland; maintaining an economic agricultural use; protecting historical, scenic and natural beauty areas; providing for open spaces and parks; developing attractive residential, institutional and industrial areas; and using floodplains and other problem areas for recreation buffer zones and conservation education uses.

Land Development Plans

As more specific plans, such as plans for subdivisions, are developed for smaller areas, SCS can furnish more detailed information and interpretations. This information will help determine the suitability of the site for the kind of development to be made. It will also help in planning and treating these lands to greatly reduce erosion and sediment problems during construction.

Certain basic data need to be assembled before adequate technical information and interpretations can be provided for a subdivision or other type of specific plan. These data consist primarily of:

1. <u>Geography of the Area to be Developed</u>

   Conditions of proposed areas to be developed need to be examined early in the planning stages. These conditions include location, accessibility, present land use, size of proposed tract, topography, drainage pattern, geology, hydrology, soils, vegetation and climate. Such information is obtained from on-site examinations and existing technical reports, maps, records and other documented material usually available from local sources.

2. <u>Study of Soils in the Area to be Developed</u>

   Soils information, interpretations and data are basic to urban land uses. These studies provide an understanding of the capabilities and general limitations of the site. They point out the feasibility of planned land uses, economic considerations and conservation requirements of the site.

   Soils information such as detailed soil maps and interpretation sheets may be available in local SCS and Soil and Water Conservation District offices and will specifically provide the following soils information:

   A. descriptions, erodibility, limitations and capabilities;

   B. engineering properties of soils;

   C. suitability of the soil as a resource material for topsoil, gravel, sand highways, dams and levees;

   D. site suitability for buildings, roads, winter grading, foundations, septic tank disposal fields, sanitary land fills, vegetation, reservoirs, dams, artificial drainage, recreational areas and wildlife development. Generalized soils information, also useful for some purposes, is usually available in SCS offices.

Erosion and Sediment Control Plan

An erosion and sediment control plan should be prepared for all land development and construction activities when it is determined that soil erosion and sedimentation, if not controlled, may have a significant affect on the environment. Appendix A, New York State Department of Environmental Conservation TOGS 5.1.10 provides guidance for initiating erosion and sediment control plans.

A great deal of information must be assimilated to develop an efficient plan to minimize erosion and control sedimentation at a construction site. An erosion and sediment control plan shows the site's existing topography, and how and when it will be altered. It also shows the erosion and sediment control measures that will be used to minimize the risk of sediment pollution, and how and when they will be implemented and maintained. The coordination of erosion and sediment control practices with construction activities is explained on the plan by a phasing schedule.

The Planning Process

The following procedure is recommended to develop a plan that will efficiently control erosion and sedimentation throughout the site development process.

1. <u>Plan the Development to Fit the Site</u>

   Assess the physical characteristics of the site to determine how it can be developed with the smallest risk of environmental damage. Minimize grading by utilizing the existing topography wherever possible. Avoid disturbing wetlands or other environmentally sensitive areas Minimize offsite impacts by maintaining vegetative buffer strips between disturbed and adjacent areas.

2. Determine Limits of Clearing and Grading

Decide exactly which areas must be disturbed in order to accommodate the proposed construction. Pay special attention to critical areas (e.g. steep slopes, highly erodible soils, surface water borders) which must be disturbed. Staged clearing and grading should be considered as an alternative to massive clearing and grading.

3. Divide the Site into Natural Drainage Areas

Determine how runoff will drain from the site. Consider how erosion and sedimentation can be controlled in each small drainage area before looking at the entire site. Remember, it is more advantageous to control erosion at the source and prevent any problems than to design perimeter controls to trap sediment.

4. Select Erosion and Sediment Control Practices

Erosion and sediment control practices can be divided into vegetative and structural controls. This handbook should be used for the selection and design of vegetative and structural practices. Vegetative and structural controls are outlined below.

A. Vegetative Controls - The best way to protect the soil surface and limit erosion is to preserve the existing vegetative groundcover. Where land disturbance is necessary, temporary seeding or mulching should be used on areas which will be exposed for long periods of time prior to construction. Permanent stabilization should be performed as soon as possible after completion of grading. Erosion and sediment control plans must contain provisions for permanent stabilization of disturbed areas. Seed type, soil amendments, seedbed preparation, and mulching should be described on the plans. Selection of permanent vegetation should include the following considerations for each plant species:

1) establishment requirements;
2) adaptability to site conditions;
3) aesthetic and natural resource values;
4) maintenance requirements.

B. Structural Controls - Structural sediment control practices may be necessary when disturbed areas cannot be promptly stabilized with vegetation. Structural practices shall be constructed and maintained in accordance with these guideline standards and specifications.

An acceptable erosion and sediment control plan includes:

1) a map of the existing topography and proposed grading;
2) provisions for erosion and sediment control;
3) a time schedule of proposed construction activity and erosion and sediment control implementation; and
4) maintenance phasing.

Standard symbols are used to facilitate the understanding and review of plans. The symbols, Figure 4.1 on page 4.3, are designed to be easy to apply to plans by drafting or by using stick on materials. They should be bold and easily discernible on the plans. The following scales are recommended for use on erosion and sediment control plans because they facilitate the plan review process: 1 in. = 20 ft., 1 in. = 30 ft., 1 in. = 40 ft., or 1 in. = 50 ft.

The contour interval for these plans shall be two feet or less. Other scales or contour intervals may be favored for special types of land disturbance projects. For example, strip mine plans are often drawn to scales of 1 in. = 200 ft. or 1 in. = 500 ft. with contour intervals of 5 to 20 feet. Consult the appropriate plan review agency prior to finalizing the selection of plan scale. A sample checklist is contained in the appendix.

Implementation of Erosion and Sediment Controls

Effective implementation of erosion and sediment controls requires good construction management. Proper management can reduce the need for maintenance of structural controls, regrading of severely eroded areas, and reconstruction of controls that were improperly implemented. Good site management results in efficient use of manpower and financial savings.

Site management for effective implementation of erosion and sediment controls involves the following:

1. Clear only what is required for immediate construction activity. Large projects should be cleared and graded as construction progresses. Mass clearing and grading of the entire site should be avoided.

   Restabilize disturbed areas as soon as possible after construction is completed. Certain sections of large construction projects may be completed before others and be ready for stabilization before the total project is completed. Waiting until the end of the project to commence all site stabilization may leave areas exposed for an unnecessarily long duration.

2. Divert offsite runoff from highly erodible soils and steep slopes and convey to stable areas.
3. Physically mark off limits of land disturbance on the site with tape, signs, or other methods, so the workers can see areas to be protected.
4. Make sure that all workers understand the major provisions of the erosion and sediment control plan.

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5. Designate responsibility for implementing the erosion and sediment control plan to one individual.
6. Implement a daily inspection program to determine when erosion and sediment control measures need maintenance or repair. Pay particular attention to the inspection following rainfall events.

Predicting Soil Losses

Estimates of soil losses can be made for construction sites by using the Universal Soil Loss Equation. This equation uses rainfall intensity or erosion index, soil erodibility, and slope factors in calculating the estimated soil loss. The equation is used to determine sheet and rill erosion losses on the site.

Predictions of soil losses in areas to be developed is directly related to resource planning. The predictions will influence the degree of planning and treatment required for proper control of erosion and sediment. Predicted soil losses may also create an awareness among developers, local government agencies and others of the urgent need to install conservation measures before or concurrent with construction.

Soil losses on a construction site may be predicted for a whole year, a part of a year or on the basis of "probability" storms and magnitudes of single storms. (Refer to Appendix B for instructions and examples on how the Universal Soil Loss Equation is used for this purpose.)

Estimating Sediment Yield

Sediment yield involves both soil erosion on the site and the transport mechanism acting to carry the eroded material off the site.

Where sediment yields from a developing area are needed for calculation of sediment basin design, etc., the methods in Section 8 can be used for determining the amount of the eroded material that will leave the site as sediment.

Planning Assistance

Planning assistance may be available from the county Soil and Water Conservation District.

Based upon data and information described above, planning assistance during the development of a plan may include the following considerations:

1. Planning of streets and lots should relate to site conditions. Streets laid out at right angles to contours often have excessive grades that increase erosion hazards and sedimentation.
2. Construction plans for public utilities should include steps needed to reduce sediment producing hazards when pipelines, electric transmission and telephone lines are installed.
3. Environmental quality is enhanced when open spaces, parks, recreational areas, ponds, wildlife habitat and other areas of public use become integral parts of the plan. These areas should be well delineated and protected from damages that may occur from nearby construction. Selections of such areas should be based upon soils, vegetation, water, topography, accessibility, wildlife, and aesthetic values.
4. Integrated surface and storm drainage systems are essential parts of any planned development. The plan should clearly specify: location and capacities of diversions and debris basins; paved or other types of lined chutes, outlets and waterways; drop inlets; open or closed drains; stream channel protection and bank erosion structures.
5. Stabilizing land with plant materials or mulches should be part of a planned development. Retention of existing natural vegetation in strategic areas is beneficial and desirable.
6. Installation of the control measures before or as soon as possible during construction will greatly reduce erosion and sediment damages.
7. Temporary and/or permanent erosion control measures may be needed. They should also be installed as soon as possible. Provisions for maintenance of these measures should be part of the plan and enforced.

Erosion and Sediment Control Ordinances and Subdivision Regulations

Local ordinances or regulations dealing with erosion and sediment controls enhance and implement resource planning and development in areas that are to be urbanized. The SCS does not, in any way, participate in the enactment or enforcement of ordinances. This is strictly the responsibility of authorized government agencies and officials. At the request of local Districts, the SCS can furnish any available technical information or data that may be useful to authorized local government agencies when preparing to formulate ordinances or regulations.

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STEPS IN THE SELECTION OF CONTROL MEASURES

Step 1: Identify Control Method - On any construction site the objective in erosion and sediment control is to prevent off-site sedimentation damage. Three basic methods are used to control erosion on construction sites: runoff control, soil stabilization, and sediment control. Controlling erosion should be the first line of defense. Where soil properties and topography of the site make the design of sediment trapping facilities impractical, runoff control and soil stabilization should be used. Controlling erosion is very effective for small disturbed areas such as single lots or small areas of a development that do not drain to a sediment trapping facility.

Sediment trapping facilities should be used on large developments where mass grading is planned, where it is impossible or impractical to control erosion, and where sediment particles are relatively large. A minimum of cost for erosion and sediment control is usually accomplished by using a combination of vegetative and structural erosion control and sedimentation control measures.

Step 2: Identify Problem Areas - Once a method of control is selected, potential erosion and sediment control problem areas are identified. Areas where erosion is to be controlled will usually fall into categories of slopes, graded areas or drainage ways. Slopes include graded rights-of-way, stockpile areas, and all cut or fill slopes. Graded areas include all stripped areas other than slopes. Drainage ways are areas where concentrations of water flow naturally or artificially, and the potential for gully erosion is high. Problem areas where sediment is to be controlled fall into categories of large or small drainage areas. Small areas are usually 1 acre or less while large areas are larger than 1 acre.

Step 3: Identify Required Strategy - The third step in erosion and sediment control planning is to follow the planning matrix from the problem area to the strategy that can be taken to solve the problem. Strategies can be used individually or in combination. For example, if there is a cut slope to be protected from erosion, the strategies may be to protect the ground surface, divert water from the slope or shorten it. Any combination of the above can be used. If no rainfall except that which falls on the slope has the potential to cause erosion and if the slope is relatively short, protecting the soil surface is often all that is required to solve the problem.

Step 4: Identify Control Measure Group - Once required strategies are identified, the planning matrix leads to the group or groups of control measures that will accomplish one strategy. Control measures within each group have similar purpose, scope, application, design, criteria, standard plans, and construction specifications. Therefore, any measure within a group will solve the problem in question.

Step 5: Select Specific Control Measure - The final step in erosion and sediment control planning can be accomplished by completing final design. This involves adaptation of any control measure within a group to solve the specific erosion and sediment control problem. From descriptions given to the right of each control measure, the one measure which is most economical, practical, efficient, and adaptable to the site can be chosen.

Once the specific control measure has been selected, the plan key symbol given in the matrix can be placed on the erosion and sediment control site plan to show where control measures will be used. Standardized design, plan, and construction specification sheets can then be completed for each control measure. This completes the planning for sedimentation control and soil erosion as part of the total natural resource plan.

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Figure 2.1

Planning Flow Chart - Runoff Control

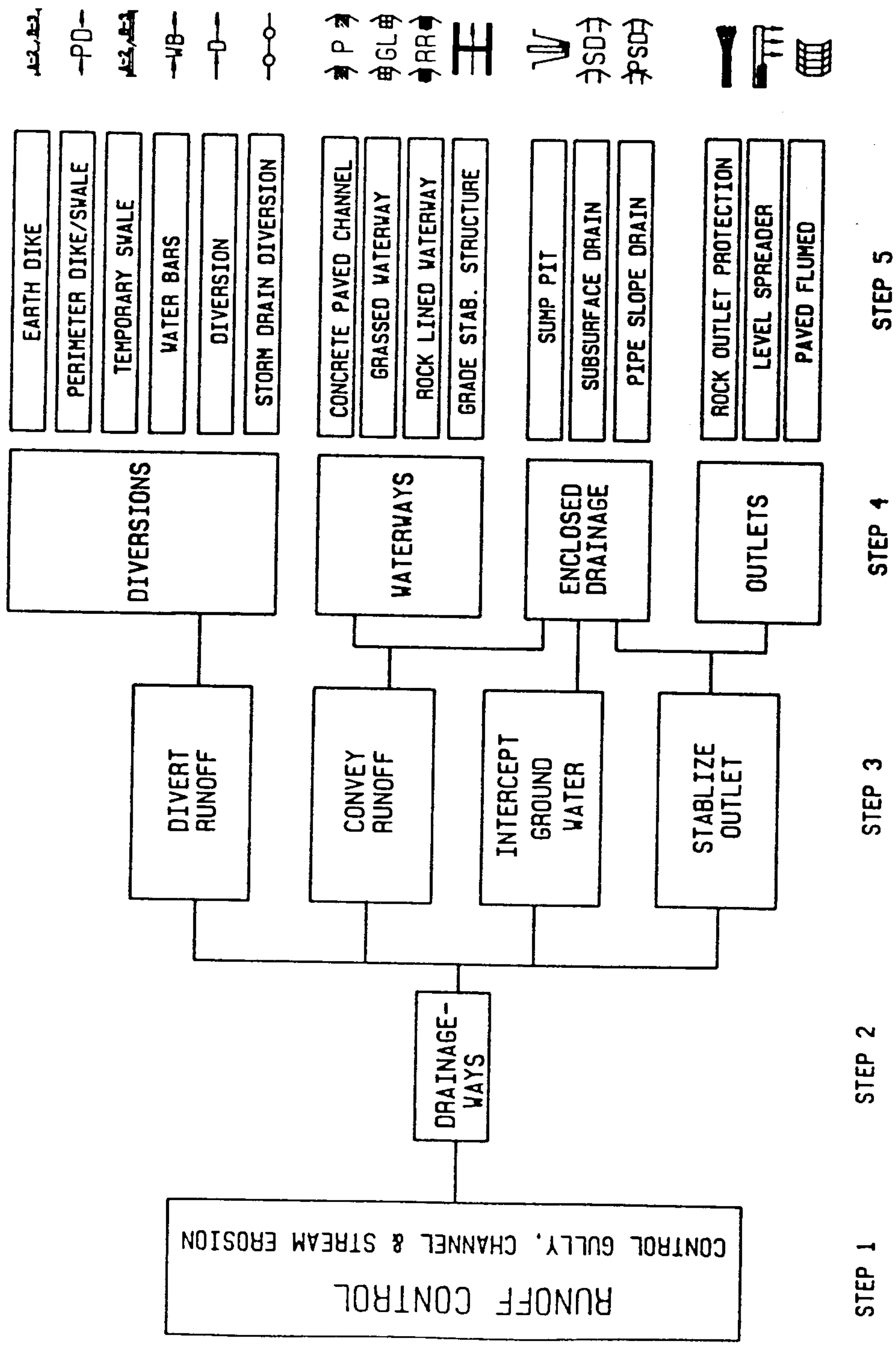

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Figure 2.2
Planning Flow Chart - Soil Stabilization

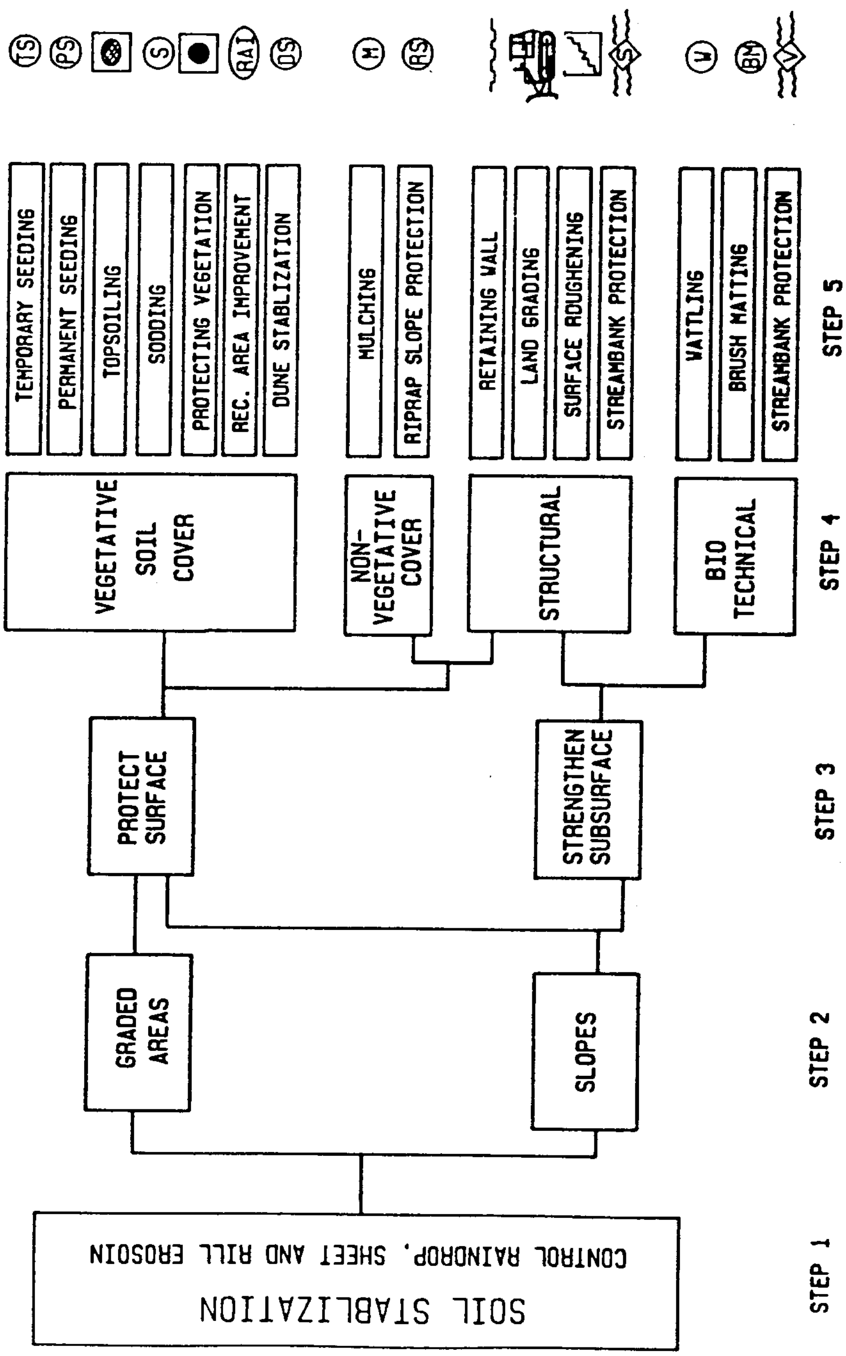

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Figure 2.3
Planning Flow Chart - Sediment Control

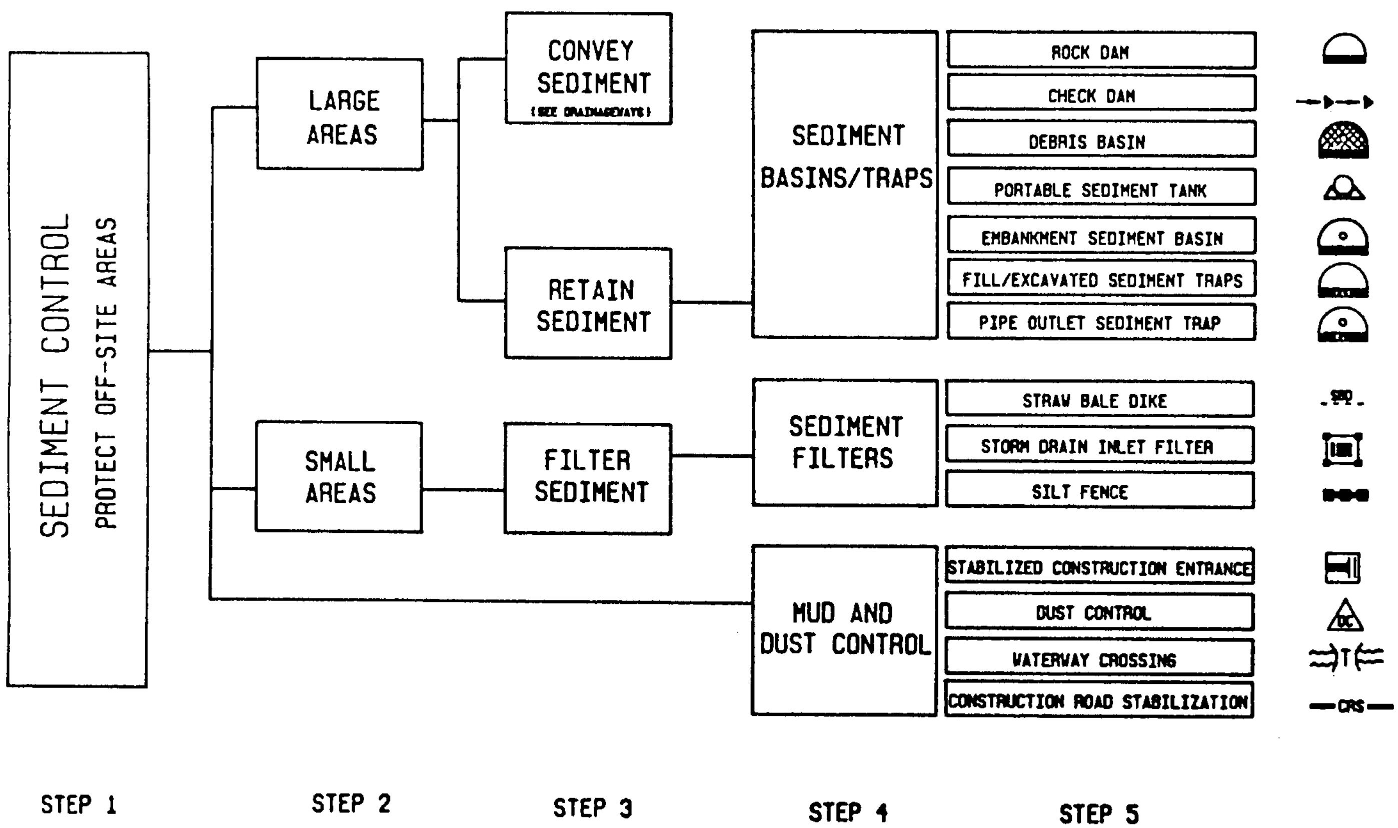

Table 2.1
Erosion and Sediment Control Matrix

Practice	Primary Purpose	Site Characteristics	Estimated Design Life	Associated Practices
Brush Matting	Stabilize soil; prevent erosion	Streambank slopes	5-10 years	Rock slope protection, structural streambank protection, subsurface drain
Check Dam	Control sediment/ runoff	Drainage area ≤ 2 Ac.	1 year	Lined waterway, rock outlet protection
Construction Road Stabilization	Control sediment	All construction routes	2 years	Dust control, temporary swales, temporary or permanent seeding.
Debris Basin	Capture sediment	Maximum drainage area = 200 acres	Up to 25 years	Sediment basin
Diversion	Intercept and divert runoff	Minimum 10 yr. Design Q	10-25 years	Permanent seeding, rock outlet protection, level spreader, sediment basin
Dune Stabilization	Stabilize sand dunes	Sand dune reinforcement	5-10 years	--
Dust Control	Stabilize soil	Access points, construction roads	Site specific	Stabilized construction entrance, contruction road stabilization
Earth Dike	Control runoff	DA ≤10 Acres	1 year	Sediment trap, rock outlet protection, storm drain inlet
Grade Stabilization Structure	Prevent erosion	Minimum Design Q = 10 yr.; 24 hr.	10+ years	Permanent seeding, rock slope protection, structural streambank protection
Grassed Waterway	Convey runoff	Minimum 10 yr. Design Q	Min. 10 years	Rock outlet protection, vegetated waterways, sediment basin, level spreader
Land Grading	Stabilize soil	Site specific shaping	Permanent	Topsoiling, subsurface drain, seeding
Level Spreader	Discharge runoff	10 year Q; ≤30 cfs; outlet <10%	1 year	Diversion, grassed waterway, temporary swales
Lined Waterway, (rock materials)	Convey runoff	Minimum design Q = 10 yr. 24 hr.	Min. 10 years	Rock outlet protection, subsurface drain

Table 2.1 (cont'd)
Erosion and Sediment Control Matrix

Practice	Primary Purpose	Site Characteristics	Estimated Design Life	Associated Practices
Mulching	Stabilize soil	Site specific	1-2 years	Permanent seeding, Recreation area improvement
Paved Channel, (concrete)	Convey runoff	Minimum design Q = 10 yr. 24 hr.	Min. 10 years	Rock outlet protection, subsurface drain
Paved Flume	Convey runoff	Minimum design Q = 10 yr. 24 hr.	10 years	Rock outlet protection
Perimeter Dike/Swale	Divert runoff	Drainage area ≤5 Ac.	1 year	Sediment trap, level spreader, temporary seeding
Pipe Slope Drain	Convey runoff downslope	Drainage area ≤5 Ac.	1 year	Rock outlet protection
Portable Sediment Tank	Retain sediment	16 times pump discharge	2 years	Sediment trap, sediment basin
Protecting Vegetation	Preserve existing vegetation	Site specific	1-10 years	Recreation area improvement
Recreation Area Improvement	Protect areas/soils	Site specific	Permanent	Permanent seeding, mulching, topsoiling
Retaining Wall	Stabilize soil	Site specific constraints	10+ years	Rock slope protection, permanent seeding, subsurface drain
Riprap Slope Protection	Stabilize soil, Prevent erosion	Max. 1:5 to 1 slope	10 years	Lined waterway, rock outlet stabilization, structural streambank protection
Rock Dam	Capture sediment	Drainage Area ≤50 Ac.	3 years	Debris basin, sediment basin
Rock Outlet Protection	Prevent erosion	Rock varies with pipe discharge	10+ years	Diversion, grassed waterway, sediment basin, sediment traps
Sediment Basin	Capture sediment	Drainage Area ≤100 Ac.	3 years	Rock outlet protection, temporary seeding
Sediment Traps				
I. Pipe Outlet	Trap Sediment	Drainage Area ≤5 Ac.	2 years	Sediment basin, debris basin
II. Grass Outlet	Trap Sediment	Drainage area ≤5 Ac.	1 year	Rock outlet protection

Table 2.1 (cont'd)
Erosion and Sediment Control Matrix

Practice	Primary Purpose	Site Characteristics	Estimated Design Life	Associated Practices
III. Storm Inlet	Trap Sediment	Drainage area ≤3 Ac.	1 year	Rock outlet protection
IV. Swale	Trap Sediment	Drainage area ≤2 Ac.	1 year	Rock outlet protection
V. Stone Outlet	Trap Sediment	Drainage area ≤5 Ac.	2 years	Rock outlet protection
VI. Riprap Outlet	Trap Sediment	Drainage area ≤15 Ac.	2 years	Rock outlet protection
Seeding, Temporary	Stabilize soil	Site specific	1-2 years	Surface roughening, topsoiling, sodding
Seeding, Permanent	Stabilize soil	Site specific	Permanent	Surface roughening, topsoiling, sodding
Silt Fence	Control sediment	2:1 slopes maximum 50 ft. spacing	1 year	Strawbale dike
Sodding	Stabilize soil	Need quick cover, aesthetics	Permanent	Inlet protection, topsoiling, permanent seeding
Stabilized Construction Entrance	Control sediment	Access points	2 years	Filter fence, construction road stabilization
Storm Drain Inlet Protection				
I. Excavated	Trap Sediment	Drainage area ≤1 Ac.	1 year	Sediment traps, storm drain diversion
II. Filter Fabric	Trap Sediment	Drainage area ≤1 Ac.	6 months	Sediment traps, storm drain diversion
III. Stone and Block	Trap Sediment	Drainage area ≤1 Ac.	6 months	Sediment traps, storm drain diversion
IV. Sod	Trap Sediment	Drainage area ≤2 Ac.	5-10 years	Sediment traps, storm drain diversion
V. Curb	Trap Sediment	Drainage area ≤1 Ac.	6 months	Sediment traps, storm drain diversion
Straw Bale Dike	Control sediment	2:1 slopes maximum 25 ft. spacing	3 months	Silt fence

Table 2.1 (cont'd) Erosion and Sediment Control Matrix

Practice	Primary Purpose	Site Characteristics	Estimated Design Life	Associated Practices
Streambank Protection				
I. Structural	Prevent erosion	Minimum 10 yr. design Q; velocity >6 fps	10 years	Rock slope protection
II. Vegetative	Prevent erosion	Minimum 10 yr. design Q; velocity <6 fps	10 years	Structural streambank protection
Subsurface Drain	Intercept and convey drainage water	Drainage Coefficient - 1"	10 years	Rock outlet protection, land grading retaining wall
Sump Pit	Control sediment	Site specific	6 months	Sediment trap, sediment basin
Surface Roughening	Stabilize soil	Construction slopes	Permanent	Temporary seeding, perm. seeding, mulching
Temporary Access Waterway Crossings				
Temporary Access Bridge	Prevent sediment	8 ft. centerline piers	2 years	Rock slope protection
Temporary Access Culvert	Prevent sediment	Minimum 12 in.; 40 ft. length	2 years	Structural streambank protection
Temporary Access Road	Prevent sediment	Streambanks <4 ft.	1 year	Structural streambank protection
Temporary Storm Drain Diversion	Divert runoff	On site drainage area >50% total	1 year	Sediment trap/basin
Temporary Swale	Divert runoff	Drainage area ≤10 acres	1 year	Sediment traps, storm drain inlets, sediment basin, level spreader
Topsoiling	Provide growing conditions	Poor site soil characteristics	Permanent	Surface roughening, temporary seeding, permanent seeding
Vegetating Waterways	Stabilize soil	Site specific	Permanent	Grassed waterways, permanent seeding
Water Bars	Divert runoff	Slope areas <100 ft. width	2 years	Rock outlet protection, level spreader

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Table 2.1 (cont'd)
Erosion and Sediment Control Matrix

Practice	Primary Purpose	Site Characteristics	Estimated Design Life	Associated Practices
Wattling	Stabilize soil	Maximum 1.5:1 slopes	10 years	Diversion, subsurface drain, temporary swale

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References

1. Northeastern Illinois Soil and Sedimentation Control Steering Committee. October 1981. Procedures and Standards for Urban Soil Erosion and Sediment Control in Illinois.

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SECTION 3
VEGETATIVE MEASURES
FOR EROSION AND SEDIMENT CONTROL

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VEGETATIVE MEASURES FOR EROSION AND SEDIMENT CONTROL, RECREATION, AND AESTHETICS IN URBAN AREAS

There are several basic principles that apply to establishing vegetation for any use.

1. Slopes should be stable. If they are too steep, continual sloughing will not allow a good stand to become established.
2. Excess surface and underground water must be controlled.
3. Whenever possible, stockpile and reapply topsoil to the areas that are to be vegetated.
4. Retain and protect trees, shrubs, and other natural plants wherever possible.
5. Select species of plants that are adapted to the site and for the intended use of the area. When clovers or trefoil are selected, inoculate seed at the time of planting with appropriate inoculum. The inoculum is a bacteria which lives on roots and converts nitrogen for plant use.
6. Prepare an adequate seed bed.
7. Apply needed lime and fertilizer.
8. Following seeding, firm soil where possible to get good soil seed contact.
9. Mulch to protect germinating plants from drying out and to prevent erosion.
10. Protect seeding for one year to allow development of a dense sod.
11. Use sod, rocks, netting, etc., in concentrated water flow areas.
12. Seed bare soil within 15 days of exposure, unless construction will begin within 30 days. If construction is suspended, or sections completed, areas should be seeded down or mulched immediately.

In the following section the Standard and Specifications for Critical Area Planting on page 3.3 should be followed to stabilize all bare soils except for: (1) waterways, (2) sand and gravel pits, (3) sand dunes and tidal banks, and (4) areas that will be closely mowed such as lawns, athletic fields, playgrounds, parks, and other recreation areas. For situations 1, 2, and 3, use the subject specification. For situation 4, refer to the Standard and Specifications for Recreation Area Improvement on page 3.5.

Tree and shrub planting generally does little for erosion control unless densely planted at which time the leaves and branches break the impact of rain drops. Overland flow of water under trees and shrubs can still cause erosion, therefore, grasses and/or legumes should be planted in conjunction with trees and shrubs.

Trees and shrubs are generally planted in urban areas for aesthetics, shade, noise reduction, screening, windbreaks and/or wildlife food and cover. "Trees Suitable for Landscape and Conservation Plantings in New York State", Table 3.3 in Standard and Specifications for Recreation Area Improvement on page 3.14 will be helpful in selecting species to do the intended job.

Directions for planting trees and shrubs are also contained in the Standard and Specifications for Recreation Area Improvement on page 3.5.

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STANDARD AND SPECIFICATIONS FOR CRITICAL AREA SEEDINGS

Definition

Establishing grasses and/or legumes on critical areas. A critical area is any disturbed, denuded area.

Purpose

To reduce erosion and sedimentation. All bare areas of soil contribute to degradation of the local environment by contributing silt or dust. Vegetating bare areas, accompanied with an appropriate water management plan, will resolve pollution problems.

Conditions Where Practice Applies

This practice applies to all disturbed areas void of vegetation except where specific seeding/planting recommendations exist in other standards and specifications for specific uses such as recreation. This practice does not apply to sand dunes (see Standard and Specifiction for Vegetating Sand Dunes and Tidal Banks on page 3.41), or to sand and gravel pits which will not have topsoil replaced (see Standard and Specification for Vegetative Stabilization of Sand and Gravel Pits on page 3.37).

Criteria

1. Surface and subsurface water control practices may be required.

2. Planned use of the area must be considered when selecting an appropriate seed mix.

3. Site preparation will include:

   A. Seedbed preparation - scarify if compacted. Remove debris and obstacles such as rocks and stumps.

   B. Soil Amendments

      1) Lime to pH of 6.0.

      2) Fertilize with 600 lbs. of 5-10-10 or equivalent per acre (14 lbs./1000 sq. ft.).

   C. Seed Mixtures

      1) Temporary Seedings

         a. Ryegrass (annual or perennial) @ 30 lbs. per acre (0.7 lbs./1000 sq. ft.).

         b. Certified 'Aroostook' winter rye (cereal rye) @ 100 lbs. per acre (2.5 lbs./1000 sq. ft.).

      Use winter rye if seeding in October/November.

      2) Permanent Seedings

         a. Rough or occasionally mowed areas:

	lbs/acre	lbs/1000sq.ft
Empire birdsfoot trefoil[1] **OR**	8	0.20
Common white clover[1]	8	0.20
PLUS		
Tall fescue	20	0.45
PLUS		
Redtop **OR**	2	0.05
Ryegrass (perennial)	5	0.10

[1] add inoculant immediately prior to seeding.

         b. Frequently mowed areas: Refer to Standard and Specification for Recreation Area Improvement on page 3.5.

   D. Time of Seeding

   The optimum time for permanent seedings with legumes (birdsfoot trefoil or clover) is early spring.

   Permanent seedings may be made any time of year if properly mulched and adequate moisture is provided. Mid summer is not a good time to seed, but these seedings, if construction is complete, will facilitate covering the land. Portions may fail and may need reseeding the following year.

   Temporary seedings should be made within 24 hours of construction or disturbance. If not, the soil must be scarified prior to seeding.

   E. Method of Seeding

   Broadcasting, drilling with cultipack type seeder or hydroseeding are acceptable. Good soil to seed contact is the key to successful seedings.

   F. Mulching and Mulch Anchoring

   Mulching is essential to obtain a uniform stand of plants. See Standard and Specifications for Mulching on page 3.31.

G. Irrigation

Watering may be essential to establish a new seeding. Weather conditions and the intended use of the area will dictate when to water. Irrigation is a specialized practice and care needs to be taken not to exceed the application rate/infiltration rate of any given soil. Each application must be uniformly applied and 1 to 2 inches of water should be applied per application set up.

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STANDARD AND SPECIFICATIONS FOR RECREATION AREA IMPROVEMENT

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Definition

Establishing grasses, legumes, vines, shrubs, trees, or other plants or selectively reducing stand density and trimming woody plants to improve an area for recreation.

Purpose

To increase the attractiveness and usefulness of recreation areas and to protect the soil and plant resources.

Conditions Where Practice Applies

On any area planned for recreation use, lawns and areas that will be maintained in a closely mowed condition.

Specifications

ESTABLISHING GRASSES (Turfgrass)

The following applies for playgrounds, parks, athletic fields, camping areas, picnic areas, passive recreation areas such as lawns and similar areas.

1. Time of Planting

   Fall planting is preferred. Seed after August 15. In the spring plant until May 15.

   If seeding is done between May 15 and August 15, irrigation may be necessary to insure a successful seeding.

2. Site Preparation

   A. Install needed water and erosion control measures and bring area to be seeded to desired grades. A minimum of 4 in. topsoil is required.

   B. See Standard and Specification of Topsoiling on page 3.29

   C. Prepare seedbed loosening soil to a depth of 4 - 6 inches.

   D. Remove all stones over 1 inch in diameter, sticks and foreign matter from the surface.

   E. Lime to pH of 6.5.

   F. Fertilize as per soil test or apply 850 pounds of 5-10-10 or equivalent per acre (20 lbs/1,000 sq. ft.).

   G. Incorporate lime and fertilizer in top 2 - 4 inches of topsoil.

   H. Smooth and firm the seedbed.

3. Planting

   Use a cultipacker type seeder if possible. Seed to a depth of 1/8 to 1/4 inch. If seed is to be broadcast, cultipack or roll after seeding. If hydroseeded, lime and fertilizer may be applied through the seeder and rolling is not practical.

4. Mulching

   Mulch all seedings in accordance with Standard and Specifications for Mulching on page 3.31.

5. Seed Mixtures

   Select seed mixture for site conditions and intended use from Table 3.1 on page 3.9.

6. Select Adapted Varieties

   Select varieties from Table 3.2 on page 3.10, "Characteristics of Turfgrasses," based on intended use and site conditions.

   When Kentucky bluegrass is used it is desirable to use two or more varieties in the seeding for disease resistance.

   Tall fescue is a coarse grass but is the most resistant grass to foot traffic. Do not mix it with fine textured grasses such as bluegrass and red fescue.

   Common ryegrass and redtop which are relatively short lived species provide quick green cover. Improved lawn cultivars of perennial ryegrass provide excellent quality turf.

   Common white clover (Kent or New York) can be added to mixtures at the rate of 1 - 2 lbs/acre to help maintain green color during the dry summer period, however, they will not withstand heavy traffic. Avoid using around swimming areas as flowers attract bees which may be stepped on.

7. Fertilizing - First Year

   Three to four weeks after germination (spring seedings) apply 1 pound nitrogen/1,000 square feet using a complete fertilizer with a 2-1-1 or 4-1-3 ratio or as recommended by soil test results. Summer and early fall seedings, apply as above unless air temperatures are above 85° F for extended period. Wait until heat wave is over to fertilize. Late fall/winter seedings, fertilize in spring.

8. Restrict Use

New seedings should be protected from use for one full year to allow development of a dense sod with good root structure.

MAINTAINING GRASSES

1. Maintain a pH of 6.0 - 7.0.

2. Fertilize in late May to early June as follows with 10-10-10 analysis fertilizer at the rate of 10 lbs./1,000 sq. ft. and repeat in late August if sod density is not adequate. Top dress weak sod annually in the spring but at least once every 2 to 3 years.

3. Aerate compacted or heavily used areas, like athletic fields, annually as soon as soil moisture conditions permit. Aerate area six to eight times using a spoon or hollow tine type aeration. Do not use solid spike equipment.

4. Reseed bare and thin areas annually with original species.

ESTABLISHING TREES, SHRUBS, AND VINES

1. Planting nursery stock

A. Select species to serve the intended purpose. See Table 3.3 "Trees Suitable for Landscape and Conservation Plantings in New York" on page 3.14 Where planting of trees is to be done in recreation areas, use those species listed in Table 3.4, "Susceptibility of Tree Species to Compaction" on page 3.21 whenever possible. If the soil on the site is naturally well drained, those species in the "intermediate" group may be used. In no case should species having "susceptible" rating be planted or exposed to compaction unless the soil is clearly "compaction resistant." An example is the Palmyra gravelly soil.

B. Plant materials

1) Plants shall conform to the species, variety, size, number, and conditions as stated in a conservation plan or on a plant list shown on landscape drawings. "American Standard for Nursery Stock" by American Association of Nurserymen will be used to develop the plant list for landscape drawings and to check quality of plant materials.

2) Durable, legible labels with the scientific and common name and cultivar shall be securely attached to plants, bundles of seedlings, containers or flats.

C. Plant Protection

Prior to delivery, the trunk, branches, and foliage of the plants shall be sprayed with non-toxic antidesicant applied according to the manufacturers recommendations. Does not apply to state nursery seedlings.

D. Planting Time

Deciduous trees and shrubs: April 1 to June 1 and October 15 to December 15.

Evergreen trees and shrubs: April 1 to June 1 and September 1 to November 15

E. Spacing

Plant all trees and shrubs well back from buildings to allow for planting pits and mature crown size. The following are guides for planning:

Large trees:	50 - 60 feet apart
Small trees:	20 - 30 feet apart
Columnar species:	6 - 8 feet apart
Hedges:	1 - 4 feet apart
Shrubs:	for clumps, plan spacing so mature shrubs will be touching or overlapping by only 1 or 2 feet.

F. Site Preparation

1) Individual sites for planting seedlings can be prepared by scalping the sod away from a one foot square area where the seedling is to be planted.

2) All planting beds shall be cultivated to a depth of 8 inches and raked to remove sod clumps, weeds, stones, and other foreign material exceeding two inches in diameter.

G. Planting

1) Plants shall be located as shown on plans and/or drawings and where necessary located on the site by stakes, flags or other means.

2) The plants shall be set upright in holes as illustrated in Fig. 3.1 on page 3.7.

3) All plants shall be thoroughly watered on the same day of planting. Plants that have settled shall be reset to grade.

H. Wrapping

Immediately after planting wrap deciduous tree trunks from the bottom to the first limb with a 4 inch wide bituminous impregnated, insect resistant tape or paper manufactured for that purpose. Tie with jute (bag strings) at top and bottom.

I. Mulching

Mulch the disturbed area around individual trees and shrubs with a 4 inch layer of wood chips. Extend a 2 inch thick layer of mulch over tne saucer. Mulch planting beds with 2 inches of wood chips.

J. Pruning

After planting, prune to remove injured twigs and branches. Natural habit or shape of the plant should not be changed.

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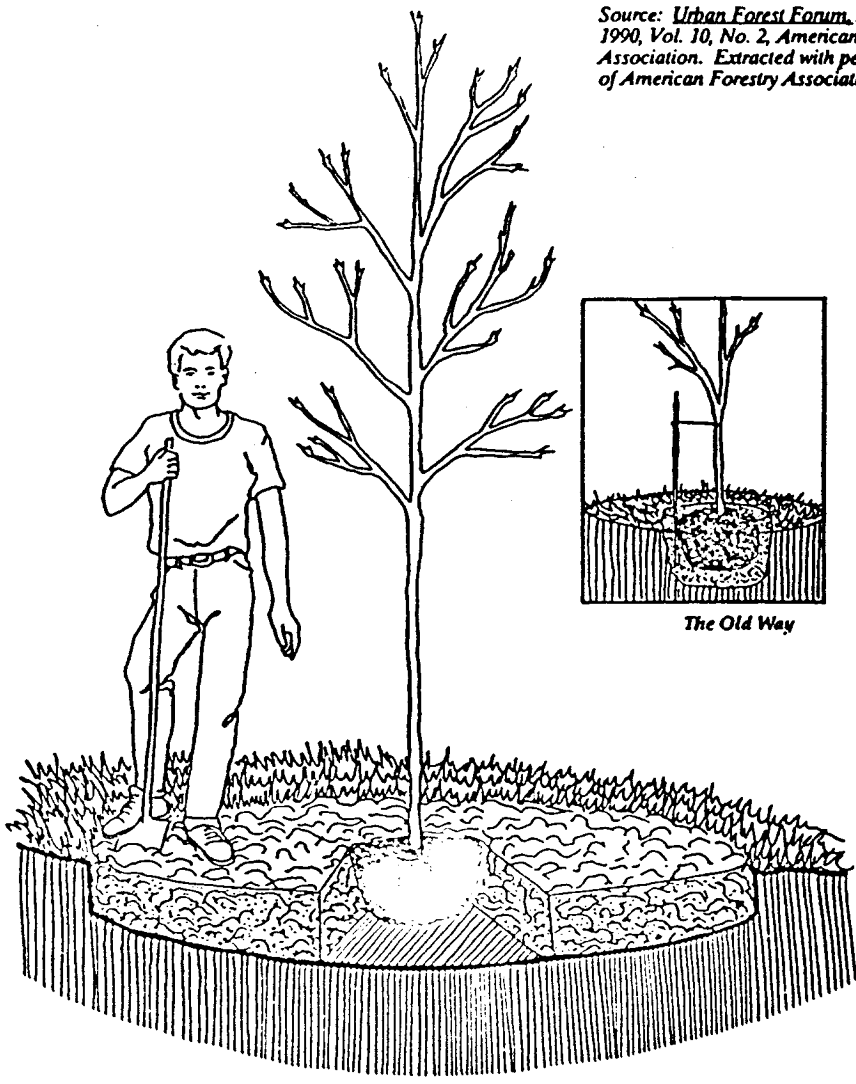
FIGURE 3.1
New Tree Planting Procedure

Figure 2: New Tree Planting Procedure

Source: Urban Forest Forum, April/May 1990, Vol. 10, No. 2, American Forestry Association. Extracted with permission of American Forestry Association.



The Old Way

The new method of tree planting will result in better survival and growth than the old method. Grass competition and soil compaction are two of the most common factors in poor performance. The New Method: Prepare a planting area five times the diameter of the root ball or container. Use a rototiller and/or spades to loosen and mix the soil to a depth of about 12 inches. Organic matter (well decomposed) can be added. Dig a hole in the center to set the tree, so that the root ball will rest on solid ground. Backfill around the root area, pressing the soil but not packing it. Mulch the entire prepared area with 2 to 4 inches of bark, wood chips, decomposed sawdust, or leaves. Reference the article for a full explanation.

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K. Cleanup and Maintenance

1) After all work is complete all excess soils, peat moss, debris, etc., shall be removed from the site.

2) Water plants two weeks after planting. For two years water plants every two weeks during dry periods which exceed three weeks without a good soaking rain. Shrubs may require 5 to 10 gallons and trees 20 to 30 gallons for each watering.

3) Remove trunk wrap one year after planting.

2. Transplanting "Wild" Stock

Successful transplanting of wild stock will require heavy equipment and considerable labor as a large weight of soil must be moved with the roots.

A. Select trees and shrubs with good form and full crowns.

B. Transplant only when plants are dormant and soil is moist. Wrap soil ball with burlap to prevent soil from separating from roots.

C. Table 3.5 on page 3.21 shows minimum diameter and approximate weight of soil ball that must be moved with each size plant.

D. Plant and maintain as described above for nursery stock.

PRUNING AND THINNING

1. Pruning

A. Remove trees, limbs and limb stubs to the following widths and heights for the intended use.

Use	Cleared Width Each Side of Trail Tread (feet)	Cleared Height (feet)
TRAILS		
Hiking	1	8
Bicycle	2	10
Motorbike	2	10
Horse	2	12
X-Country Ski	Total: 3 - 12	12[1]
Snowmobile	Total: 6 - 12	12[1]
PICNIC & CAMPING AREAS		
Campfire/Grill	10 ft. dia.	15 + Locations

[1] Includes allowance for snow depth and snow load on branches.

B. Remove dead, diseased or dying limbs that may fall.

C. Do not remove more than one-third of the live crown of a tree in a year.

D. Cut limbs flush to the branch bark ridge.

E. Use the three cut pruning method on all branches over 2 inches in diameter: (1) under cut limb 6 - 12 in. from trunk; (2) cut through limb 1 - 2 in. further out limb: and (3) final cut down and slightly out from in front of branch bark ridge.

2. Thinning

A. Remove dead, diseased, dying, poorly anchored trees that pose a hazard to recreationists as well as those trees that interfere with intended use.

B. Clear trees from an area 10 feet in diameter around all fireplaces and grills.

C. To maintain grass cover in a wooded area thin according to formula Dx3 (average diameter of the trunk of overstory trees times three. Answer is in feet which is the spacing between trees to be left). For example, for trees with average diameter of 6 inches, spacing after thinning should leave trees 18 feet apart on average. Crown cover after thinning should be about 50 percent.

D. Selectively thin as needed to favor those trees that are most "resistant" to compaction around their roots. See Table 3.4, "Susceptibility of Tree Species to Compaction" on page 3.21. If the soil on the site is naturally well drained, those species in the "intermediate" group may also be favored. In no case should species in the "susceptible" group be favored unless they are on a compaction resistant soil (an example is the Palmyra gravelly soil).

PROTECTING TREES IN HEAVY COMPACTION AREAS

The compaction of soil over the roots of trees and shrubs by the trampling of recreationists, vehicular traffic, etc., reduces oxygen, water, and nutrient uptake by feeder roots. This weakens and may eventually kill the plants. Table 3.4, rates the "Susceptibility of Tree Species to Compaction" on page 3.21.

Where heavy compaction is anticipated, apply and maintain a 3 to 4 inch layer of undecayed wood chips or 2 inches of No. 2 washed, crushed gravel.

Table 3.1 Recreation Turfgrass Seed Mixtures

Site - Use	species (% by weight)	lbs/1,000 sq. ft.	lbs./acre
1. Sunny Sites (well, moderately well and somewhat poorly drained soils)			
a. Athletic fields and similar areas			
	80% Kentucky bluegrass blend	2.4-3.2	105-138
	20% perennial ryegrass	0.6-0.8	25-37
		3.0-4.0	130-175
	(for southern NY)		
	50% Kentucky bluegrass	1.5-2.0	65-88
	50% perennial ryegrass	1.5-2.0	65-87
		3.0-4.0	130-175
	100 % Tall fescue	3.4-4.6	150-200
b. General recreation areas and lawns (Medium to high maintenance)			
	65% Kentucky bluegrass blend	2.0-2.6	85-114
	20% perennial ryegrass	0.6-0.8	26-35
	15% fine fescue	0.4-0.6	19-26
		3.0-4.0	130-175
2. Sunny droughty sites - general recreation areas and lawns, low maintenance (somewhat excessively to excessively drained soils). Excluding Long Island.			
	65% fine fescue	2.6-3.3	114-143
	15% perennial ryegrass	0.6-0.7	26-33
	20% Kentucky bluegrass blend	0.8-1.0	35-44
		4.0-5.0	175-220
3. Shady dry sites (well to somewhat poorly drained soils).			
	65% fine fescue	2.6-3.3	114-143
	15% perennial ryegrass	0.6-0.7	26-33
	20% Kentucky bluegrass blend	0.8-1.0	35-44
		4.0-5.0	174-220
	80% blend of shade-tolerant Kentucky bluegrass	2.4-3.2	105-138
	20% perennial ryegrass	0.6-0.8	25-37
		3.0-4.0	130-175
4. Shady wet sites (somewhat poor to poorly drained soils).			
	70% rough bluegrass	1.4-2.1	60-91
	30% blend of shade-tolerant Kentucky bluegrass	0.6-0.9	25-39
		2.0-3.0	85-130

Table 3.2
Characteristics of Turfgrasses

Kentucky Bluegrass Varieties[1]

Variety	Description: Color	Description: Texture	Description: Density	Description: Growth Habit	Adaptation: Low Temp. Color	Adaptation: Spring Green Up	Adaptation: Cold Toler.	Adaptation: Heat Toler.	Adaptation: Drought Toler.	Adaptation: Shade Toler.	Adaptation: Estab. Rate	Adaptation: Close Mowing Toler.	Adaptation: Low Fertility
Adelphi	VD	M	H	L	Mo	G	G	G	G	P	G	Mo	G
America	D	F	H	VL	Mo	Mo	G	M	M	Mo	--	--	Mo
Aquila	MD	MF	H	ML	Mo	Mo	G	--	--	--	--	--	G
Baron	D	MC	H	L	Mo	Mo	G	--	--	P	R	--	P
Birka	D	MF	H	L	G	G	G	--	--	P	--	Mo	G
Bonnieblue	D	M	H	L	E	G	G	--	--	P	G	Mo	E
Bristol*	D	M	H	L	G	G	G	--	--	E	--	Mo	G
Cheri	D	M	H	L	Mo	G	G	--	--	P	R	--	G
Columbia	MD	M	M	L	G	G	G	G	--	Mo	G	Mo	G
Eclipse	D	M	G	L	Mo	Mo	E	G	G	G	G	G	Mo
Enmundi	D	M	G	VL	Mo	E	G	G	G	--	--	G	G
Flyking	D	MF	H	L	G	G	G	--	G	P	G	G	E
Glade*	D	M	H	L	Mo	G	G	--	--	G	G	--	G
Majestic	D	M	H	SP	Mo	G	G	--	--	P	G	Mo	E
Merion	D	MC	H	L	Mo	G	G	--	G	P	S	M	P
Mystic	MD	F	H	L	G	G	G	--	--	--	--	G	--
Parade	MD	M	MH	L	Mo	G	G	--	--	P	G	--	P
Plush	M	M	MH	L	G	G	G	--	--	P	G	Mo	G
Ram	D	MF	H	L	Mo	E	G	--	--	--	--	G	E
Rugby	D	M	H	L	Mo	Mo	G	M	M	P	R	E	G
Sydsport	MD	M	H	L	Mo	E	G	--	--	P	G	--	G
Touchdown*	M	MF	N	ER	G	E	G	--	--	G	--	G	G
Vantage	M	MF	M	ER	G	G	G	E	E	P	--	--	G
Victa	D	MC	H	L	Mo	G	G	--	--	P	R	--	P

Source: Descriptions were adapted from Grounds Maintenance magazine (November 1979), by Dr. James B. Beard, turfgrass physiologist, Texas A&M, College Station, Texas. Adaptation features were rated under New York State conditions. Characteristics that were not evaluated under New York State conditions were left blank in the table.

Attention: Seed may not be available in all areas of the state.

[1] See key to abbreviations on page 3.13

Table 3.2 (cont'd)
Characteristics of Turfgrasses

Fescue Varieties[1]

Variety	Description: Color	Description: Texture	Description: Growth Habit	Adaptation: Low Temp. Color	Adaptation: Spring Green Up	Adaptation: Heat Toler.	Adaptation: Drought Toler.	Adaptation: Shade Toler.	Adaptation: Estab. Rate	Adaptation: Close Mowing Toler.	Adaptation: Recuperative Potential
Chewings Fescue											
Agram	MD	F	L	G	G	--	--	--	G	G	G
Checker	M	VF	L	G	G	G	G	--	M	--	M
Highlight	M	VF	--	--	--	--	P	--	--	G	--
Waldorf	M	F	LP	M	G	G	G	--	VG	VG	Mo
Jamestown	MD	F	L	--	--	--	--	--	--	G	--
Creeping Red Fescue											
Ensylva	MD	MF	ML	G	G	Mo	E	G	VG	G	G
Hard Fescue											
Reliant	MD	F	L	Mo	Mo	G	G	--	Mo	Mo	Mo
Scaldis	MD	F	L	M	G	--	--	VG	Mo	Mo	Mo
Tournament	D	F	L	M	M	G	G	--	Mo	Mo	Mo
Waldina	D	F	VL	Fa	G	--	--	VG	Fa	Fa	Fa
Meadow Fescue											
Beaumont	M	MC	SE-B	G	G	Fa	Fa	P	VG	--	--

[1] See key to abbreviations on page 3.13

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Table 3.2 (cont'd)
Characterististics of Turfgrasses

Tall Fescue Varieties[1]

	Description		Adaptation			
Variety	Color	Texture	Heat Tolerance	Drought Tolerance	Shade Tolerance	Close Mowing Tolerance
Adventure	MD	M	G	G	VG	I
Brookston	M	M	G	G	G	I
Clemfine	M	C	--	--	--	P
Falcon	M	M	G	--	Mo	P
Finelawn	M	M	G	G	G	I
Houndog	M	M	G	G	--	P
Jaguar	MD	M	G	G	G	I
Kentucky 31	--	C	--	--	--	--
Marathon	MD	M	G	G	Mo	P
Maverick	MD	M	G	G	G	I
Olympic	D	M	--	--	G	P
Rebel	MD	M	G	--	G	I

[1] See key to abbreviations on page 3.13

Table 3.2 (cont'd) Characteristics of Turfgrasses

Perennial Ryegrass Varieties

Variety	Description: Color	Description: Texture	Adaptation: Low Temp. Color	Spring Green Up	Cold Toler.	Heat Toler.	Drought Toler.	Estab. Rate	Close Mowing Toler.	Recuperative Potential
Allstar	MD	F	G	G	--	--	--	--	--	--
Belle	MD	MF	E	G	M	M	M	E	G	E
Blazer	MD	MF	E	VG	G	G	--	E	E	--
Citation	M	MF	G	G	I	G	G	E	G	VG
Dasher	MD	F	VG	VG	I	G	G	VG	G	--
Derby	MD	F	M	G	G	G	G	VG	G	--
Elka	M	VF	G	I	G	F	Mo	I	E	I
Manhattan	M	MF	VG	G	G	M	Mo	VG	G	--
Omega	M	F	M	G	M	G	G	VG	VG	--
Palmer	DG	MF	G	G	G	G	G	E	E	E
Pennant	MD	MF	E	E	MG	G	G	E	G	E
Pennfine	MD	MF	E	G	G	M	Mo	VG	G	--
Prelude	DG	MF	E	E	G	G	G	E	G	E
Premier	DG	MF	E	E	G	G	G	E	G	E
Regal	D	F	M	M	M	G	G	VG	I	--
Yorktown II	D	F	G	G	VG	G	G	E	G	--

Key

D - dark green
MD - medium dark
VD - very dark
F - fine
MF - medium fine
M - medium

C - coarse
MC - medium coarse
L - low
ML - moderately low
VL - very low
LP - low prostrate

SP - semiprostrate
SEB - semierect bunch
ER - erect
MH - moderately high
H - high
Mo - moderately

MP - moderately poor
P - poor
VP - very poor
Fa - fair
G - good
VG - very good

I - intermediate
E - excellent
S - slow
MS - moderately slow
R - rapid
V - very

* recommended for shady sites

Table 3.3
Trees Suitable for Landscape and Conservation Plantings In New York

TREE SIZE:

Large Sized Trees (75' +) - Trees that exceed this height at maturity.

Medium Sized Trees (35'- 75') - Trees in this height range at maturity.

Small Sized Trees (15'- 35') - Trees relatively low at maturity.

VAR; (x) = varieties of the species are available for various uses.

FOLIAGE:

E = evergreen

c = colorful in fall

l = lustrous; shiny

D = deciduous

d = dense

u = unusual leaves

f = fine textured

SITE TOLERANCE:

cold = hardy in zones 2 and 3 (northeastern mountains)

wet = tolerant of moderately well to somewhat poorly drained soils.

dry = tolerant of sandy, gravelly, excessively drained soils.

shade = will tolerate some shady sites.

sea = trees which may tolerate seaside conditions.

city = trees that withstand usual city conditions.

PEST:

F = usually free   S = susceptible

FEATURES:

Habit = general shape of open grown plants.

Bo - broad open (wide)

Co - columnar

FEATURES: (cont'd)

Ho - horizontal branching

Na - narrow

Op - open

Ov - ovoid/oblong

Pe - pendulous

Py - pyramidal

Ro - round

S - spreading

Up - upright

Wo - wide/open

BRK; (x) = bark has interesting characteristics of color, texture or form.

FLR; (x) = flowers are colorful and interesting.

f = fragrant;

s = showy;

u = unusual shape.

FRU; (x) = fruits are interesting and/or edible.

LVS; (x) = leaves have attractive color and/or unusual shape.

USES:

WIND; (x) = suitable for windbreaks and screening.

SHD; (x) = suitable as lawn shade trees.

STRT; (x) = trees often selected for street planting.

WILD; F/c = trees offering food and cover to wildlife.

F = trees providing food from fruits.

W/c = trees offering winter cover.

BARR; (x) = trees which can be used as a barrier to some traffic.

ORN; (x) = trees whose main value is ornamental.

A. LARGE SIZED TREES (75 ft.+)

1. DECIDUOUS SPECIES	HEIGHT	VAR	FOLIAGE	COLD (SITE TOLERANCE)	WET	DRY	SHADE	SEA	CITY	PEST	HABIT (FEATURES)	BRK	FLR	FRU	LVS	WIND (USES)	SHDE	STRT	WILD	BARR	ORN
BEECH, EUROPEAN Fagus sylvatica	90'	X	D,c,d,l								Py	X			X		X				
BIRCH, PAPER Betula papyrifera	90'		D,c	X							Py	X			X						X
BIRCH, RIVER Betula nigra	90'		D,c		X						Py	X			X						
CHERRY, BLACK Prunus serotina	90'	X	D,d,l	X				X			S	X	X	X					F		X
GINKGO Ginkgo biloba	120'		D,c,u						X	F	Wo				X		X	X			
GUM, BLACK TUPELO Nyssa sylvatica	90'		D,c,d,l		X			X			Py				X						X
HICKORY, PIGNUT Carya glabra	120'		D,c			X					Ro				X				F		X
HICKORY, SHAGBARK Carya ovata	120'	X	D,c								Na/Up	X			X				F		X
HONEYLOCUST Gleditsia spp.	135'	X	D,c,u			X			X	F	Bo						X	X			
JAPANESE ZELKOVA Zelkova serrata	90'		D,c	Substitute for American Elm							Ro				X		X				
KATSURA TREE Cercidiphyllum japonicum	60-100'		D,c,u							F	Ro				X		X				
LINDEN, LITTLE-LEAF Tilia cordata	90'	X	D,d	X					X		Py		X	X			X	X			
LONDON PLANE TREE X Platanus acerifolia	100'		D								S	X			X		X				
MAPLE, NORWAY Acer platanoides	90'	X	D,c	X							Ro		X		X	X	X				
MAPLE, RED Acer rubrum	120'	X	D,c	X	X						Ro	X	X		X	X	X				
MAPLE, SUGAR Acer saccharum	120'	X	D,c	X							Ov				X		X	X			
OAK, WHITE Quercus alba	90'		D,c								Ro/S				X		X		F		X
POPLAR, HYBRID X Populus	90'	X	D								varies					X	X				
POPLAR, WHITE Populus alba	90'	X	D,c,u	X		X		X			S		X		X						X
SWEET-GUM Liquidambar styraciflua	125'	X	D,c,u		X					F	Py				X		X	X			X

Table 3.3 (cont'd)
Trees Suitable for Landscape and Conservation Plantings in New York

A. LARGE SIZED TREES (75 ft.+)

2. EVERGREEN SPECIES	HEIGHT	VAR	FOLIAGE	SITE TOLERANCE: COLD	WET	DRY	SHADE	SEA	CITY	PEST	FEATURES: HABIT	BRK	FLR	FRU	LVS	USES: WIND	SHDE	STRT	WILD	BARR	ORN
CEDAR, EASTERN RED Juniperus virginiana	90'	X	E,d	X		X		X		F	Py	X		X		X			WC		
FIR, DOUGLAS Pseudotsuga menziesii	300'	X	E,d								Py			X		X			WC		X
FIR, WHITE Abies concolor	120'	X	E,c								Py				X	X			WC		
HEMLOCK, CANADA Tsuga canadensis	90'	X	E,d	X							Py					X			WC		X
LARCH, EUROPEAN Larix decidua	100'	X	D,c	X							Py			X							X
PINE, AUSTRIAN Pinus nigra	90'	X	E					X			Py					X			WC		X
PINE, EASTERN WHITE Pinus strobus	100-150'	X	E	X							Ro/Py					X			WC		X
PINE, JAPANESE BLACK Pinus thunbergii	90'		E					X			S								WC		X
SPRUCE, COLORADO Picea pungens	100'	X	E,c,d	X				X		S	Py				X	X			WC		X
SPRUCE, NORWAY Picea abies	150'	X	E,d	X							Py			X		X			WC		
SPRUCE, SERBIAN Picea omorika	90'		E,c,d								Py				X	X			WC		X
SPRUCE, WHITE Picea glauca	90'	X	E	X							Py				X	X			WC		X

Table 3.3 (cont'd)
Trees Suitable for Landscape and Conservation Plantings in New York

B. MEDIUM SIZED TREES (35'-75')

1. DECIDUOUS SPECIES	HEIGHT	VAR	FOLIAGE	COLD	WET	DRY	SHADE	SEA	CITY	PEST	HABIT	BRK	FLR	FRU	LVS	WIND	SHDE	STRT	WILD	BARR	ORN
				SITE TOLERANCE							FEATURES					USES					
ALDER, EUROPEAN Alnus glutinosa	75'		D	X	X						Ov					X					
ALDERS Alnus spp.	60'-75'	X	D,d	X	X					S	Ro			X		X					
ASH, FLOWERING Fraxinus ornus	60'		D,d								Ro		X,f					X			X
ASH, GREEN Fraxinus pennsylvanica	60'	X	D,c,d	X							Ro				X		X	X			
BIRCH, SWEET Betula lenta	75'		D,c	X							Py	X			X		X				X
CHERRY, EUROPEAN BIRD Prunus padus	45'	X	D,u	X							Op		X,f	X					F		
CHERRY, PIN Prunus pensylvanica	36'		D,c,f	X		X	X				Op	X	X	X	X				F		X
CHERRY, SARGENT Prunus sargentii	75'	X	D,c,d								Up	X	X				X	X	F		X
CHESTNUT, CHINESE Castanea mollissima	60'		D,c,d,l								Ro				X				F		
CHOKECHERRY, AMUR Prunus maackii	45'		D,d	X							Ro	X	X						F		X
CRAB APPLE, SIBERIAN Malus baccata	50'	X	D,d	X						S	Ma		X,f	X					F		X
CRIMEAN LINDEN X Tilia euchlora	60'	X	D,d,l								Pe		X,f				X	X			
DOGWOOD, FLOWERING Cornus florida	40'	X	D,c,d,l							F	Mo	X	X,u	X	X			X			X
ELM, SIBERIAN Ulmus pumila	75'	X	D,f			X					Ro/OpF					X					
HAWTHORN, COCKSPUR Crataegus crus-galli	36'	X	D,d,l			X				S	Ro/S		X	X	X				F	X	X
HOLLY, AMERICAN Ilex opaca	45'	X	E,d,u					X		F	Py			X	X				WC		X
HORNBEAM, AMERICAN Carpinus caroliniana	36'	X	D,c,d	X						F	Ro	X		X	X		X	X	F		
HORNBEAM, EUROPEAN Carpinus betulus	60'	X	D,d								Py				X			X		X	
HORNBEAM, HOP Ostrya virginiana	60'		D,d							F	Py			X	X				F	X	X

Table 3.3 (cont'd) Trees Suitable for Landscape and Conservation Plantings in New York

B. MEDIUM SIZED TREES (35'-75')

1. DECIDUOUS SPECIES	HEIGHT	VAR	FOLIAGE	SITE TOLERANCE: COLD	WET	DRY	SHADE	SEA	CITY	PEST	FEATURES: HABIT	BRK	FLR	FRU	LVS	USES: WIND	SHDE	STRT	WILD	BARR	ORN
JAPANESE PAGODA TREE Sophora japonica	75'	X	D			X				F	Ro	X	X				X	X			X
LOCUST, BLACK Robinia pseudoacacia	75'	X	D	X		X					Ov		X								
MAPLE, STRIPED Acer pensylranicum	36'	X	D,u	X			X				Op	X			X						X
MOUNTAIN-ASH, EUROPEAN Sorbus aucuparia	45'	X	D							S	S		X	X	X				F		X
MOUNTAIN-ASH, KOREAN Sorbus alnifolia	60'	X	D,d								Py/Ro	X	X	X	X						X
MULBERRY, WHITE Morus alba	45'	X	D,d,u			X		X			Ro			X	X				F		
OAK, RED Quercus borealis	75'		D,d,l	X					X		Ro			X	X		X	X	F		
OAK, SWAMP WHITE Quercus bicolor	60'		D,d	X	X						Na/Ro				X		X		F		
OAK, WILLOW Quercus phellos	50'		D,f								Ro							X			X
POPLAR, SIMON Populus simonii	50'	X	D,d	X							Na					X					X
REDBUD, EASTERN Cercis canadensis	36'	X	D,c,u								Wo		X		X						X
SASSAFRAS Sassafras albidum	60'		D,u								So	X		X	X						X
SERVICEBERRY Amelanchier spp.	25'-60'		D,c				X	X		S	S	X	X	X	X				F		X
SORREL TREE Oxydendrum arboreum	75'		D,c,d,l								Py		X	X	X						X
WILLOW, THURLOW WEEPING X Salix elegantissima	40'		D,f		X					S	Pe										X
WILLOW, WHITE Salix alba	75'	X	D	X	X						Up	Colored winter twigs									X
YELLOW-WOOD, AMERICAN Cladrastis lutea	50'	X	D,c,d	X							Ro	X	X		X						X

Table 3.3 (cont'd)
Trees Suitable for Landscape and Conservation Plantings In New York

B. MEDIUM SIZED TREES (35'-75')

2. EVERGREEN SPECIES	HEIGHT	VAR	FOLIAGE	------SITE TOLERANCE------- COLD	WET	DRY	SHADE	SEA	CITY	PEST	------FEATURES------- HABIT	BRK	FLR	FRU	LVS	------------USES----------- WIND	SHDE	STRT	WILD	BARR	ORN
ARBORVITAE, AMERICAN Thuja occidentalis	60'	X	E,u	X	X		X	X			Co					X			WC		X
FIR, KOREAN Abies koreana	50'		E,d								Py				X	X			WC		X
FIR, VEITCH Abies veitchii	75'		E,c	X							Py				X	X			WC		
HEMLOCK, CAROLINA Tsuga caroliniana	75'		E,d						X		Py/Pe					X	X		WC	X	
PINE, JACK Pinus banksiana	75'		E	X		X					Bo								WC		
PINE, PITCH Pinus rigida	75'		E			X					Op								WC		
PINE, RED Pinus resinosa	75'		E	X		X					Py					X			WC		
PINE, SCOTCH Pinus sylvestris	75'	X	E	X				X			Op/Py	X				X			WC		
PINE, SWISS STONE Pinus cembra	75'		E,d	X							PyS								WC		X

Table 3.3 (cont'd) Trees Suitable for Landscape and Conservation Plantings in New York

C. SMALL SIZED TREES (15'-35')

1. DECIDUOUS SPECIES	HEIGHT	VAR	FOLIAGE	SITE TOLERANCE: COLD	WET	DRY	SHADE	SEA	CITY	PEST	FEATURES: HABIT	BRK	FLR	FRU	LVS	USES: WIND	SHDE	STRT	WILD	BARR	ORN
BIRCH, GRAY Betula populifolia	30'		D	X		X				S	several stems	X			X						X
BLACKHAW Viburnum prunifolium	30'		D,c,l	X									X	X	X	X			F	X	
CHERRY, CORNELIAN Cornus mas	24'	X	D,l							F	Ro		X	X	X				F		
CHERRY, SOUR Prunus cerasus	30'	X	D	X							Ro		X	X					F		X
CORK TREE, AMUR Phellodendron amurense	30'		D	X							Wo	X		X	X						
CRABAPPLES Malus spp	15'-30'		D	X						S	Ro		X,s	X				X	F		X
DOGWOOD, JAPANESE Cornus kousa	20'	X	D,d,l								No		X,s	X	X						X
HAWTHORNS Crataegus spp	15'-30'	X	D,d	X		X				S	Ro/thorny		X	X	X	X			F	X	
LABURNUM SCOTCH Laburnum alpinum	30'	X	D								Up		X			X					
LILAC, JAPANESE TREE Syringa amurensis japonica	30'		D,coarse									X	X,u			X					X
MAPLE, AMUR Acer ginnala	20'	X	D,c,d,	X			X				Up/Ro		X,f	X	X	X					X
MAPLE, MOUNTAIN Acer spicatum	25'		D,coarse	X			X				Ov			X	X						X
MOUNTAIN-ASH, SHOWY Sorbus decora	30'	X	D	X						S	shrubby		X	X							X
NANNYBERRY Viburnum lentago	30'		D,c,l	X			X				dense/ shrubby		X	X	X	X			F		X
RHODODENDRON, ROSEBAY Rhododendron maximum	12'-36'	X	E	X			X				Ro		X								X
RUSSIAN OLIVE Elaeagnus angustifolia	20'		D	X		X					S	X	X,f		X	X			F		X
SEA-BUCKTHORN, COMMON Hippophae rhamnoides	30'			X				X			Ro/o		X	X	X						X

Table 3.4 Susceptibility of Tree Species to Compaction[1]

Resistant:

Box elder	Acer negundo
Green Ash	Fraxinus pennsylvanica
Honey locust	Gleditsia triacanthos
Eastern cottonwood	Populus deltoides
Swamp white oak	Quercus bicolor
Hophornbeam	Ostrya virginia
Willows	Salix spp.
American elm	Ulmus americana
Red elm	Ulmus rubra
Hawthornes	Crataegus spp.
Bur oak	Quercus macrocarpa
Northern white cedar	Thuja occidentalis

Intermediate:

Red maple	Acer rubrum
Silver maple	Acer saccarinum
Hackberry	Celtis occidentalis
Black gum	Nyssa sylvatica
Red oak	Quercus rubra
Basswood	Tilia americana
Sweetgum	Liquidambar styraciflua
Norway maple	Acer platanoides
Shagbark hickory	Carya ovata
London plane	Platanus x acerifolia
Pin oak	Quercus palustris

Susceptible:

Sugar maple	Acer saccarum
White pine	Pinus strobus
Blue spruce	Picea pungens
White oak	Quercus alba
Red pine	Pinus resinosa
Austrian pine	Pinus nigra
White ash	Fraxinus americana
Paper birch	Betula paprifera
Mountain ash	Sorbus aucuparia
Japanese maple	Acer palmatum

[1]If a tree species does not appear on the list, insufficient information is available to rate it for this purpose.

Table 3.5 - Size and Weight of Earth Ball Required to Transplant Wild Stock

Shade Trees (Maple, Ash, Oak, Birch, etc.)			Small Trees & Shrubs (Crabapple, Thornapple, Viburnum, Dogwood, etc.)		
Caliper[1] (Inches)	Minimum Diameter Ball (Inches)	Weight of Ball (lbs.)	Up to 6 ft. Height -- 6 ft. and Caliper[1]	Minimum Diameter Ball (Inches)	Weight of Ball (lbs.)
1/2	14	88	2	12	55
3/4	16	130	3	14	88
1	18	186	4	16	130
1-1/4	20	227	5	18	186
1-1/2	22	302	3/4	18	186
1-3/4	24	390	1	20	227
2	28	621	1-1/2	22	302
3	32	836	1-3/4	24	390
3-1/2	38	1,400	2	28	621
4	42	1,887	2-1/2	32	836
			3	38	1,400

[1]Caliper is a diameter measurement of trees at a height of 6 inches above the ground.

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STANDARD AND SPECIFICATIONS FOR VEGETATING WATERWAYS

Definition

Waterways are a natural or constructed outlet, shaped or graded. They are vegetated as needed for safe disposal of runoff water.

Purpose

To provide for the safe disposal of excess surface water from construction sites and urban areas without damage from erosion.

Conditions Where Practice Applies

This standard applies to vegetating waterways and similar water carrying structures.

Supplemental measures may be required with this practice. These may include subsurface drainage to permit the growth of suitable vegetation and to eliminate wet spots, a section stabilized with asphalt, stone or other suitable means, or additional storm drains to handle snowmelt or storm runoff.

Retardance factors for determining waterway dimensions are shown in Table 3.6 on page 3.25 and "Maximum Permissible Velocities for Selected Grass and Legume Seed Mixtures" are shown in Table 3.7 on page 3.26.

Design Criteria

Waterways or outlets shall be protected against erosion by vegetative means as soon after construction as practical. Vegetation must be well established before diversions or other channels are outletted into them. Consideration should be given to the use of jute matting, excelsior matting, or sodding of channels to provide erosion protection as soon after construction as possible.

1. Liming, fertilizing and seedbed preparation.
   - A. Lime to pH 6.5.
   - B. Apply at least 50 lbs. of N, P, and K per acre (1.0- 1.25 lbs/1,000 sq. ft.).
   - C. Lime and fertilizer shall be mixed thoroughly into the seedbed during preparation.
   - D. Channels, except for paved sections, shall have at least 4 inches of topsoil.
   - E. Remove stones and other obstructions that will hinder maintenance.
2. Timing of Seeding.
   - A. Early spring and late August are best.
   - B. Temporary cover to protect from erosion is recommended during periods when seedings may fail.
3. Seed Mixtures:

Mixtures	Rate per Acre (lbs)	Rate per 1,000 sqft. (lbs)
A. Birdsfoot trefoil or ladino clover[1]	8	0.20
Tall fescue or smooth bromegrass	20	0.45
Redtop[2]	2	0.05
	30	0.70
or		
B. Kentucky bluegrass[3]	25	0.60
Creeping Red fescue	20	0.50
Perennial ryegrass	10	0.20
	55	1.30

[1] Inoculate with appropriate inoculum immediately prior to seeding. Ladino or common white clover may be substituted for birdsfoot trefoil and seeded at the same rate.

[2] Perennial ryegrass may be substituted for the redtop but increase seeding rate to 5 lbs/acre (0.1 lb/1,000 sq.ft.).

[3] Use this mixture in areas which are mowed frequently. Common white clover may be added if desired and seeded at 8 lbs/acre (0.2 lb/1,000 sq. ft.)

4. Seeding.

Select the appropriate seed mixture and apply uniformly over the area. Rolling or cultipacking across the waterway is desirable.

Waterway centers or crucial areas may be sodded. efer to the Standard and Specification for Stabilization with Sod on page 3.35. Be sure sod is securely anchored using staples or stakes.

5. Mulching.

All seeded areas will be mulched. Channels more than 300 feet long and or where the slope is 5 percent or more, must have the mulch securely anchored. Refer to the Standard and Specification for Mulching on page 3.31 for details.

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6. Maintenance.

Fertilize, lime and mow as needed to maintain dense protective vegetative cover.

Waterways shall not be used for roadways.

If rills develop in the bottom of a waterway, prompt attention is required to avoid the formation of gullies. Either hay or straw bales, riprap, excelsior or filter fabric may be used during the establishment phase. See Figure 3.3, Rill Maintenance Measures on page 3.27. Spacing between rill maintenance barriers shall not exceed 100 feet.

Table 3.6
Retardance Factors for Various Grasses and Legumes

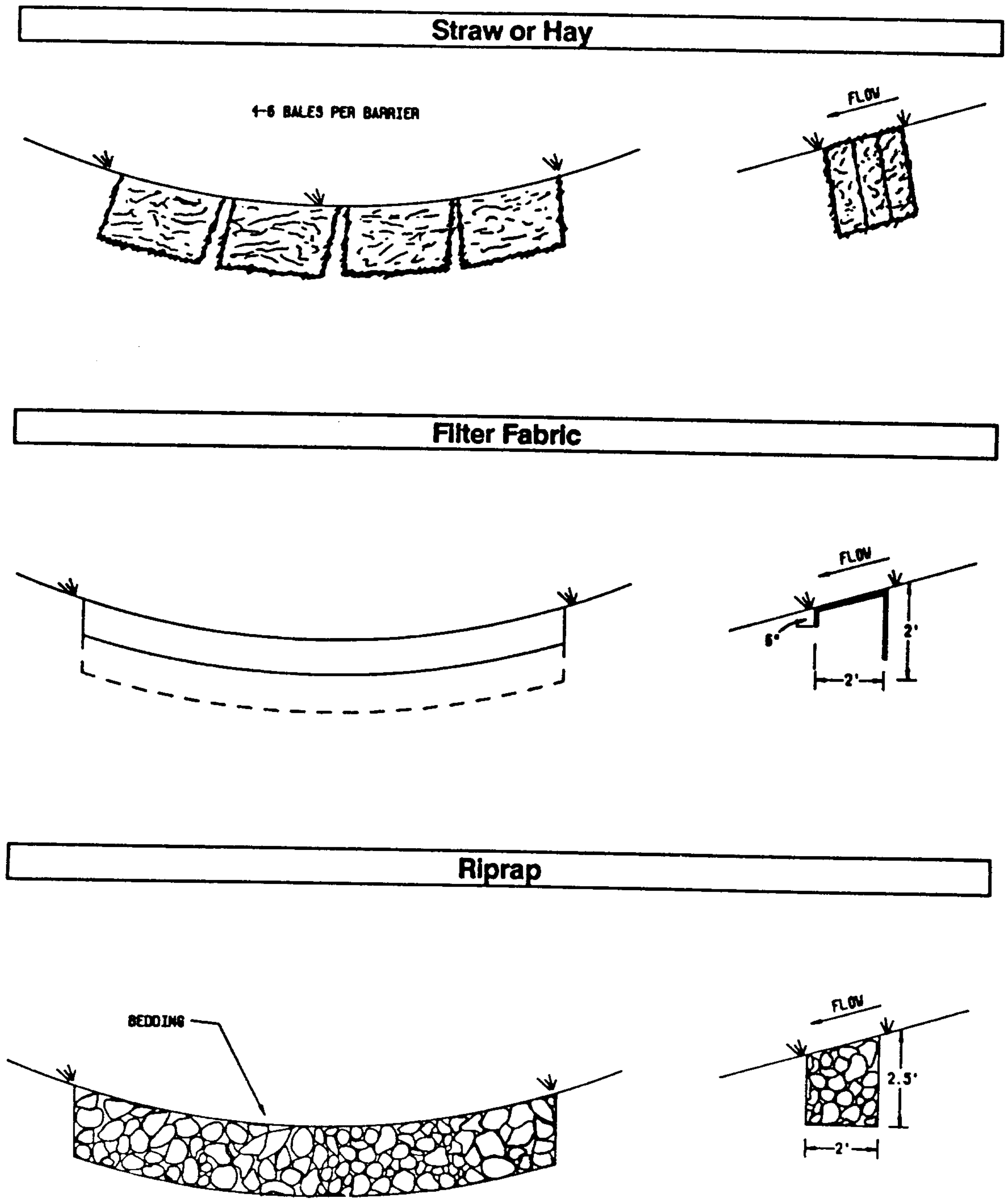
Retardance	Cover	Condition
A	Reed canarygrass..................................	Excellent stand, tall (average 36 inches)
B	Smooth bromegrass................................ Tall fescue....................................... Grass-legume mixture--Timothy, smooth bromegrass, or orchard grass with birdsfoot trefoil.......... Reed canarygrass................................. Tall fescue, with birdsfoot trefoil or ladino clover	Good stand, mowed (average 12 to 15 inches) Good stand, unmowed (average 18 inches) Good stand, uncut (average 20 inches) Good stand, mowed (average 12 to 15 inches) Good stand, uncut (average 18 inches)
C	Redtop... Grass-legume mixture--summer (Orchard grass, redtop, Annual ryegrass, and ladino or white clover)..... Kentucky bluegrass..............................	Good stand, headed (15 to 20 inches) Good stand, uncut (6 to 8 inches) Good stand, headed (6 to 12 inches)
D	Red fescue....................................... Grass-legume mixture--fall, spring (Orchard grass, redtop, Annual ryegrass, and white or ladino clover..	Good stand, headed (12 to 18 inches) Good stand, uncut (4 to 5 inches)

Table 3.7
Maximum Permissable Velocities for Selected Seed Mixtures

Cover	Slope range 2/ (percent)	Permissible Velocity 1/	
		Erosion resistant soils (ft. per sec.) K=0.10 - 0.35 3/	Easily eroded soils (ft. per sec.) K=0.36 - 0.80
Bermudgrass	0-5 5-10 over 10	8 7 6	6 5 4
Kentucky bluegrass Smooth brome Tall fescue	0-5 5-10 over 10	7 6 5	5 4 3
Grass mixtures Reed canarygrass	2/ 0-5 5-10	5 4	4 3
Redtop Alfalfa Red fescue	4/ 0-5	3.5	2.5
Sudangrass 5/	6/ 0-5	3.5	2.5

1/ Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
2/ Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
3/ K is the soil erodibility factor used in the Universal Soil Loss Equation. Consult USDA, SCS Technical Guide for list of K values for New York soils.
4/ Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.
5/ Annuals—use on mild slopes or as temporary protection until permanent covers are established.
6/ Use on slopes steeper than 5 percent is not recommended.

Figure 3.2
Rill Maintenance Measures



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STANDARD AND SPECIFICATIONS FOR TOPSOILING

Definition

Spreading a specified quality and quantity of topsoil materials on graded or constructed subsoil areas.

Purpose

To provide acceptable plant cover growing conditions, thereby reducing erosion; to reduce irrigation water needs; to reduce the need for nitrogen fertilizer application.

Conditions Where Practice Applies

Topsoil is applied to subsoils that are droughty (low available moisture for plants), stony, slowly permeable, salty or extremely acid. It is also used to backfill around shrub and tree transplants.

Design Criteria

1. Preserve existing topsoil in place, thereby reducing the need for added topsoil.

2. Conserve and stockpile topsoil and friable fine textured subsoils that must be stripped from the excavated site and applied after final grading where vegetation will be established.

3. Refer to USDA Soil Conservation Service soil surveys or soil interpretation record sheets for further soil texture information.

Site Preparation (Where topsoil is to be added)

1. As needed, install erosion control practices such as diversions, channels, sediment traps and stabilizing measures or maintain if already installed.

2. Complete rough grading and final grade, allowing for depth of topsoil to be added.

3. Scarify all compact, slowly permeable, medium and fine textured subsoil areas. Scarify at approximately right angles to the slope direction in soil areas that are steeper than 5 percent.

4. Remove refuse, woody plant parts, stones over 3 inches in diameter, and other litter.

Topsoil Materials

1. Topsoil shall have at least 2 percent by weight of fine textured stable organic material, and no greater than 6 percent. Muck soil shall not be considered topsoil.

2. Topsoil shall have not less than 20 percent fine textured material (passing the No. 200 sieve) and not more than 15 percent clay.

3. Topsoil treated with soil sterilants or herbicides shall be so identified to the purchaser.

4. Topsoil shall be relatively free of stones over 1 & 1/2 inches diameter, trash, noxious weeds such as nutsedge and quackgrass, and will have less than 10 percent gravel by volume.

5. Topsoil containing soluble salts greater than 500 ppm shall not be used.

Application and Grading

1. Topsoil shall be distributed to a uniform depth over the area. It shall not be placed when it is partly frozen, muddy, or on frozen slopes or over ice, snow, or standing water puddles.

2. Topsoil placed and graded on slopes steeper than 5 percent shall be promptly fertilized, seeded, mulched and stabilized by "tracking" with suitable equipment.

3. Apply topsoil in the following amounts:

Site Conditions	Intended Use	Minimum Topsoil Depth
1. Deep sand or loamy sand	Mowed lawn	6 in.
	Tall legumes, unmowed	2 in.
	Tall grass, unmowed	1 in.
2. Deep sandy loam	Mowed lawn	5 in.
	Tall legumes, unmowed	2 in.
	Tall grass, unmowed	none
3. Six inches or more: silt loam, loam, or silt	Mowed lawn	4 in.
	Tall legumes, unmowed	1 in.
	Tall grass, unmowed	1 in.

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STANDARD AND SPECIFICATIONS FOR MULCHING

Definition

Applying plant residues or other suitable materials to the soil surface.

Purpose

To conserve moisture and modify surface soil temperature fluctuations; prevent surface compaction or crusting; reduce runoff and erosion; control weeds; and help establish plant cover.

Conditions Where Practice Applies

On soils subject to erosion on which low residue producing crops, such as grapes, berries and small fruits are grown; on critical areas; and on soils that have a low infiltration rate.

Design Criteria

1. SITE PREPARATION

A. Prior to mulching, install the necessary temporary or permanent erosion control (structural) practices and drainage systems within or adjacent to area to be mulched.

B. Slope, grade and smooth the site if conventional equipment is to be used in applying and anchoring the mulch.

C. Remove all undesirable stones and other debris depending on anticipated land use.

D. Compacted or crusted soil surface should be loosened to at least two inches by disking or other suitable methods.

2. MULCHING MATERIALS

A. Select from attached Table 3.8 on page 3.32 the type of mulch and application rate that will best meet the need and availability of material.

B. If needed, select the anchoring method from Table 3.9 on page 3.34 that will best meet the need.

C. The best combination for grass/legume establishment is straw (small grain) mulch applied at 2 ton/acre (90 lbs/1,000 sq. ft.) and anchored with wood fiber mulch (hydromulch) at 500 - 750 lbs./acre (11 - 17 lbs./1,000 sq. ft.). The wood fiber mulch must be applied through a hydroseeder immediately after mulching.

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Table 3.8
Guide to Mulch Materials, Rates and Uses

Mulch Material	Quality Standards	Application Rates per 1000 Sq. Ft.	Application Rates per Acre	Depth of Application	Remarks
Sawdust green, or composted	Free from objectionable-coarse material.	83-500 cu. ft.	--	1-7"	Most effective as a mulch around ornamentals, small fruits and other nursery stock. Requires 30-35 lbs. N/ton to prevent N deficiency while decaying mulch. One cubic foot weighs 25 lbs
Wood Chips or Shavings	Green or air-dried Free of objectionable coarse material.	500-900 lbs.	10-20 tons	2-7"	Has about the same use and application as sawdust, but requires less N/ton (10 - 12 lbs.). Resistant to wind blowing. Decomposes slowly.
Wood Excelsior	Green or airdried burred wood fibers.	90 lbs. (1 bale)	2 tons	--	Decomposes slowly. Subject to some wind blowing. Packaged in 80-90 lbs. bales.
Wood Fiber Cellulose (Partly digested woodfibers)	Made from natural wood usually with green dye and dispersing agent.	50 lbs.	2,000 lbs.	--	Apply with hydromulcher. No tie down require. Less erosion control provided than 2 tons of hay or straw.
Compost or Manure	Well shredded,free of of excessive coarse materials.	400-600 lbs.	8-10 tons		Use straw manure where erosion control is needed. May create problem with weeds. Excellent moisture conserver. Resistant to wind blowing.
Cornstalks, shredded or chopped	Air-dried, shredded into 8" to 12" lengths.	150-300 lbs.	4-6 tons	--	Effective for erosion control, relatively slow to decompose. Excellent for mulch on crop fields. Resistant to wind blowing.
Gravel, Crushed Stone or Slag	Washed; Size 2B or 3A - 1 1/2".	9 cu. yds.	--	3"	Excellent mulch for short slopes and around plants and ornamentals. Use 2B where subject to traffic. (Approximately 2,000 lbs./cu.yd.). Frequently used over black plastic for better weed control.

Table 3.8 (cont'd)
Guide to Mulch Materials, Rates and Uses

Mulch Material	Quality Standards	Application Rates per 1000 Sq. Ft.	Application Rates per Acre	Depth of Application	Remarks
Hay or Straw	Air-dried; free of undesirable seeds & coarse materials	90-100 lbs. 2-3 bales	2 tons 100-120 bales	cover about 90 % surface	Use straw where mulch is maintained for more than three months. Subject to wind blowing unless anchored. Most commonly used mulching material. Best micro-environment for germinating seeds.
Peat Moss	Dried, compressed free of coarse materials	200-400 cu. ft.	1/2 -1 tons	2"-4"	Most effective as a mulch around ornamentals. Subject to wind blowing unless kept wet. 100 lbs. bales (6 cu.ft.). Excellent moisture holding capacity.
Jute Twisted Yarn	Undyed, unbleached plain weave. Warp 78 ends/yd., Weft 41 ends/yd. 60-90 lbs/roll	48" x 50 yds. or 48" x 75 yds.	--	-	Use without additional mulch. Tie down as per manufacturers specifications.
Excelsior Wood Fiber Mats	Interlocking web of excelsior fibers with photodegradable plastic netting	48"x100" 2 sided plastic, 48" x 180" 1 sided plastic	--	--	Use without additional mulch. Excellent for seeding establishment. Tie down as per manufacturers specifications. Approximately 72 lbs/roll for excelsior with plastic on both sides. Use two sided plastic for centerline of waterways.
Glass Fiber	1/4" thick, 7/16" dia., holes on 1" centers, 56 lb. rolls.	72"x30 yds.	--	--	Use without additional mulch. Tie down with T bars as per manufacturers specifications.
Plastic	2-4 mils	Variable	--	--	Use black for weed control. Effective for moisture conservation and weed control for small fruits and ornamentals.
Filter Fabrics	Woven or Spun	Variable	--	--	--
Straw or coconut fiber or combination	Photodegradable plastic net on one or two sides.	most are 6.5 ft. x 83.5 ft.	81 rolls	--	Designed to tolerate higher velocity water flow, centerlines of waterways.. 60 sq. yds. per roll.

Table 3.9
Mulch Anchoring Guide

Anchoring Method or Material	Kind of Mulch to be Anchored	How To Apply
A. Manual		
1. Peg and Twine	Hay or straw	After mulching, divide areas into blocks approx. 1 sq. yd. in size. Drive 4-6 pegs per block to within 2" to 3" of soil surface. Secure mulch to surface by stretching twine between pegs in criss-cross pattern on each block. Secure twine around each peg with 2 or more turns. Drive pegs flush with soil where mowing and maintenance is planned.
2. Mulch netting	Hay or straw	Staple the light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Should be biodegradable. Most products are not suitable for foot traffic.
3. Soil & stones	Plastic	Plow a single furrow along edge of area to be covered with plastic, fold about 6" of plastic into the furrow and plow furrow slice back over plastic. Use stones to hold plastic down in other places as needed.
4. Cut-in	Hay or straw	Cut mulch into soil surface with square edged spade. Make cuts in contour rows spaced 18" apart. Most successful on contour in sandy soils.
B. Mechanical		
1. Asphalt spray (emulsion)	Compost, wood chips, wood shavings, hay or straw	Apply with suitable spray equipment using the following rates: asphalt emulsion 0.04 gallons per sq. yd.: on slopes use 200 gal/acre, on level use 150 gal/acre; liquid asphalt: (rapid, medium, or slow setting) 0.10 gallons per sq/yd., 400 gal/acre.
2. Wood cellulose	Hay or straw	Apply with hydroseeder immediately after mulching. Use 750 lbs wood fiber per acre. Some products contain an adhesive material.
3. Pick chain	Hay or straw	Use on slopes steeper than 3:1. Pull across slopes with suitable power equipment.
4. Mulch anchoring tool or disk	Hay or straw, manure/mostly straw	Apply mulch and use pull a mulch anchoring tool over mulch. When a disk (smooth) is used, set in straight position and pull across slope with suitable power equipment. Mulch material should be "tucked" into soil surface about 3".
5. Chemical	Hay or straw	Apply Terra Tack AR 120 lbs/ac in 480 gal. of water (#156/ac.) or Aerospray 70 (60 gal/ac.) according to manufacturer's instructions. Avoid application during rain. A 24 hour curing period and a soil temperature higher than 45° F are required.

STANDARD AND SPECIFICATIONS FOR STABILIZATION WITH SOD

Definition

Stabilizing silt producing areas by establishing long term stands of grass with sod.

Purpose

To stabilize the soil; reduce damage from sediment and runoff to downstream areas; enhance natural beauty.

Conditions Where Practice Applies

On exposed soils that have a potential for causing off site environmental damage where a quick vegetative cover is desired. Moisture, either applied or natural, is essential to success.

Design Criteria

1. Sod shall be bluegrass or a bluegrass/red fescue mixture or a perennial ryegrass for average sites. Use tall fescue for shady, droughty or otherwise more critical areas. For variety selection, see Table 3.2 on page 3.11.

2. Sod shall be machine cut at a uniform soil thickness of 3/4 inch, plus or minus 1/4 inch. Measurement for thickness shall exclude top growth and thatch.

3. Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape when suspended vertically from a firm grasp on the upper 10 percent of the section.

4. Sod shall be free of weeds and undesirable coarse weedy grasses. Wild native or pasture grass sod shall not be used unless specified.

5. Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

6. Sod shall be harvested, delivered and installed within a period of 36 hours. Sod not transplanted within this period shall be inspected and approved by the contracting officer or his designated representative prior to its installation.

Site Preparation

Fertilizer and lime application rates shall be determined by soil tests. Under unusual circumstances where there is insufficient time for a complete soil test and the contracting officer agrees, fertilizer and lime materials may be applied in amounts shown in subsection 2 below.

1. Prior to sodding, the surface shall be smoothed and cleared of all trash, debris, and of all roots, brush, wire, grade stakes and other objects that would interfere with planting, fertilizing or maintenance operations.

2. Where the soil is acid or composed of heavy clays, ground limestone shall be spread at the rate of 100 lbs. per 1,000 square feet. In all soils 20 lbs. of 5-10-10 or equivalent, per 1,000 square feet shall be uniformly applied and mixed into the top 3 inches of soil with the required lime.

Sod Installation

1. The operation of laying, tamping and irrigating for any area sod shall be completed within eight hours. During periods of excessively high temperature the soil shall be lightly moistened immediately prior to laying the sod.

2. The first row of sod shall be laid in a straight line with subsequent rows placed parallel to and tightly wedged against each other. Lateral joints shall be staggered to promote more uniform growth and strength. Insure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause air drying of the roots. On sloping areas where erosion may be a problem, sod shall be laid with the long edges parallel to the contour and with staggered joints.

3. Secure the sod by tamping and pegging or other approved methods. As sodding is completed in any one section, the entire area shall be rolled or tamped to insure solid contact of roots with the soil surface.

4. Sod shall be watered immediately after rolling or tamping until the underside of the new sod pad and soil surface below the sod are thoroughly wet.

Sod Maintenance

1. In the absence of adequate rainfall, watering shall be performed daily or as often as deemed necessary by the inspector during the first week and in sufficient quantities to maintain moist soil to a depth of 4 inches. Watering should be done during the heat of the day to help prevent wilting. Avoid excessive water during applications.

2. After the first week, sod shall be watered as necessary to maintain adequate moisture and insure establishment.

3. First mowing should not be attempted until sod is firmly rooted. No more than 1/3 of the grass leaf shall be removed by the initial cutting or subsequent cuttings. Grass height shall be maintained between 2 and 3 inches unless other-

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wise specified. Avoid heavy mowing equipment for several weeks to prevent rutting.

4. Fertilize three to four weeks after sodding, applying 1 pound nitrogen/1,000 sq. ft. Use a complete fertilizer with a 2-1-1 ratio, or as recommended by soil test results.

5. Weed Control: Target herbicides for weeds present. Consult current Cornell Pest Control Recommendations for commercial turfgrass management or consult the local office of Cooperative Extension.

6. Disease Control: Consult the local office of the Cooperative Extension.

Additional References

1. Guideline Specifications, Soil Preparation and Sodding. MD-VA. Pub. #1. Cooperative Extension Service, University of Maryland-Virginia Polytechnic Institute. Revised 1973.
2. Guideline Specifications for Sodding. American Sod Producers Association, Inc. New Brunswick, N.J.
3. Cornell Cultural Recommendations for Commercial Turfgrass Management. Cornell University, Ithaca, N.Y., 1985.

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STANDARD AND SPECIFICATIONS FOR VEGETATIVE STABILIZATION OF SAND AND GRAVEL PITS

Definition

Stabilizing inactive borrow areas with herbaceous, perennial plants.

Purpose

1. To stabilize the soil, preventing wind or water erosion from causing on-site or offsite damages.
2. To improve the aesthetic appeal and the ability of the site to support wildlife.

Condition Where Practice Applies

Sand and gravel borrow areas which have had:

1. The soil profile replaced to approximate original conditions.
2. Where the soil profile has been removed.

Design Criteria

1. The surface shall be graded with a maximum slope of 15 percent (8.5 degrees).
2. Rocks and other debris shall be removed from the site or buried during grading.
3. Surface materials shall be sampled and analyzed to determine:

   A) Percent fines (particles less than .074 mm - 200 mesh sieve).

   B) pH.

   C) Phosphorus and potassium availability.

4. Lime and fertilizer requirements:

   The surface material shall be limed to a pH of 6.0 using agricultural ground limestone. The lime shall be incorporated into the top 3 inches of surface material.

   Fertilizer shall be applied per soil test to achieve moderate levels of available phosphorus (P_2O_5) and potassium (K_2O). In addition, 30 pounds per acre of nitrogen in a slow release formulation shall be applied. The fertilizer will be incorporated (about 1/4 -1/2 inch) along with the seed. See subsection F, Planting instructions, of this standard.

5. Seeding mixture selection:

   A) Temporary cover may be obtained by seeding oats at 2 bu/acre.

   B) When the fines fraction is less than 15 percent, the following warm season grass mixture shall be used:

Species	Variety	Certified Seed PLS*/Acre (lbs)
Switchgrass	Blackwell, Shelter or Pathfinder	2.0
Coastal panicgrass	Atlantic	2.0
Big Bluestem	Niagara	4.0
Little Bluestem	Aldous or Camper	4.0
Sand Lovegrass	Nebraska 27 or Bend	2.0
Total mix (PLS/acre)		14.0 lbs.

*Pure Live Seed (PLS) = (% germination x % purity)/100.

Pounds to be seeded = (100 x lbs. of 100% PLS required)/% PLS of commercial seed being used.

   C) When the fines fraction is 15 percent or greater, one of the following grass/legume mixture shall be used:

Species	Variety	Live Seed per Acre(lbs.)
Tall fescue	Ky-31	10.0
Redtop	Common	2.0
Perennial ryegrass	Pennfine	5.0
Birdsfoot trefoil*	Empire	8.0
Total mix (lbs. PLS/acre)		25.0

* legume in seed mixture needs to be inoculated.

or

Species	Variety	Live Seed per Acre(lbs.)
Flatpea*	Lathco	10.0
Perennial pea*	Lancer	2.0
Crownvetch	Penngift/Chemung	10.0
Tall fescue	KY-31/Rebel	10.0
Total mix (lbs./acre)		32.0

* legume in seed mixture needs to be inoculated.

6. Planting instructions:

   A) Planting dates are early spring until May 20. The birdsfoot trefoil/grass mix may be fall seeded after August 15. A temporary cover of 2 bushels of oats/acre may be planted from August 15 to September 15 (oats will winter kill).

   B) The legumes shall be inoculated at 4 times the standard rate immediately prior to seeding.

C) The seed shall be uniformly broadcast mechanically, by hydroseeder, or by hand.

D) The seed and fertilizer shall be incorporated by either:

1) "Tracking" the area with a bulldozer having cleats at least 1 inch in depth. Operation of the dozer shall be perpendicular to the contour and such that the entire area is covered by the tracks.

2) Pulling a cultipacker over the entire site with the tines set to till no deeper than 1 inch.

E) The entire site shall be mulched with 3,000 pounds of small grain straw per acre when warm season grasses are planted. When the grass/legume mix is used, 4,000 pounds of grain straw will be used.

F) The mulch shall be anchored by the bulldozer tracking technique (may be simultaneous with seed incorporation) or by a method selected from Standard and Specification for Mulching on page 3.31.

7. Site protection:

For the seeding to be successful, vehicles and foot traffic must be kept off the site for at least 2 years.

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STANDARD AND SPECIFICATIONS FOR PROTECTING VEGETATION DURING CONSTRUCTION

Definition

The protection of trees, shrubs, ground cover and other vegetation from damage by construction equipment.

Purpose

To preserve existing vegetation determined to be important for soil erosion control, water quality protection, shade, screening and other values.

Conditions Where Practice Applies

On planned construction sites in wooded areas where valued vegetation exists and needs to be preserved.

Design Criteria

1. Planning Considerations

A. Inventory:

1) Property boundaries, topography, vegetation and soils information should be gathered. Identify potentially high erosion areas, areas with tree windthrow potential, etc. A vegetative cover type map should be made on a copy of a topographic map which shows other natural and manmade features. Vegetation that is desirable to preserve because of its value for screening, shade, critical erosion control, endangered species, aesthetics, etc., should be identified and marked on the map.

2) Based upon these data, general statements should be prepared about the present condition, potential problem areas and unique features of the property.

B. Planning:

1) After engineering plans (plot maps) are prepared, another field review should take place and recommendations made as to vegetation to be saved. Minor adjustments in location of roads, dwellings and utilities may be needed. Construction on steep slopes, erodible soils, wetlands and streams should be avoided. Clearing limits should be delineated.

2) Areas to be seeded and planted should be identified. Remaining vegetation should blend with the surroundings and/or provide special function such as a filter strip, buffer zone or screen.

3) Trees and shrubs of special seasonal interest, such as flowering dogwood, red maple, striped maple, and shadbush and valuable potential shade trees should be identified and marked for special protective treatment as appropriate.

4) Trees to be cut should be marked on the plans. If timber can be removed for salable products, a forester should be consulted for marketing advice.

5) Trees that may become a hazard to people, personal property, or utilities should be designated to be removed. These include trees subject to windthrow, weak-wooded, disease-prone species, and trees with severely damaged root systems.

6) The vigor of remaining trees may be improved by a selective thinning. A forester should be consulted for implementing this practice.

2. Measures to Protect Vegetation

A. Limit soil placement over existing tree and shrub roots to a maximum of 3 inches. Soils with loamy texture and good structure should be used.

B. Use retaining walls and terraces to protect roots of trees and shrubs when grades are lowered. Lowered grades should start no closer than the dripline of the tree. For narrow-canopied trees and shrubs, the stem diameter in inches is converted to feet and doubled, such that a 10 inch tree should be protected to 20 feet.

C. Trenching across tree root systems should be the same minimum distance from the trunk, as in "B." Tunnels under root systems for underground utilities should start 18 inches or deeper below the normal ground surface. Tree roots which must be severed should be cut clean. Backfill material to be in contact with the roots should be topsoil or a prepared planting soil mixture.

D. Construct sturdy fences, wood or steel barriers, or other protective devices surrounding valuable vegetation from construction equipment.

Place barriers far enough from trees so that tall equipment such as backhoes and dumptrucks do not contact tree branches.

E. Construction limits should be identified and clearly marked to exclude equipment.

F. Avoid spills of oil/gas and other contaminants.

G. Obstructive and broken branches should be pruned properly. The branch collar on all branches whether living or dead should not be damaged. The 3 or 4 cut

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method should be used on all branches larger than two inches at the cut. First cut about one-third the way through the underside of the limb (about 6-12 inches from the tree thrunk). Then (approximatlely an inch further out) make a second cut through the limb from the upper side. When the branch is removed, there is no splintering of the main tree thrunk. Remove the stub. If the branch is larger than 5-6 inches in diameter, use the four cut system. Cuts 1 and 2 remain the same and cut 3 should be from the underside of the limb, on the outside of the branch collar, and cut 4 should be from the top and in alignment with the 3rd cut. Cut 3 should be 1/4 to 1/3 the way down the limb. This will prevent the bark from peeling down the trunk. Do not paint the cut surface.

H. Penalities for damage to valuable trees, shrubs and herbaceous plants should be clearly spelled out in the contract.

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STANDARD AND SPECIFICATIONS FOR VEGETATING SAND DUNES AND TIDAL BANKS

Definition

Establishing and maintaining vegetative cover for coastal shoreline protection.

Purpose

1. To stabilize frontal sand dunes and provide for sand entrapment for dune building where possible and necessary.

2. To provide for protection of dune vegetation from foot traffic and vehicles.

3. To stabilize tidal banks and provide for long term protection.

Conditions Where Practice Applies

On any coastal shoreline including the Great Lakes, where vegetation can be expected to effectively stabilize the site. To determine potential effectiveness, refer to the procedure outlined in Table 3.10, "Vegetative Treatment Potential for Eroding Tidal Shorelines in the Mid-Atlantic States" on page 3.453

Specifications

1. Sand Dunes

A. Where stabilization of existing sand dunes and/or reestablishment of beachgrass is needed.

1) Certified 'Cape' American beachgrass shall be planted on all frontal dunes. Planting shall be accomplished by April 30, following the planting recommendations found in Figure 3.3, Page 3.44 "Conservation Plant Sheet No. 28".

2) Certified 'Atlantic' coastal panicgrass shall be planted on back dunes at 10 pounds, pure live seed, per acre. Plant from March 1 to June 15. See pg. 3.37 to calculate actual pounds of pure live seed.

3) Immediately after planting a sand fence (snow fence) will be built to protect the beachgrass from vehicle and foot traffic. The fence shall surround the planted area at a distance of 15 feet from the planted area. Passageways should be provided to allow pedestrians to cross the planted area at 300 foot intervals. Boardwalks are desirable. Move the opening and boardwalk when beachgrass becomes weak.

B. Where sand dunes must be reconstructed through sand entrapment and shore conditions allow for sand deposition, a specialist from Sea Grant or SCS shall make the determinations of feasibility. Appropriate permits for altering shorelines must be obtained prior to work beginning.

2. Building, Planting and Maintaining Coastal Sand Dunes

Dune stabilization work must start at least one hundred (100) feet (horizontal distance) from the mean high tide (MHT) line as a minimum. Whenever feasible, leave room for two or more dune lines, a double layer of protection. Dunes grow toward the sand supply, which is the ocean or the lake.

A. Building the dune:

1) Vegetatively.

Where blowing sand is available, a simple, relatively inexpensive and successful method exists for building dunes. It consists of planting American beachgrass strips parallel to the coastline. As the windblown sand moves off the beach landward it drops its load of sand, beginning the natural cycle of dune growth. The row closest to the ocean should be at least 100 feet (horizontal distance) from the MHT line. The plantings will trap most of the windblown sand, particularly during the growing season when the grass will continue to grow up through the newly trapped sand.

Plant certified 'Cape' American beachgrass according to instructions found in Conservation Plant Sheet No. 28, Figure 3.3.

2) Sand Fences (Snow Fence Material).

Use of sand fence is effective. It is readily available. It may be more expensive than building dunes vegetatively, but is less expensive than doing it with machinery. Normally it is also much faster than with vegetation alone.

To form a barrier dune, erect the sand fences, a minimum of 100 feet (horizontal distance) from the MHT line in two (Three or four rows may be used where sufficient land area and sand is available.) parallel lines 30 or 40 feet apart. The fences should be roughly parallel to the water line and yet be as nearly as possible at a right angle to the prevailing winds. See Figure 3.5 on page 3.45.

Where this is not possible, erect a single line of fence parallel with the sea at least 140 feet from the MHT line and space 30 foot long perpendicular spurs 40 feet apart along the seaward side to trap lateral drift.

As the fences fill with sand, additional sets of fence can be placed over those filled until the barrier dune has reached a protective height.

To widen an old dune, the fencing should be set seaward at a distance of 15 feet from its base.

3) Materials -

Use standard 4 foot sand (snow) fence. The fence should be sound, free of decay, broken wire and missing or broken slats.

Wood posts, for fence support should be black locust, red cedar, white cedar or other wood of equal life or strength. They do not need to be treated. They should be a minimum of 6 ft. 6 in. long and a minimum diameter of 3 inches. Standard fence post length is usually 7 ft. - 8 ft. and should be used where possible.

Four (4) wire ties should be used to fasten fence to wood posts. Weave fence between posts so that every other post will have fence on ocean side of posts. Tie wires should be no smaller than 12 gauge galvanized wire.

Posts are to be set no further than 10 feet apart. Posts will be set at least 3 feet deep.

The bottom of the fence should be set about 3 inches into the sand, or a mechanical grader could be used to push some sand against the bottom of fence.

4) Sand fence plus vegetation -

The combination of these two approaches is more effective than either of two alone. The sand fence should be placed as discussed above. Bands of vegetation should then be planted parallel to the fence on the landward and seaward side as shown in Figure 3.5 on page 3.45. Each band of vegetation should be about 20 feet wide and placed 10 to 15 feet from the sand fence. As the sand fills between the two fences additional fence can be erected or the area between the fences can be planted as shown in Figure 3.6 on page 3.46. Such a combination can trap most or all the wind blown sand crossing the dune area and produce a much broader based dune than either approach alone.

3. Tidal Streams and Estuaries

The procedures to determine the effectiveness potential of stabilization of tidal streams and estuaries are found in Table 3.10.

Plants to be used are as follows:

A. Certified 'Cape' American Beachgrass.

B. Smooth cordgrass.

C. Saltmeadow cordgrass.

Planting instructions are found in Figure 3.7, USDA-SCS Conservation Plant Sheet No. 70 on page 3.46.

4. Additional Reference

"Best of Beach Vegetation" by W. Curtis Sharp. Reprints from Parks and Recreation Resources, Volume 1, Nos. 1, 2, 4 & 5, 7 & 8. Published in January, February, May/June, July/August 1982.

Table 3.10
Vegetative Treatment Potential for Eroding Tidal Shorelines in the Mid-Atlantic States

DIRECTIONS FOR USE

1. Evaluate each of the first four shoreline variables and match the site characteristics of the variable to the appropriate descriptive category.
2. Place the Vegetative Treatment Potential (VTP) assigned for each of the four variables in the right hand column.
3. Obtain the Cumulative Vegetative Treatment Potential for variables 1, 2, 3 & 4 by adding the VTP for each.
4. If it is 23 or more, the potential for the site to be stabilized with vegetative is very good and the rest of the table need not be used. If it is below 23, go to step 5.
5. Determine the VTP for shoreline variable 5 through 9 and obtain the cumulative VTP for variables 1-9.
6. Compare the cumulative VTP score with the Vegetative Treatment Potential Scale at the bottom of this page.

SHORELINE VARIABLES — DIRECTION FOR USE — VTP

The Vegetative Treatment Potential (VTP) is located in bold type.

SHORELINE VARIABLES						VTP
1. Fetch: Average distance in miles of open water-measured perpendicular tothe shore and 45 degrees ither side of perpendicular to shore.	Less than 0.5 miles **8**	0.5 thru 1.4 miles **7**	1.5 thru 3.4 miles **4**	3.5 thru 4.9 miles **2**	over 5 miles[1] **0**	
2. General shape of shoreline for distance of 200 yards on each side of planting site.	Coves **8**	Irregular shoreline **3**		Headland or straight shoreline **0**		
3. Shoreline orientation: General geographic direction the shoreline faces.	Any less than 1/2 mile fetch **5**	West to North **3**	South to West **2**	South to East **1**	North to East **0**	
4. Boat traffic: Proximity of site torecreational & commercial boat traffic.	None **5**	1-10 per week within 1/2 mi. of shore. **3**	More than 10 per week within 1/2 mi. of shore. **2**	1-10 per week within 100 yds. of shore. **1**	More than 10 per week within 100 yds. of shore. **0**	

Cumulation Vegetative Treatment Potential for Variables 1, 2, 3 & 4 ______________

If this score is 23 or above, the potential for the site is very good and the rest of the table need not be used. If it is below 23, go to step 5 below.

5. Width of beach above mean high tide in feet	Greater than 10 ft. **3**	10 ft. thru 7 ft. **2**	6 ft. thru. 3 ft. **1**	Less than 3 ft. **0**	
6. Potential width[2] of Planting area in feet	More than 20 ft. **3**	20 ft. thru 15 ft. **2**	14 ft. thru 10 ft. **1**	Less than 10 ft. Do not plant	
7. On shore gradient slope from MLW to toe of bank.	below 8% **6**	8% thru 14% **3**	15% thru 20% **1**	Over 20% **0**	
8. Beach Vegetation	Vegetation below toe of slope **3**		No vegetation below toe of slope **0**		
9. Depth of sand[3] at mean high tide in inches.	more than 10 in. **3**	10 in. thru 3 in. **2**	less than 3 in. **0**		

Cumulative Vegetative Treatment Potential for Variables 1-9 ______________

1. Do not plant.
2. If tidal fluctuation is 2.5 feet or less, measure from MLW to toe of bank. If tidal fluctuation is over 2.5 feet, measure from MW to toe of bank.
3. Refers to depth of sand deposited by littoral drift over the substrata.

Vegetative Treatment Potential Scale

If the VTP is, Between	And	Potential of site to be Stabilized with Vegetation
40	33	Good
32	24	Fair
23	16	Poor
below 16		Do not plant

Figure 3.3
American Beachgrass Information Sheet
(Ammophila breviligulata Fern.)

Adapted from USDA-SCS Conservation Plant Sheet No. 28[2]

Use: Major use is to stabilize moving sand along the Atlantic Sea coast and Great Lakes region. It is the best species for the initial stabilization of frontal dunes.

Useful as an erosion control plant on non-dune areas where soils are very sandy and the site conditions make establishment of seeded species very difficult. Also used on soils high in salinity such as industrial waste needing vegetative cover.

Description: American beachgrass is a leafy, spreading, bunch-type grass with many stems per clump. It may reach a height of two to three feet. The seed head is a spike-like panicle, about ten inches long, and appears in late July or August. Leaves are long and narrow, and may become rolled or folded as it matures.

One outstanding growth characteristic is the strong underground stems (rhizomes) that spread beneath the sand and give rise to many new plants. Its vigorous growth enables the plant to withstand heavy deposits of sand and grow up through it.

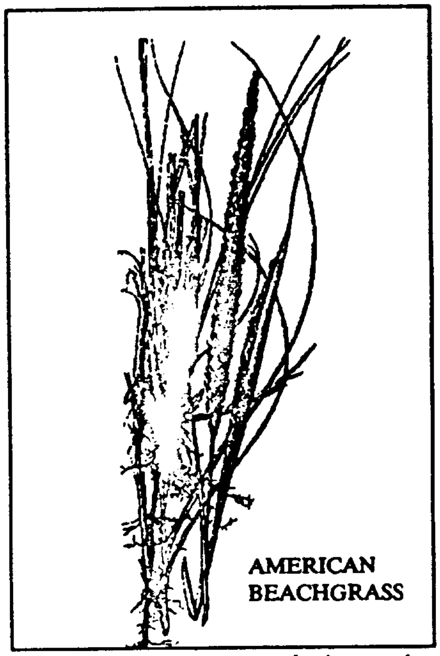
Adaptation: It is native to the mid-Atlantic coastal region from Maine to North Carolina, and the Great Lakes region. It will grow on island sites, high in sand and/or saline content, provided applications of fertilizers containing nitrogen are made.

Varieties: 'Cape' is the most recent variety and was developed by the Soil Conservation Service at the Cape May Plant Materials Center, Cape May Court House, N.J. 'Hatteras' developed by the Agricultural Experiment Station in North Carolina is a variety possibly better adapted to southern climates.

Source: Both are commercially available vegetatively. Seed not available.

Establishment: The best time to plant beachgrass is from October 1 to April 30. If properly planted, good survival can be expected at any time during this period except when soil is frozen. Summer plantings are not satisfactory. American beachgrass can be planted either by hand or by mechanical equipment designed for this work. The stems of plants called 'culms' are used for planting stock. Two or three culms are planted per hole. Space plants 18" by 18" unless wind erosion is severe, then spacing is reduced to 12" by 12". Stagger the plantings in alternate rows to provide maximum erosion control. On very stable areas where wind is not a factor, a spacing of 24" x 24" is suitable. An 18" x 18" spacing requires 58,500 culms per acre, or 1,350 culms per 1,000 square feet.

Beachgrass culms must be planted at least 8" deep. This prevents plants from drying out, as well as being blown out by the wind. A tiling or ditching spade is an excellent tool for opening the planting hole. A two man crew works best in planting on frontal dunes and loose sandy areas. The culms and roots must be kept moist before and during planting. Success of planting will increase if the stock is dormant or has made very little growth.



Fertilizer properly applied is the key to good vigorous growth, as coastal sands are rather infertile.

Fertilize annually in March or April with 30 to 40 pounds of inorganic Nitrogen per acre.

Management: Once the stand is well established, the rate of fertilizer applied can be reduced by half, or applied only when the stand appears to be weakening.

Pedestrian and vehicular traffic that bends or breaks the culms will seriously damage the plants and may kill them if traffic is intensive. On frontal dunes, any area devoid of protective cover is subject to blowing and eventual ruin. Replanting of beachgrass stands that become open should be an annual operating procedure.

Exclude vehicular traffic if possible and provide boardwalks for pedestrians. Move boardwalks when beachgrass underneath it begins to weaken.

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Figure 3.4
Combination of Sand Fence and Vegetation for Dune Building

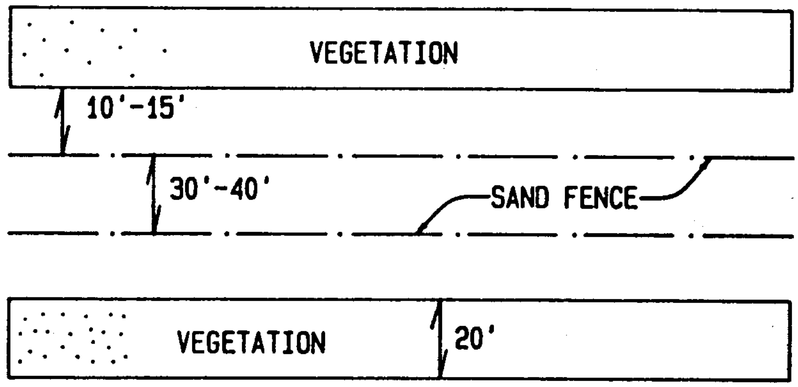

Figure 3.5
Typical Cross-Section Created by a Combination of Sand Fence and Vegetation

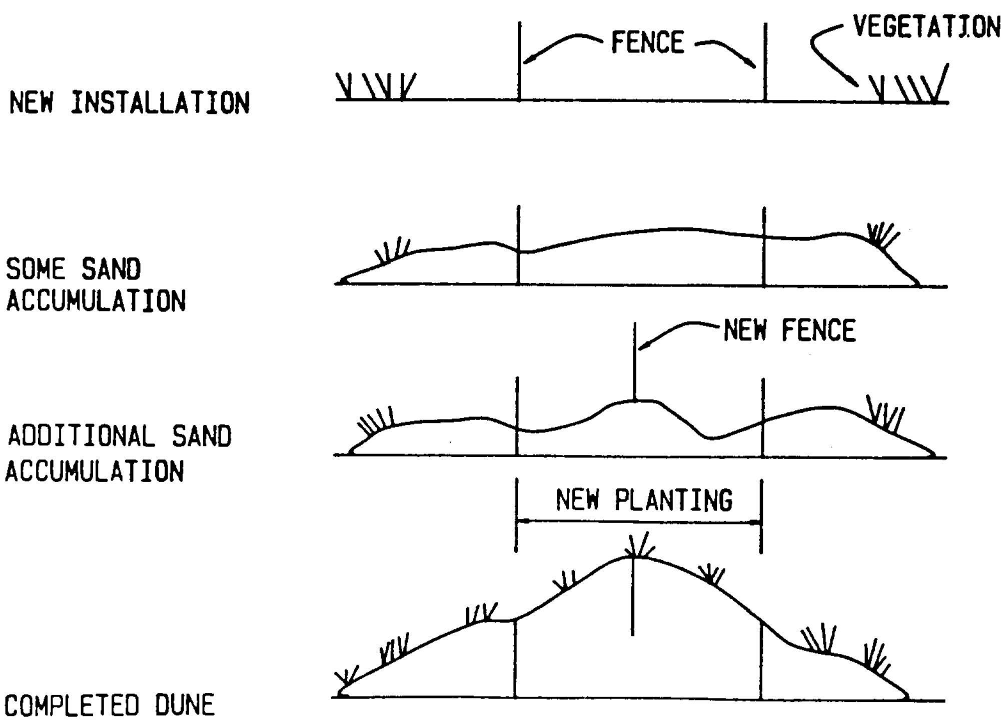

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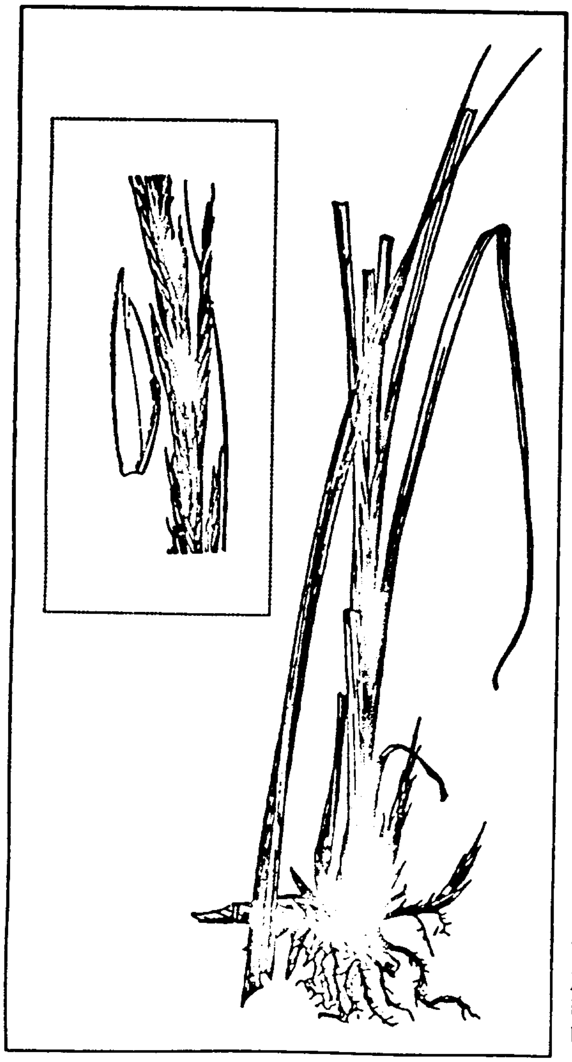
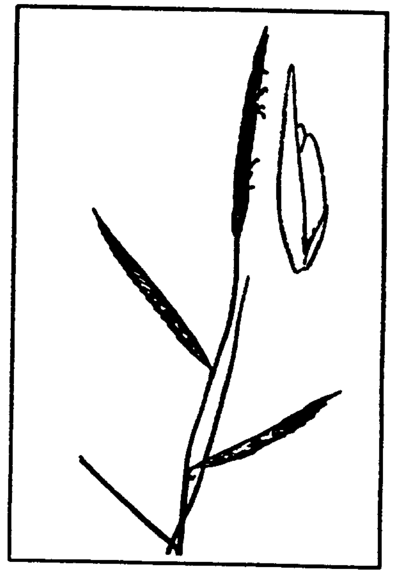
Figure 3.6
Cordgrass Information Sheet
Smooth Cordgrass (Spartina alterniflora)
and
Saltmeadow Cordgrass (Spartina patens)

Adapted from USDA-SCS Conservation Plant Sheet No. 70[3]

Description: Smooth cordgrass, a long life perennial, is the dominant, most productive marsh plant in the regularly flooded intertidal zone along the Atlantic and Gulf coast from Newfoundland to Florida and Texas. Smooth cordgrass grows three to seven feet tall with stems up to 1/2 inch in diameter. The leaves are twelve to twenty inches long, taporing to a point. The seedheads, produced in September and October, are ten to twelve inches long and hold twelve to fifteen spikelets, each two-three inches long. Its primary method of spread is by vigorous, hollow rhizomes.



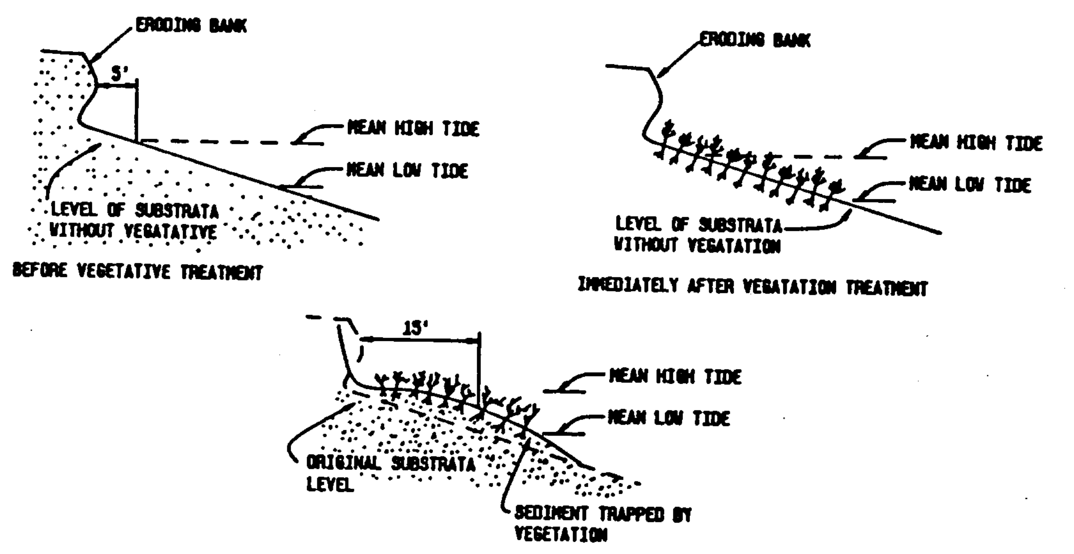


Saltmeadow cordgrass grows in salt marshes and sandy meadows along the Atlantic and Gulf coasts from Quebec to Florida and Texas. It occupies the area immediately above the intertidal zone. Mature plants are grayish green, usually one to three feet tall. The leaf sheath is rounded; the leaf blade is long and narrow, usually rolled inward giving a wiry appearance; the upper side of the leaf is rough. The seed heads produced in October have spikelets that grow almost at right angles to spikelets. Saltmeadow cordgrass reproduces rapidly by long, scally, slender rhizomes. Both smooth and saltmeadow cordgrasses are used by waterfowl as a source of food. Saltmeadow cordgrass is also used by muskrats for housing materials.

Uses: Because of their adaptation to brackish water, smooth and saltmeadow cordgrasses occur naturally or can be planted to stabilize eroding shorelines. Planted long the shoreline, the cordgrasses absorb the wave energy and collect the sediment brought in by water. As the sediment is dropped, the band of vegetation expands, pushing the mean high tide away from the tow of the bank, thus reducing the potential for continuous erosion as shown on page 3.49.

Establishment of Shoreline Plantings: Smooth cordgrass is planted between the mean low water level and the mean high water level. Saltmeadow cordgrass is planted above

Anticipated Results From Vegetative Treatment



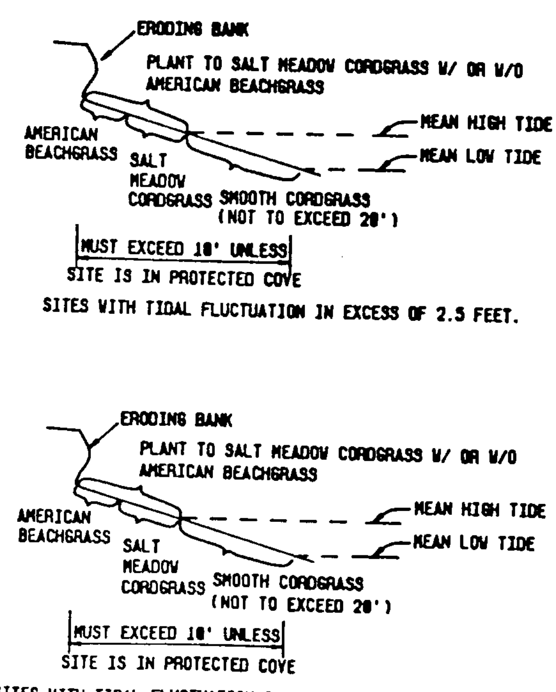
ANTICIPATED RESULTS FROM VEGETATIVE TREATMENT

the smooth cordgrass from mean high water to the toe of the slope. If the distance from the mean high water to the toe of the slope exceeds 10 feet, American beachgrass should also be planted in the upper part of the slope. See recommended planting arrangements.

Establishment of Plants: There are three types of plant materials that can be used for planting along the shoreline. One type is seedlings grown in peat pots. Such plants should be about 12 inches tall with 3-5 stems per container before they are large enough for transplanting. The container is planted with the root mass.

A second method is to grow the plants in containers which allow the plants with the root mass to slip out at the time of planting. Their size, etc., are the same as above. The advantage of this method is that it eliminates the barrier occasionally created by the peat pots that may produce a slight turbulence around the plant and wash it out.

Recommended Planting Arrangements



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A third type is to harvest culms from natural or cultivated stands which are then planted directly to the shoreline. If the plants are to be taken from natural stands, they should be growing in sandy substrata. The stands should be open and developing rather than dense and mature. The culms will be ready for digging and transplanting when the top growth is six to ten inches tall. Each culm should have a well developed root.

Methods one, two and three are equally recommended for smooth cordgrass. Methods one and two are recommended for saltmeadow cordgrass, although method three can be used but performance expectations will be less than with the other two methods.

When making plantings, place the hills 18 to 36 inches apart within and between rows. The spacing to be used is influenced by the severity of the site. On sites that have a potential of being washed away, the spacing should be closer. In protected areas where there is little danger from the planting being initially destroyed, the spacing can be wider. The hole made in the substrata should fully accommodate the plant roots. Be sure to seal the hole by pressing the soil around the roots with your heal.

One or two ounces of fertilizer should be placed in the bottom of the planting hole or in a separate hole to one side of the plant. If this approach is used, a slow released fertilizer such as Osmocote, at one ounce per hill is recommended. An alternate treatment is to broadcast about 500 lbs. of 10-10-10 fertilizer over the planted area at low tide about three weeks after planting. This amount is about twelve pounds per 1,000 sq. ft. Putting fertilizer in the hole at planting time and some about six weeks after planting will give the most rapid growth to the new plantings.

Plantings should be made between mid spring and July 1. The early spring plantings are more hazardous because of storms and less favorable soil temperatures. Actual dates are influenced by location. Late spring plantings are preferred.

Site Suitability: A high percentage of plantings made on tidal shorelines fail due to shoreline conditions, storms, etc. Most shoreline conditions can be identified and their likelihood of contributing to success or failure estimated. They are shown in Table 3.10. Its use is self-explanatory.

While the procedure outlined in Table 3.10 has been tested against actual plantings, there is no guarantee the outcome of the planting will be as the guideline suggests. For instance unexpected storms could completely eliminate the value of these guidelines and destroy the planting.

Management of Established Plantings: Plantings should be monitored frequently each year. Plants destroyed or washed out should be replanted as quickly as possible. If plant development and growth is inferior to surrounding natural marshes, fertilize in late May or June at low tide with 300-500 lbs. per acre of 10-10-10 fertilizer. All debris washed onto the plantings should be immediately removed to prevent smothering the plants.

Sources: Smooth and saltmeadow cordgrasses are available commercially or can be dug locally from an existing marsh. Because commercial sources are subject to change, contact your local USDA Soil Conservation Service office for sources closest to you.

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2. U.S.D.A., Soil Conservation Service, undated. "American Beachgrass", Conservation Plant Sheet No. 28, Northeast Regional Technical Center, Broomall, PA.

3. Sharp, W.C., 1983. "Smooth Cordgrass and Saltmeadow Cordgrass", U.S.D.A. Soil Conservation Service, Construction Plant Sheet No. 28, Northeast Regional Technical Center, Broomall, PA.

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BIO-TECHNICAL MEASURES

SECTION 4
BIOTECHNICAL MEASURES FOR EROSION AND SEDIMENT CONTROL

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List of Figures

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BIOTECHNICAL SLOPE PROTECTION MEASURES FOR EROSION AND SEDIMENT CONTROL

Introduction

Biotechnical slope protection is the specialized use of woody plant materials to stabilize soil. As noted in Section 1, one of the factors that influences erosion is vegetative cover. The more cover soil has the more protected it is from the attacking forces of rainfall and runoff. Also working to hold the soil in place is the root mass that vegetation produces. Biotechnical measures generally combine basic engineering principles with plant science to create a system of stability for critical areas such as streambanks or roadside slopes. These systems may combine structural measures, such as those detailed in Section 5, with woody plants and shrubs to effect a strengthening of the soil structure and improved vegetative cover to resist surface erosion.

There are many advantages to biotechnical slope protection measures:

- they are often less expensive to install
- they don't require specialized skills to install
- generally heavy equipment is not required
- they are environmentally compatible
- they provide a natural aesthestic appearance
- they provide wildlife habitat and cover
- they can be self repairing during and after stress
- they use natural/native materials

On the other hand there are some disadvantages to these measures:

- higher risk due to less control with vegetation compared to structural practices
- require higher maintenance attention
- need an establishment period
- more sensitive to seasonal changes

Biotechnical slope protection is actually an old technology. These techniques have been practiced for centuries in Europe. The Soil Conservation Service used and promoted this technology in the 1940's in Vermont on the Winooski River and also in New York on Buffalo Creek where plant materials (willows) were used in combination with rock riprap, concrete slabs, pinned rock, and cellular modules to halt streambank erosion.

These biotechnical approaches are being "rediscovered" primarily due to their cost effectiveness over more traditional structural measures and for their environmental compatibility, aesthetics and wildlife benefits. There are many areas in towns and counties in New York that experience erosion on streambanks or sloughs on roadside slopes that could be controlled with biotechnical protection measures. The low cost and ease of installation is very attractive to units of government and highway departments looking to maximize their budget dollars.

Principles of Biotechnical Slope Protection

Generally a biotechnical slope protection system consists of both a structural or mechanical element and vegetative elements working together to stabilize a site specific condition. Structural components are employed to allow establishment of vegetative elements while at the same time providing a level of protection for stability. The vegetative components are not just landscaping plantings for a structural project, but perform a functional role in preventing erosion by protecting the surface while also stabilizing soil by preventing shallow mass movements.

Woody plant materials (usually dormant shrub willow branches) are placed into the soil in ways which provide an immediate degree of stability to the slope. As the branches take root and grow, the slope becomes more and more resistant to failure by shallow mass movements due to:

1. Mechanical reinforcement from the root system
2. Soil water depletion through transpiration and interception.
3. Buttressing and soil arching action from embedded stems.

The vegetation also tends to prevent surficial (rainfall) erosion by:

1. Binding and restraining soil particles in place
2. Filtering soil particles from runoff
3. Intercepting raindrops
4. Retarding velocity of runoff
5. Maintaining infiltration

As the stability improves, native vegetation will volunteer, helping to blend the site into the surroundings.

There are many techniques used in biotechnical work. Some of the most common are:

- wattling
- brush layering
- brush matting
- live cribwall
- live staking
- reed trench terracing
- gully - lead plugs

- breast - wall staking
- check dams for gully control
- wattle flow deflectors

Properly designed structural measures may be necessary to help protect the toe or face of a slope against scour or erosion from moving water and against mass-moving of soil. These structures are generally capable of resisting much higher lateral earth pressures and higher shear values than vegetation. They can be natural, such as field stone, rock and timbers; or they can be artificial like concrete, and steel. Some can be a combination like gabions which are wire baskets containing stone. These can be used as retaining walls, grade stabilization structures and slope protection. Many of these types of structures can be planted or vegetated with materials to strengthen the system.

Planning Considerations

There are many facets that need to be considered when designing a biotechnical system for a site:

Method - What is the appropriate method for the particular problem encountered?

Materials - What type should be selected? How much is needed to do the job? Where can they be obtained?

Schedule - When is the best time to maximize the successful rooting or germination of materials?

Equipment - Since this process is somewhat labor intensive it is necessary to make sure the proper type and amount of tools such as shovels, pick axe, tile spade, hammers etc. are available for proper installation of material.

Site characteristics - The need for engineering structures will depend on potential hazard, management of site water, soil conditions and providing site access. Aesthetics and follow-up maintenance are also important considerations. Protection from livestock is mandatory.

Plant Materials

Plant materials for biotechnical slope protection may be obtained in two basic ways. One method is to locate stands of appropriate species and obtain easements to harvest materials from these strands for incorporation in the project. Criteria for selecting native species are easy rooting; long, straight, flexible whips; and plentiful supply near the site.

A second method is to grow and harvest materials from managed production beds that are maintained for commercial distribution. This allows selection of cultivars that have proven performance records and high survival rates.

The most popular materials in use are the shrub willows. Willows have a tremendous ability to sprout roots and stems when in contact with moist soil. Willows are found growing in all parts of the world so biotechnical slope protection techniques employ them more than any other group of plants. Two of the tested, proven willow cultivars in the Northeast are:

'Streamco' purpleosier willow (Salix purpurea)

'Bankers' dwarf willow (Salix cottetii - hybrid)

'Streamco' and 'Bankers' willow are both shrubs. 'Streamco' has an ultimate height of 10-15 feet, while 'Bankers' is limited to 6-8 feet. Supplies of both are being developed by commercial and state nurseries in the Northeast.

In addition to willows, redosier dogwood and poplars are other groups of plants effective for use in biotechnical systems.

All plant materials should be installed on site within 8 hours of cutting unless provisions for proper storage are made. Materials should be fresh, dormant and non-dessicated when installed.

STANDARD AND SPECIFICATIONS FOR WATTLING

Definition

The placement of groups or bundles of twigs, whips, or withes in shallow trenches, on the contour, on either cut or fill slopes.

Purpose

To stabilize slopes by slowing water movement off the slope, increasing infiltration, trapping slope sediments, and increasing soil stability with root system.

Conditions Where Practice Applies

On sloping areas such as road cuts, slumped areas, road fills, gullies, and streambanks, subject to erosion, seepage, or weathering, which have a low to medium hazard potential should slope failure occur. Slopes must be 1:1 or flatter.

Design Criteria

Materials - Shall be a native or nursery grown cultivar that is capable of performing the intended function.

Wattles - Shall be made by forming the bundles 6-8 feet long, 4 inches minimum in diameter, from stems no more than 1 inch in diameter. The wattles should be tapered in each end in a manner that the wattle length is 18 inches longer than the individual stem length.

Lap - Wattles should be overlapped at the tapered ends a minimum of 1.5 feet.

Vertical Spacing - The spacing of the contours for the wattles is dependent on the degree of erosion or potential erosion at the site. Factors include slope steepness, soil type, drainage, and existing ground cover. The following is a general guide to selecting contour interval:

Slope	Contour Interval
1:1	3'
1.5:1	3'
2:1	4'
2.5:1	4'
3:1	5'
3.5:1	5'
4:1	6'
6:1	8'

See figure 4.1 on page 4.4 for details.

Construction Specifications

1. Wattles shall be 4 inches minimum in diameter and bundled with tapered ends to an overall length 18 inches longer than the stems.
2. Prior to wattling slope shall be smoothed and graded with obstructions removed. Any structural measures for revetment, drainage or surface water management will be installed first.
3. Anchor stakes will be placed on the slope at the designed contour interval.
4. Working from the bottom of the slope to the top, excavate wattle trench just above stakes. Place wattles in trench and anchor with additional stakes spaced at 18 inches. Cover wattles with soil leaving about 10% exposed to view. Wattles shall be overlapped 18 inches minimum in the trench.
5. Soil shall be worked into the wattle and compacted by walking on the wattling being covered.
6. All disturbed areas should be seeded upon completion of wattling operations.

Maintenance

Regular inspection and maintenance of wattling installations should be conducted especially during the first year of establishment. Loose stakes should be reset and settled fill areas should be brought back to grade. Prompt corrections to gullies, sloughs or other evident problems should be made.

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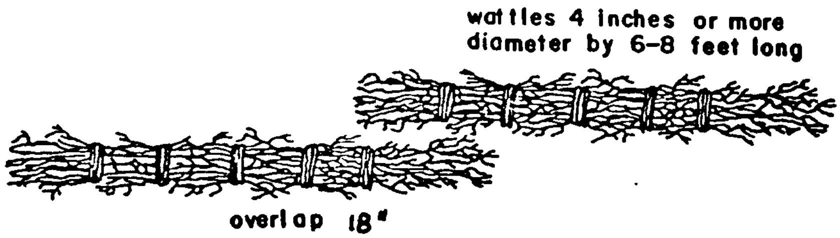
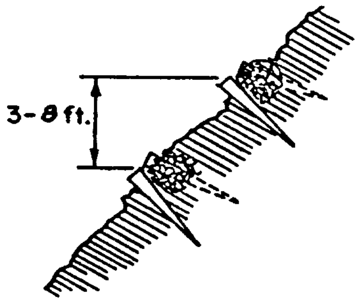
Figure 4.1
Wattling Details





DESIGN TABLE					
SLOPE	1:1	2:1	3:1	4:1	6:1
CONTOUR INTERVAL	3	4	5	6	8

CONSTRUCTION SPECIFICATIONS

1. WATTLES SHALL BE 4" MINIMUM DIAMETER AND BUNDLED WITH TAPERED ENDS TO AN OVERALL LENGTH 18 INCHES LONGER THAN THE STEMS.
2. STRUCTURAL MEASURES SUCH AS REVETMENT, DRAINAGE, SURFACE DITCHES WILL BE INSTALLED PRIOR TO WATTLING. SLOPE SHALL BE GRADED AND SMOOTHED WITH OBSTRUCTIONS REMOVED.
3. ANCHOR STAKES WILL BE PLACED ON THE SLOPE AT THE DESIRED CONTOUR INTERVAL.
4. WORKING FROM THE BOTTOM OF THE SLOPE TO THE TOP, EXCAVATE WATTLE TRENCH JUST ABOVE THE STAKES. TRENCH SHALL BE HALF THE DIAMETER OF THE WATTLES. PLACE WATTLES IN TRENCH ANCHORING WITH ADDITIONAL STAKES AT 18 INCH INTERVALS. LOWER WATTLES WITH SOIL LEAVING ABOUT 10% EXPOSURE.
5. SOIL SHALL BE WORKED INTO THE WATTLES AND COMPACTED BY FOOT TRAFFIC.
6. ALL DISTURBED AREAS SHALL BE SEEDED UPON COMPLETION OF WATTLING OPERATIONS.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	WATTLING	STANDARD SYMBOL (W)

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STANDARD AND SPECIFICATIONS FOR BRUSH MATTING

Definition

A mulch or mattress of hardwood brush layed on a slope and fastened down with stakes and wire.

Purpose

To protect the soil surface on slopes from erosive forces and act as a mulch for seeding and plant use until they are established.

Conditions Where Practice Applies

Brush matting is used primarily on streambanks where the velocity is less than 6 feet per second and excessive runoff from streamflow has created erosive conditions. This practice can resist temporary inundation but not scour or undercutting.

Design Criteria

Layer Thickness - The brush shall be a minimum of 12 inches thick.

Height - The matting shall be placed up the bank to the point of average high water. The toe of the matting should be located in a rock trench that extends from the normal water line to the channel bottom or 2 feet which ever is greater.

Slope - The maximum slope shall be 1.5:1.

Anchoring - The matting shall be anchored on the slope by a grid of 3 foot stakes driven on 3 foot centers each way. No. 9 galvanized wire is then tied between the stakes and tightened to secure the mat. The upstream edge of the mat should be keyed into the bank 2 feet.

Materials - The plant materials should be willow or dogwood brush placed downstream to upstream with stems inclined at approximately 30 degrees with the butt end placed upstream.

See figure 4.2 on page 4.6 for details.

Construction Specifications

1. Prepare slope surface by grading to a uniform, smooth surface clear of obstruction. Slopes should be planted before the brush matting is installed.
2. Lay hardwood brush beginning at the downstream end of the work. The toe should be installed first.
3. The butt end of the brush will be placed upstream and plant materials inclined approximately 30 degrees.
4. The upstream edge of the mat will be keyed into the slope 2 feet. Stakes will be driven throughout the mat on 3 foot centers each way beginning along the toe of the mat.
5. No. 9 galvanized wire will be attached to the stakes and tightened to secure the mat.
6. Slope areas above the matting will be shaped and seeded.

Maintenance

Scheduled inspections the first year are necessary to make sure the anchoring system is sound. Broken wire or missing stakes should be replaced immediately. Any toe material missing should be replaced.

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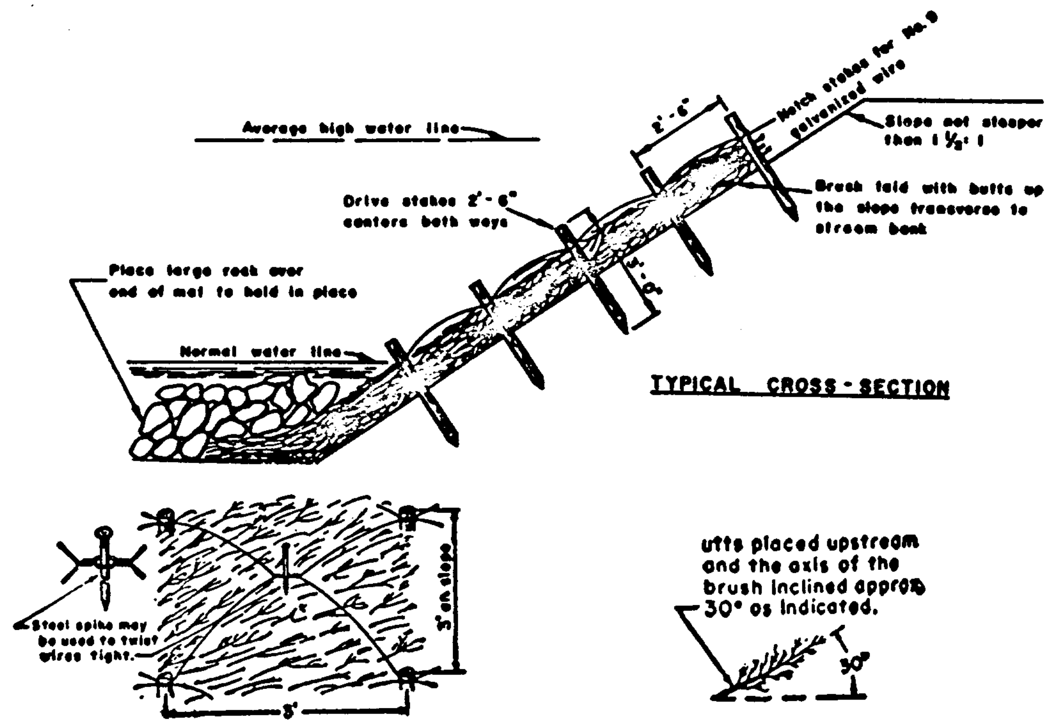
Figure 4.2
Brush Matting Details



CONSTRUCTION SPECIFICATIONS

1. PREPARE SLOPE SURFACE BY GRADING TO A UNIFORM, SMOOTH SURFACE.
2. LAY HARDWOOD BRUSH IN AN UPSTREAM DIRECTION BEGINNING AT THE DOWN-STREAM END. THE TOE SHOULD BE ESTABLISHED FIRST.
3. THE BUTT END OF THE BRUSH WILL BE PLACED UPSTREAM AND THE PLANT MATERIALS INCLINED APPROXIMATELY 30 DEGREES.
4. THE UPSTREAM EDGE OF THE MAT WILL BE KEYED INTO THE SLOPE 2 FEET. STAKES WILL BE DRIVEN THROUGHOUT THE MATTING ON 3 FOOT CENTERS EACH WAY BEGINNING ALONG THE TOE OF THE MAT.
5. NO. 9 GALVANIZED WIRE WILL BE ATTACHED TO THE STAKES OVER THE MAT AND TIGHTENED TO SECURE THE MAT.
6. SLOPE AREAS ABOVE THE MAT WILL BE SLOPED AND SEEDED.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	BRUSH MATTING	STANDARD SYMBOL (BM)

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STANDARD AND SPECIFICATIONS FOR VEGETATIVE STREAMBANK PROTECTION

Definition

Stabilization of eroding streambanks by the use of designed vegetative measures.

Purpose

To protect exposed or eroded streambanks from the erosive forces of flowing water.

Conditions Where Practice Applies

Generally applicable where flows are less than 6 feet per second and the stream bottom is not subject to degradation and scour. Structural elements may be used at points of concentration such as toes to help establish the practice on the streambank.

Design Criteria

Each channel is unique and measures designed for vegetative streambank protection will depend on soil type, size of the stream, drainage area, bedload, ice flow potential and availability of plant materials.

Protection measures should carry up the bank slope to the average high water elevation. If this is not available use the 10 year storm to evaluate limits of the protection.

Streambank protection should begin at a stable location and end at a stable location along the bank. The channel bottom should be stable or stabilized prior to installing protective measures.

Ensure that all requirements of state law and all permit requirements of local, state and federal agencies are met.

Wattling - This technique uses bundles of branches which are staked into shallow trenches, then covered with soil. They are oriented along the contour and are placed in multiple rows to help stabilize a slope. See Standard and Specifications for Wattling on page 4.3

Brush Layering - This technique is generally used to stabilize slope areas above the flowline of streambanks as well as cut and fill slopes. It involves the use of long branches that are placed with cut ends into the slope on bulldozed terraces. The tops protrude outside the finished slope. A layer usually includes three layers of brush separated with a thin (3") layer of soil. On this layer a "lift" of 3-5 feet of soil is placed to form the next terrace and so forth. See figure 4.3 on page 4.8

Live Cribwall - This is a combination of vegetation and structural elements generally used along streams where flowing water is a hazard. Layers of logs are alternated with long branches protruding out between them. The logs are spiked together and anchored into the bank with earthfill behind them to create a wall. The live stems help tie the logs together and screen the wall. See figure 4.4 on page 4.8

Live staking - These are large stakes or poles sharpened at the bottom end and forced vertically into the soft earth along the waterline usually about 1 foot apart. Depending on the size of the poles and the composition of the streambank, machinery may be required to force them into the ground or to prepare holes for planting. The poles will grow forming a very thick barrier to flow. See figure 4.5 on page 4.9

Wattle Flow Deflectors - This describes the use of wattles along the stream or river banks to deflect flow or current away from the streambank. The wattles are placed in a trench, staked and backfilled at the appropriate downstream orientation. As the willows grow, the vertical stems extend the deflector upward improving the flow control during high water. Caution should be exercised when employing this method since deflecting flow can result in the creation of erosion problems in another location. See figure 4.6 on page 4.9

Brush Matting - This method uses hardwood brush layered along a streambank as a mattress and anchored in place with a grid of stakes and wire. The toe below the waterline is anchored by rock. This living blanket acts as a mulch for seedlings and plantings established in the bank. It also prevents erosion of sloped surfaces. See Standards and Specifications for Brush Matting on page 4.5

Maintenance

Due to the susceptibility of plant materials to the physical constraints of the site, climate conditions and animal populations, it is necessary to inspect installations frequently. This is especially important during the first year or two of establishment. Plant materials missing or damaged should be replaced as soon as possible. Sloughs or breaks in drainage pattern should be reestablished for the site as quickly as possible to maintain stability.

Figure 4.3
Brush Layering Method

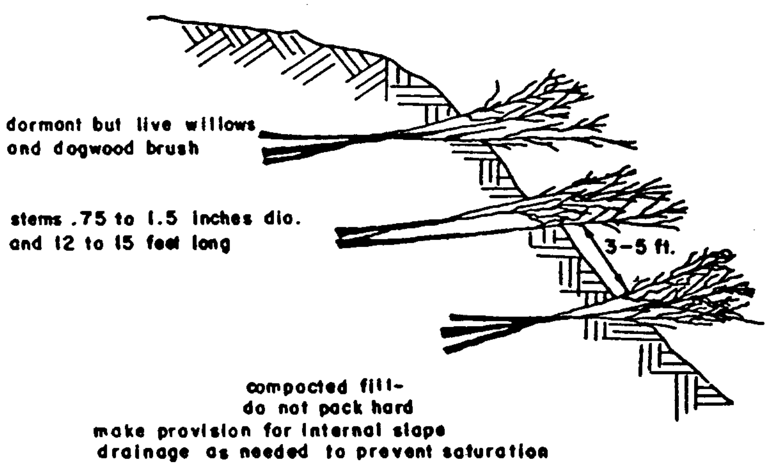

Figure 4.4
Live Cribwall Along Streambank

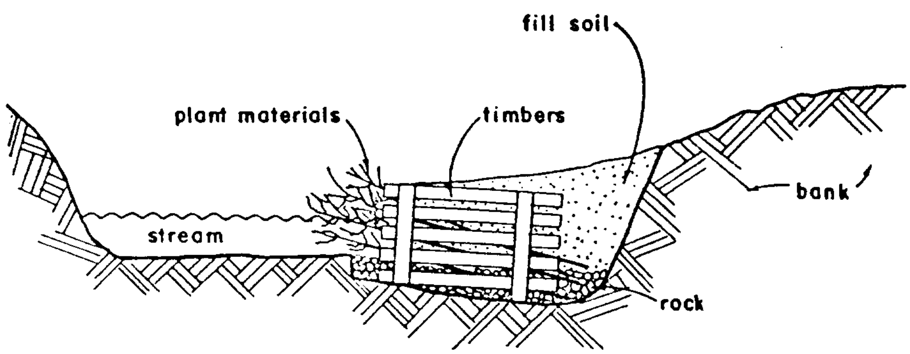

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Figure 4.5
Live Staking Along Waterline

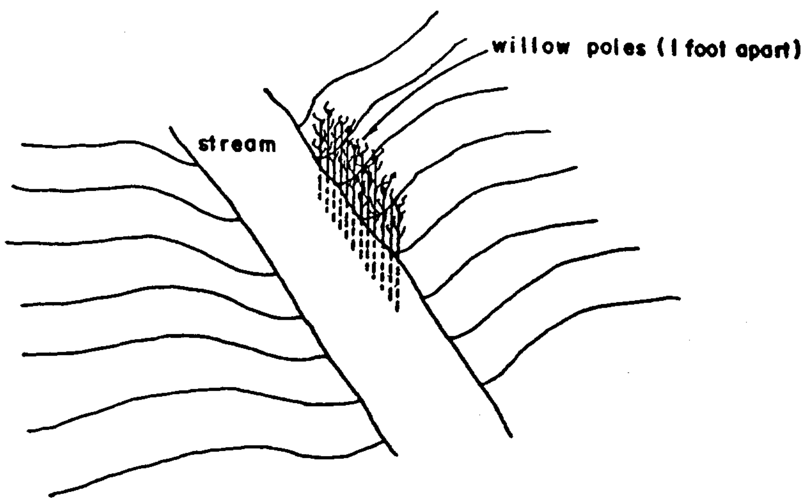
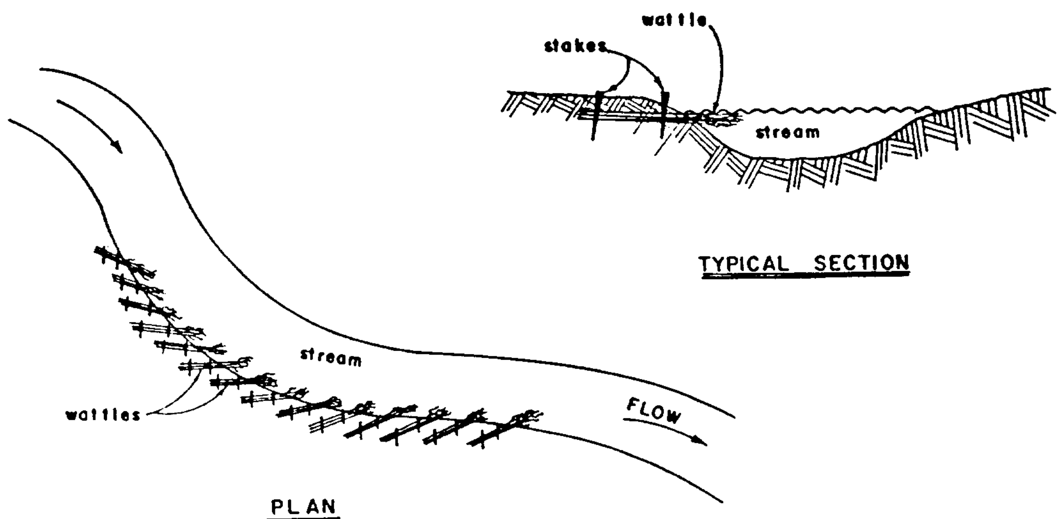


Figure 4.6
Wattle Flow Deflectors Along Waterline



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SECTION 5
STRUCTURAL MEASURES FOR EROSION AND SEDIMENT CONTROL

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STRUCTURAL MEASURES FOR EROSION AND SEDIMENT CONTROL IN URBAN AREAS

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General

Uncontrolled runoff and excess erosion often occurs in urban developments, particularly during the construction stage. This erosion forms rills and gullies; washes out roads; scours cut and fill areas; fills road ditches, storm drains, and streams; and does other damage that is costly to the developers and damaging to land and water users below. Careful inclusion of proven conservation practices in the development plan can prevent or alleviate much of this damage and should be a part of every development plan.

These practices will usually be a combination of vegetative and structural measures. They may be temporary and serve only during the construction stage or they may be permanent in nature and become a part of the completed development. Permanent structural practices should be installed as early as possible in the construction stage. This section deals with the more common structural measures that may be used. Adequate designs, plans and specifications should be prepared for the measures to be used. A number of measures and specifications are included throughout this chapter. The user of this guide should determine those elements to be installed to control erosion selected from Section 2 and follow the criteria included in the specifications.

Introduction

Structural erosion and sediment control practices have been classified as either temporary or permanent, according to how they are used. Temporary structural practices are used during construction to prevent offsite sedimentation. The length of time that temporary practices are functional varies from project to project, since the sediment control strategy may change as construction activity progresses. Permanent structural practices are used to convey surface water runoff to a safe outlet. Permanent structural practices will remain in place and continue to function after the completion of construction.

Regardless of whether the practices are temporary or permanent, runoff control measures should be the first items constructed when grading begins, and be completely functional before downslope land disturbance takes place. Earthen structures such as diversions, dikes, and swales should be stabilized before being considered functional. Only after the runoff control structures are operational and sediment control measures are in place, should clearing and grading the rest of the construction site begin.

While clearing and grading the site, it is important to minimize the amount of sediment that is produced. In general, it is advantageous to clear only as much area as necessary to accommodate construction needs. Grade and stabilize large sites in stages whenever possible. Limiting the amount of disturbed area limits the amount of sediment that is generated, thus decreasing the amount of maintenance required on sediment control measures.

Sediment generated during the construction of cut and fill slopes can also be minimized through design and grading techniques. When designing either a cut or fill slope, factors to consider include slope length and steepness, soil type, and upslope drainage area. In general, it is important to leave soil surfaces on disturbed slopes in a roughened condition and to construct a water diversion practice at the top of slopes. Rough soils surfaces do not erode as readily as smooth soil surfaces.

Although design and grading techniques can reduce soil erosion, they cannot eliminate it entirely. Therefore, practices must be installed to prevent offsite sedimentation.

Even though the specific conditions of each site determine precisely what measures are necessary to control sedimentation, some general principles apply to the selection and placement of sediment control measures.

1. Prevent clean water from getting dirty by diverting runoff from upslope areas away from disturbed areas. Earth dikes, temporary swales, perimeter dike/swales, or diversions that outlet in stable areas can be used in this capacity.
2. Remove sediment from dirty water before the water leaves the site. The method of sediment removal depends upon how the water drains from the site. Concentrated flow must be diverted to a trapping device so that suspended sediment can be deposited. Dikes or swales that outlet into traps or basins can accomplish this. A storm drain system may be used to convey concentrated sediment laden water only if the system empties into a trap or basin. Otherwise, all storm drain inlets must be protected so that sediment laden water cannot enter the drainage system before being treated to remove the sediment.
3. Surface runoff draining in sheet flow must be filtered before the water leaves the site. Straw bale dikes, silt fences, or vegetative buffer strips can be used to filter sheet flow.

All practices selected and implemented, must be properly maintained in order to remain functional. Sediment accumulated in basins and traps must be removed and disposed of in a manner that minimizes erosion and sedimentation.

Other factors should be observed during construction in order to make erosion and sediment control measures more effective in pollution control.

These are:

1. Sprinkle or apply dust suppressors. Keep dust down to a tolerable limit on construction sites and haul roads.
2. Use temporary bridges or culverts where fording of streams is objectionable. Avoid borrow areas where pollution from this operation is inevitable.
3. Protect streams from chemicals, fuel, lubricants, sewage or other pollutants.
4. Avoid disposal of fill in floodplains or drainage ways. This reduces the capacity of these areas to pass flood flows.
5. Do not locate sanitary facilities over or adjacent to live streams, wells, or springs.
6. Locate storage yards and stockpiles where erosion and sediment hazards are slight. Where this is not possible, apply necessary paving and erosion control practices.

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Figure 5.1
List of Symbols

STABILIZED CONSTRUCTION ENTRANCE
EARTH DIKE
TEMPORARY SWALE
WATER BARS
PERIMETER DIKE/SWALE
PAVED CHANNEL
GRASSED WATERWAY
LINED WATERWAY
STORM DRAIN DIVERSION
SUBSURFACE DRAIN
DIVERSION
PIPE SLOPE DRAIN
SUMP PIT
PAVED FLUME
LEVEL SPREADER
ROCK OUTLET PROTECTION
GRADE STABILIZATION STRUCTURE
ROCK DAM
CHECK DAM
DEBRIS BASIN
PORTABLE SEDIMENT TANK
EMBANKMENT SEDIMENT BASIN
FILL/EXCAVATED SEDIMENT TRAPS

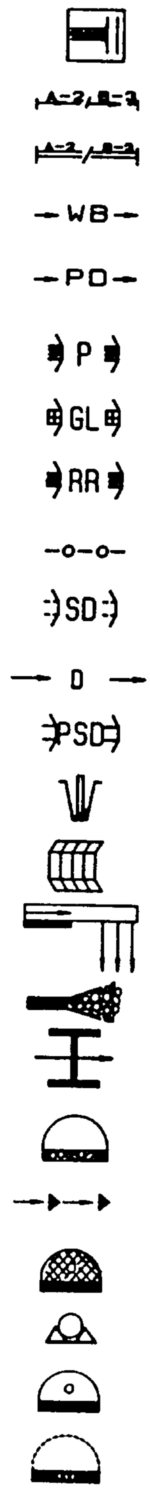

Figure 5.1 (cont'd)
List of Symbols

PIPE OUTLET SEDIMENT TRAP	
STRAW BALE DIKE	SBD
STORM DRAIN INLET FILTER	
SILT FENCE	
DUST CONTROL	DC
WATERWAY CROSSING	T
CONSTRUCTION ROAD STABILIZATION	CRS
TEMPORARY SEEDING	TS
PERMANENT SEEDING	PS
SODDING	S
RECREATION AREA IMPROVEMENT	RAI
MULCHING	M
RIPRAP SLOPE PROTECTION	RS
DUNE STABLIZATION	DS
TOPSOILING	
PROTECTING VEGETATION	
RETAINING WALL	
LAND GRANDING	
SURFACE ROUGHENING	
STRUCTURAL STREAMBANK PROTECTION	S
VEGETATIVE STREAMBANK PROTECTION	V
WATTLING	W
BRUSH MATTING	BM

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STRUCTURAL MEASURES
- TEMPORARY

SECTION 5A
TEMPORARY STRUCTURAL MEASURES
FOR
EROSION AND SEDIMENT CONTROL

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STANDARD AND SPECIFICATIONS FOR EARTH DIKE

Definition

A temporary berm or ridge or compacted soil, located in such a manner as to channel water to a desired location.

Purpose

The purpose of an earth dike is to direct runoff to a sediment trapping device, thereby reducing the potential for erosion and off site sedimentation. Earth dikes can also be used for diverting clean water away from disturbed areas.

Conditions Where Practice Applies

Earth dikes are often constructed across disturbed areas and around construction sites such as graded parking lots and subdivisions. The dikes shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

See Figure 5A.1 on page 5A.2 for details

General

	Dike A	Dike B
Drainage Area	<5 Ac	5-10 Ac
Dike Height	18 in.	36 in.
Dike Width	24 in.	36 in.
Flow Width	4 ft.	6 ft.
Flow Depth in Channel	8 in.	15 in.
Side Slopes	2:1 or Flatter	2:1 or Flatter
Grade	0.5% Min. 20% Max.	0.5% Min. 20% Max.

For drainage areas larger than 10 acres refer to the Standard and Specification for Diversion on page 5B.1.

Stabilization

Stabilization of the dike shall be completed within 10 days of installation in accordance with the standard and specifications for seed and straw mulch or straw mulch only if not in seeding season and flow channel shall be stabilized as per the following criteria:

Type of Treatment	Channel Grade[1]	Flow Channel A(≤5 Ac.)	Flow Channel B(5-10 Ac.)
1	0.5-3.0%	Seed & Straw Mulch	Seed & Straw Mulch
2	3.1-5.0%	Seed & Straw Mulch	Seed and cover with Jute or Excelsior, Sod, or lined with 2 in. stone
3	5.1-8.0%	Seed and cover with Jute, Exelsior, Sod or line with 2 in. stone	Line with 4-8 in. or stone or Recycled Concrete Equivalent[2]
4	8.1-20%	Line with 4-8 in. stone or Recycled Concrete Equivalent[2]	Engineering Design

[1] In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

[2] Recycled Concrete Equivalent shall be concrete broken into the required size, and shall contain no steel reinforcement.

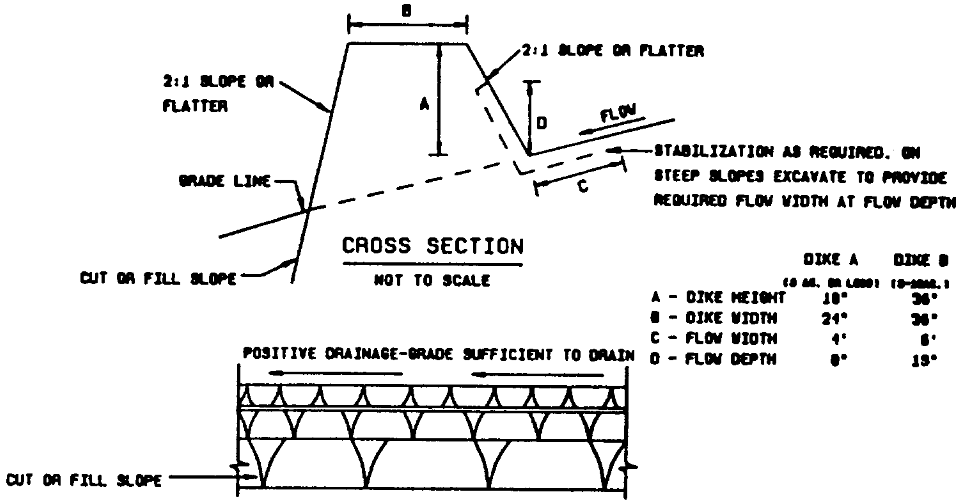
Outlet

Earth dikes shall have an outlet that functions with a minimum of erosion.

Runoff shall be conveyed to a sediment trapping device until the drainage area above the dike is adequately stabilized.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

Figure 5A.1
Earth Dike Details



	DIKE A (5 AC. OR LESS)	DIKE B (5-10AC.)
A - DIKE HEIGHT	18"	36"
B - DIKE WIDTH	24"	36"
C - FLOW WIDTH	4'	6'
D - FLOW DEPTH	8"	15"

CONSTRUCTION SPECIFICATIONS

1. ALL DIKES SHALL BE COMPACTED BY EARTH-MOVING EQUIPMENT.
2. ALL DIKES SHALL HAVE POSITIVE DRAINAGE TO AN OUTLET.
3. TOP WIDTH MAY BE WIDER AND SIDE SLOPES BE FLATTER IF DESIRED TO FACILITATE CROSSING BY CONSTRUCTION TRAFFIC.
4. FIELD LOCATION SHOULD BE ADJUSTED AS NEEDED TO UTILIZE A STABILIZED SAFE OUTLET.
5. EARTH DIKES SHALL HAVE AN OUTLET THAT FUNCTIONS WITH A MINIMUM OF EROSION. RUNOFF SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE SUCH AS A SEDIMENT TRAP OR SEDIMENT BASIN WHERE EITHER THE DIKE CHANNEL OR THE DRAINAGE AREA ABOVE THE DIKE ARE NOT ADEQUATELY STABILIZED.
6. STABILIZATION SHALL BE: (A) IN ACCORDANCE WITH STANDARD SPECIFICATIONS FOR SEED AND STRAW MULCH IF NOT IN SEEDING SEASON. (B) FLOW CHANNEL AS PER THE CHART BELOW.

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	TYPE OF GRADE	DIKE A	DIKE B
1	.5-3.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	3.1-5.0%	SEED AND STRAW MULCH	SEED USING JUTE, OR EXCELSIOR; SOD; 2" STONE
3	5.1-8.0%	SEED WITH JUTE, OR SOD; 2" STONE	LINED RIPRAP 4-8"
4	8.1-20%	LINED RIP-RAP 4-8"	ENGINEERING DESIGN

A. STONE TO BE 2 INCH STONE, OR RECYCLED CONCRETE EQUIVALENT, IN A LAYER AT LEAST 3 INCHES IN THICKNESS AND BE PRESSED INTO THE SOIL WITH CONSTRUCTION EQUIPMENT.

B. RIP-RAP TO BE 4-8 INCHES IN A LAYER AT LEAST 8 INCHES THICKNESS AND PRESSED INTO THE SOIL.

C. APPROVED EQUIVALENTS CAN BE SUBSTITUTED FOR ANY OF THE ABOVE MATERIALS.

7. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	EARTH DIKE	STANDARD SYMBOL A-2, B-3

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STANDARD AND SPECIFICATION FOR TEMPORARY SWALE

Definition

A temporary excavated drainage way.

Purpose

The purpose of a temporary swale is to prevent runoff from entering disturbed areas by intercepting and diverting it to a stabilized outlet or to intercept sediment laden water and divert it to a sediment trapping device.

Conditions Where Practice Applies

Temporary Swales are constructed:

1. To divert flows from a disturbed area.
2. Intermittently across disturbed areas to shorten overland flow distances.
3. To direct sediment laden water along the base of slopes to a trapping device.
4. To transport offsite flows across disturbed areas such as rights-of-way.

Swales collecting runoff from disturbed areas shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

See Figure 5A.2 on page 5A.4 for details.

	Swale A	Swale B
Drainage Area	<5 Ac	5-10 Ac
Bottom Width of Flow Channel	4 ft	6 ft
Depth of Flow Channel	1 ft	1 ft
Side Slopes	2:1 or Flatter	2:1 or Flatter
Grade	0.5% Min. 20% Max.	0.5% Min. 20% Max.

For drainage areas larger than 10 acres, refer to the Standard and Specifications for Waterways on page 5B.11.

Stabilization

Stabilization of the swale shall be completed within 10 days of installation in accordance with the appropriate standard and specifications for vegetative stabilization or stabilization with mulch as determined by the time of year. The flow channel shall be stabilized as per the following criteria:

Type of Treatment	Channel Grade[1]	Flow Channel A(≤5 Ac)	Flow Channel B(5-10 Ac)
1	0.5-3.0%	Seed & Straw Mulch	Seed & Straw Mulch
2	3.1-5.0%	Seed & Straw Mulch	Seed and cover with Jute or Excelsior; Sod, or lined with 2 in. stone
3	5.1-8.0%	Seed and cover with Jute or Excelsior, Sod line with 2 in. stone	Line with 4-8 in. stone or Recycled Concrete Equivalent[2]
4	8.1-20%	Line with 4-8 in. stone or Recycled Concrete Equivalent[2]	Engineering Design

[1] In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

[2] Recycled Concrete Equivalent shall be concrete broken into the required size, and shall contain no steel reinforcement.

Outlet

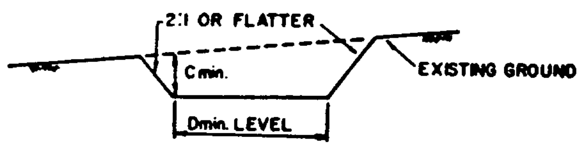
Swale shall have an outlet that functions with a minimum of erosion, and dissipates runoff velocity prior to discharge off the site.

Runoff shall be conveyed to a sediment trapping device such as a sediment trap or sediment basin until the drainage area above the swale is adequately stabilized.

The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet condition.

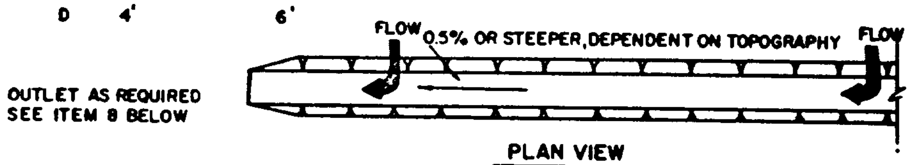
If swale is used to divert flows from entering a disturbed area, a sediment trapping device may not be needed.

Figure 5A.2
Temporary Swale Details



CROSS SECTION

	SWALE A	SWALE B
C	1'	1'
D	4'	6'



PLAN VIEW

CONSTRUCTION SPECIFICATIONS

1. ALL TEMPORARY SWALES SHALL HAVE UNINTERRUPTED POSITIVE GRADE TO AN OUTLET.
2. DIVERTED RUNOFF FROM A DISTURBED AREA SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE.
3. DIVERTED RUNOFF FROM AN UNDISTURBED AREA SHALL OUTLET DIRECTLY INTO AN UNDISTURBED STABILIZED AREA AT NON-EROSIVE VELOCITY.
4. ALL TREES, BRUSH, STUMPS, OBSTRUCTIONS, AND OTHER OBJECTIONABLE MATERIAL SHALL BE REMOVED AND DISPOSED OF SO AS NOT TO INTERFERE WITH THE PROPER FUNCTIONING OF THE SWALE.
5. THE SWALE SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE, AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED HEREIN AND BE FREE OF BANK PROJECTIONS OR OTHER IRREGULARITIES WHICH WILL IMPEDE NORMAL FLOW.
6. FILLS SHALL BE COMPACTED BY EARTH MOVING EQUIPMENT.
7. ALL EARTH REMOVED AND NOT NEEDED ON CONSTRUCTION SHALL BE PLACED SO THAT IT WILL NOT INTERFERE WITH THE FUNCTIONING OF THE SWALE.
8. STABILIZATION SHALL BE AS PER THE CHART BELOW:

FLOW CHANNEL STABILIZATION

TYPE OF TREATMENT	CHANNEL GRADE	A (5 AC OR LESS)	B (5 AC - 10 AC)
1	0.5-3.0%	SEED AND STRAW MULCH	SEED AND STRAW MULCH
2	3.1-5.0%	SEED AND STRAW MULCH	SEED USING JUTE OR EXCELSIOR
3	5.1-8.0%	SEED WITH JUTE OR EXCELSIOR; SOD	LINED RIP-RAP 4-8" RECYCLED CONCRETE EQUIVALENT
4	8.1-20%	LINED 4-8" RIP-RAP	ENGINEERED DESIGN

9. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	TEMPORARY SWALE	STANDARD SYMBOL A-2 / B-3

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STANDARD AND SPECIFICATIONS FOR PERIMETER DIKE/SWALE

VOL 12

Definition

A temporary ridge of soil excavated from an adjoining swale located along the perimeter of the site or disturbed area.

Purpose

The purpose of a perimeter dike/swale is to prevent off site storm runoff from entering a disturbed area and to prevent sediment laden storm runoff from leaving the construction site or disturbed area.

Conditions Where Practice Applies

Perimeter dike/swale is constructed to divert flows from entering a disturbed area, or along tops of slopes to prevent flows from eroding the slope, or along base of slopes to direct sediment laden flows to a trapping device.

The perimeter dike/swale shall remain in place until the disturbed areas are permanently stabilized.

Design Criteria

See Figure 5A.3 on page 5A.6 for details.

The perimeter dike/swale shall not be constructed outside the property lines without obtaining legal easements from effected adjacent property owners. A design is not required for perimeter dike/swale. The following criteria shall be used:

Drainage area - Less than 2 acres (for drainage areas larger than 2 acres but less than 10 acres see earth dike; for drainage areas larger than 10 acres, see standard and specifications for diversion).

Height - 18 inches minimum from bottom of swale to top of dike evenly divided between dike height and swale depth.

Bottom width of dike - 2 feet minimum.

Width of swale - 2 feet minimum.

Grade - Dependent upon topograpby, but shall have positive drainage (sufficient grade to drain) to an adequate outlet. Maximum allowable grade not to exceed 20 percent.

Stabilization - The disturbed area of the dike and swale shall be stabilized within 10 days of installation, in accordance with the standard and specifications for seed and straw mulch or straw mulch only if not in the seeding season.

Outlet

1. Perimeter dike/swale shall have an outlet that functions with a minimum of erosion.
2. Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area.
3. Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a sediment trap, sediment basin, or to an area protected by any of these practices.
4. The on-site location may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

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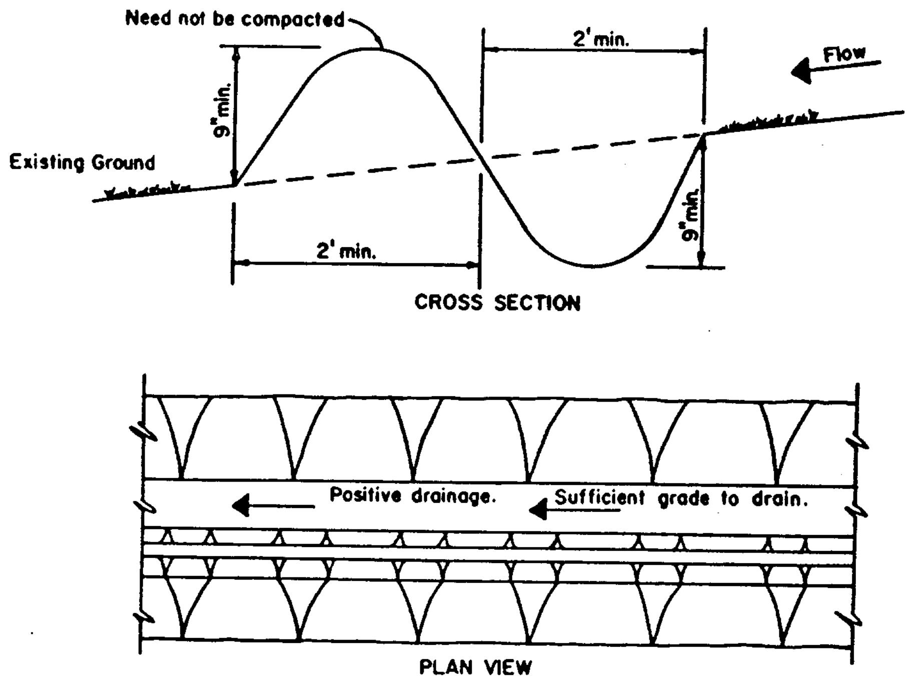
Figure 5A.3
Perimeter Dike/Swale Details

not to scale



CONSTRUCTION SPECIFICATIONS

1. ALL PERIMETER DIKE/SWALE SHALL HAVE UNINTERRUPTED POSITIVE GRADE TO AN OUTLET.
2. DIVERTED RUNOFF FROM A DISTRUBED AREA SHALL BE CONVEYED TO A SEDIMENT TRAPPING DEVICE.
3. DIVERTED RUNOFF FROM AN UNDISTURBED AREA SHALL OUTLET INTO AN UNDISTURBED STABILIZED AREA AT NON-EROSION VELOCITY.
4. THE SWALE SHALL BE EXCAVATED OR SHAPED TO LINE, GRADE, AND CROSS SECTION AS REQUIRED TO MEET THE CRITERIA SPECIFIED IN THE STANDARD.
5. STABILIZATION OF THE AREA DISTURBED BY THE DIKE AND SWALE SHALL BE DONE IN ACCORDANCE WITH THE STANDARD AND SPECIFICATION FOR SEED AND STRAW MULCH, AND SHALL BE DONE WITHIN 10 DAYS.
6. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

Max. Drainage Area Limit: 2 Acres

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PERIMETER DIKE/SWALE	STANDARD SYMBOL —PD—

STANDARD AND SPECIFICATIONS FOR TEMPORARY STORM DRAIN DIVERSION

Definition

The redirection of a storm drain line or outfall channel so that it may temporarily discharge into a sediment trapping device.

Purpose

To prevent sediment laden water from entering a watercourse, public or private property through a storm drain system, or to temporarily provide underground conveyance of sediment laden water to a sediment trapping device.

Conditions Where Practice Applies

One of the following practices or procedures shall be used whenever the off-site drainage area is less than 50 percent of the on-site drainage area to that system. A special exception may be given, at the discretion of the local plan approval agency, where site conditions make this procedure impossible.

Method of Temporary Diversion

1. Construction of a sediment trap or basin below a permanent storm drain outfall. Temporarily divert storm flow into the basin or trap constructed below permanent outfall channel.
2. In-line diversion of storm drain at an inlet or manhole, achieved by installing a pipe stub in the side of a manhole or inlet and temporarily blocking the permanent outfall pipe from that structure. A temporary outfall ditch or pipe may be used to convey storm flow from the stub to a sediment trap or basin. This method may be used just above a permanent outfall or prior to connecting into an existing storm drain system.
3. Delay completion of the permanent storm drain outfall and temporarily divert storm flow into a sediment basin or trap. Earth dike, swale or design diversion is used, depending on the drainage area, to direct flow into a sediment basin or trap. The basin or trap should be constructed to one side of the proposed permanent storm drain location whenever possible.
4. Installation of a stormwater management basin early in the construction sequence. Install temporary measures to allow use as a sediment basin. Since these structures are designed to receive storm drain outfalls, diversion should not be necessary.

Completion and Disposition

When the areas contributing sediment to the system have been stabilized, procedures can be taken to restore the system to its planned use.

The following removal and restoration procedure is recommended:

1. Flush the storm drain system to remove any accumulated sediment.
2. Remove the sediment control devices, such as traps, basins, dikes, swales, etc.
3. For sites where an inlet was modified, brick shut the temporary pipe stub and open the permanent outfall pipe.
4. Establish permanent stabilized outfall channel as noted on the plans.
5. Restore the area to grades shown on the plan and stabilize with vegetative measures.
6. For basins that will be converted to stormwater management, remove the accumulated sediment, open the low flow orifice, and seed all disturbed areas to permanent vegetation.

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STANDARD AND SPECIFICATIONS FOR WATER BAR

Definition

A ridge or ridge and channel constructed diagonally across a sloping road or utility right-of-way that is subject to erosion.

Purpose

To limit the accumulation of erosive volumes of water by diverting surface runoff at predesigned intervals.

Conditions Where Practice Applies

Where runoff protection is needed to prevent erosion on sloping access right-of-ways or either long, narrow sloping areas generally less than 100 feet in width.

Design Criteria

Design computations are not required.

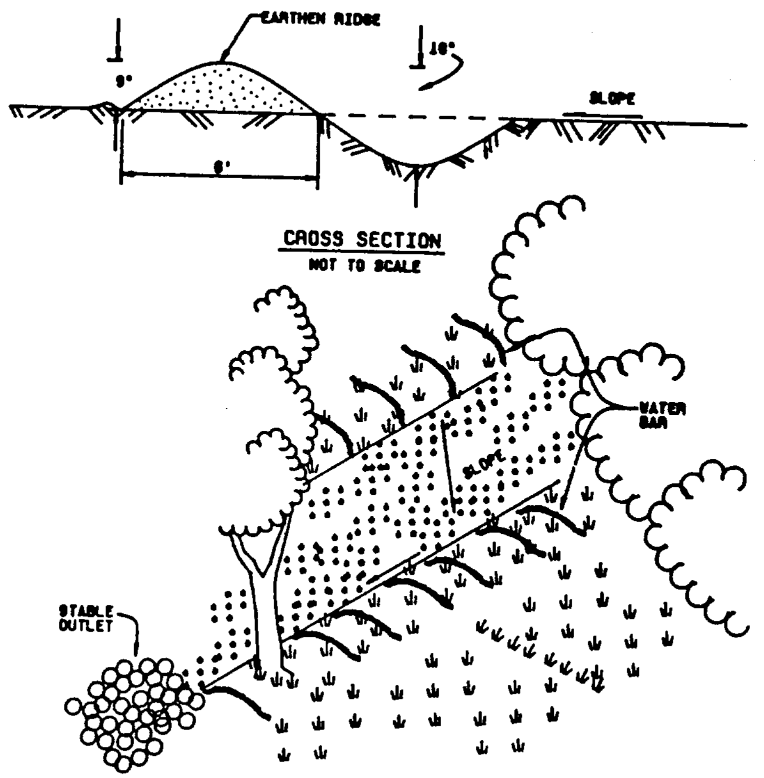
1. The design height shall be a minimum of 18 inches measured from channel bottom to ridge top.
2. The side slopes shall be 2:1 or flatter; a minimum of 4:1 where vehicles cross.
3. The base width of the ridge shall be six feet minimum.
4. The spacing of the water bars shall be as follows:

Slope (%)	Spacing (ft)
<5	125
5 to 10	100
10 to 20	75
20 to 35	50
> 35	25

5. The positive grade shall not exceed 2%. A crossing angle of approximately 60 degrees is preferred.
6. Water bars should have stable outlets, either natural or constructed. Site spacing may need to be adjusted for field conditions to use the most suitable areas for water disposal.

See figure 5A.4 on page 5A.10 for details.

Figure 5A.4
Water Bar Details



CONSTRUCTION SPECIFICATIONS

1. INSTALL THE WATER BAR AS SOON AS THE RIGHT OF WAY IS CLEARED AND GRADED.
2. DISK OR STRIP THE SOD FROM THE BASE FOR THE CONSTRUCTED RIDGE BEFORE PLACING FILL.
3. TRACK THE RIDGE TO COMPACT IT TO THE DESIGN CROSS SECTION.
4. THE OUTLET SHALL BE LOCATED ON AN UNDISTURBED AREA. FIELD SPACING WILL BE ADJUSTED TO USE THE MOST STABLE OUTLET AREAS. OUTLET PROTECTION WILL BE PROVIDED WHEN NATURAL AREAS ARE NOT ADEQUATE.
5. VEHICLE CROSSING SHALL BE STABILIZED WITH GRAVEL. EXPOSED AREAS SHALL BE IMMEDIATELY SEEDED AND MULCHED.
6. PERIODICALLY INSPECT WATER BARS FOR EROSION DAMAGE AND SEDIMENT. CHECK OUTLET AREAS AND MAKE REPAIRS AS NEEDED TO RESTORE OPERATION.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	WATER BARS	STANDARD SYMBOL — WB —

STANDARD AND SPECIFICATIONS
FOR
LEVEL SPREADER

Definition

A non-erosive outlet for concentrated runoff constructed to disperse flow uniformly across the a slope.

Purpose

To convert concentrated flow to sheet flow and release it uniformly over a stabilized area.

Conditions Where Practice Applies

Where sediment-free storm runoff can be released in sheet flow down a stabilized slope without causing erosion; where a level lip can be constructed without filling; where the area below the level lip is uniform with a slope of 10% or less and the runoff will not re-concentrate after release; and where no traffic will be allowed over spreader.

Design Criteria

The design capacity shall be determined by estimating the peak flow from the 10 year storm. The drainage area shall be restricted to limit the maximum flows into the spreader to 30 cfs. The level spreader shall have the following minimum dimensions:

Design Flow (cfs)	Minimum Entrance Width (ft.)	Depth (ft.)	End Width (ft.)	Length (ft.)
0-10	10	0.5	3	10
10-20	16	0.6	3	20
20-30	24	0.7	3	30

A transition section 20 feet in length shall be constructed from the width of the diversion or channel to the width of the spreader to ensure uniform outflow. This last transition section will blend the diversion grade to zero grade at the beginning of the spreader.

Construct the level lip in undisturbed soil to a uniform height and zero grade over the length of the spreader. Protect the lip with an erosion resistant material or mat to prevent erosion and allow vegetation to become established.

The outlet area should be a generally smooth, well vegetated area no steeper than 10 percent.

See figure 5A.5 on page 5A.12 for details.

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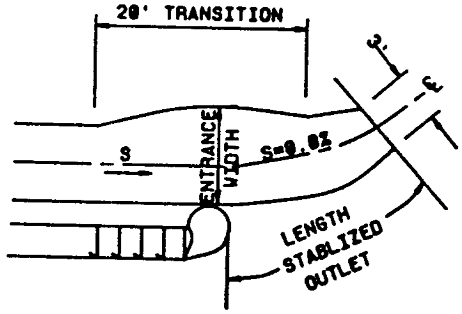
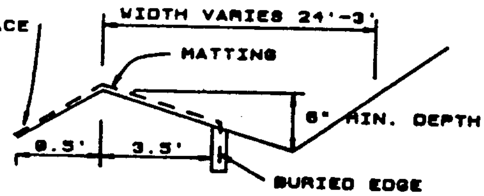
Figure 5A.5
Level Spreader Details



PLAN VIEW

NOT TO SCALE



CROSS SECTION

NOT TO SCALE

Q(cfs)	E.W.(ft)	D(ft)	LENGTH(ft)
0-10	10	0.5	10
10-20	16	0.6	20
20-30	24	0.7	30

CONSTRUCTION SPECIFICATIONS

1. THE MATTING SHOULD BE A MINIMUM OF 4FT. WIDE EXTENDING 6 INCHES OVER THE LIP AND BURIED 6 INCHES DEEP IN A VERTICAL TRENCH ON THE LOWER EDGE. THE UPPER EDGE SHOULD BUTT AGAINST SMOOTHLY CUT SOD AND BE SECURELY HELD IN PLACE WITH CLOSELY SPACED HEAVY DUTY WIRE STAPLES AT LEAST 12 INCHES IN LENGTH.
2. ENSURE THAT THE LIP IS LEVEL TO UNIFORMLY SPREAD DISCHARGE.
3. THE LIP SHALL BE CONSTRUCTED ON UNDISTURBED SOIL NOT FILL.
4. A 20 FOOT TRANSITION SECTION WILL BE CONSTRUCTED FROM THE DIVERSION CHANNEL TO THE SPREADER TO SMOOTHLY BLEND THE DIFFERENT DIMENSION AND GRADES.
5. THE RUNOFF DISCHARGE WILL BE OUTLETED ONTO A STABLIZED VEGETATED SLOPE NOT EXCEEDING 10%.
6. SEED AND MULCH THE DISTURBED AREA IMMEDIATELY AFTER CONSTRUCTION.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	LEVEL SPREADER	STANDARD SYMBOL 

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STANDARD AND SPECIFICATIONS FOR PIPE SLOPE DRAIN

Definition

A temporary structure placed from the top of a slope to the bottom of a slope.

Purpose

The purpose of the structure is to convey surface runoff down slopes without causing erosion.

Conditions Where Practice Applies

Pipe slope drains are used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. The maximum allowable drainage area shall be 5 acres.

Design Criteria

See Figures 5A.6 and 5A.7 on pages 5A.14 and 5A.15 for details.

General

Size	Pipe/Tubing Diameter (in).	Maximum Drainage Area (Ac)
PSD-12	12	0.5
PSD-18	18	1.5
PSD-21	21	2.5
PSD-24	24	3.5
PSD-30	30	5.0

Inlet

The minimum height of the earth dike at the entrance to the pipe slope drain shall be the diameter of the pipe (D) plus 12 inches.

Outlet

The pipe slope drain shall outlet into a sediment trapping device when the drainage area is disturbed. A riprap apron shall be installed below the pipe outlet where clean water is being discharged into a stabilized area.

Construction Specifications

1. The pipe slope drain shall have a slope of 3 percent or steeper.
2. The top of the earth dike over the inlet pipe and those dikes carrying water to the pipe shall be at least one (1) foot higher at all points than the top of the inlet pipe.
3. Corrugated metal pipe or equivalent shall be used with watertight connecting bands.
4. A flared end section shall be attached to the inlet end of pipe with a watertight connection.
5. The soil around and under the pipe and end section shall be hand tamped in 4 in. lifts to the top of the earth dike.
6. Where flexible tubing is used, it shall be the same diameter as the inlet pipe and shall be constructed of a durable material with hold down grommets spaced 10 ft. on centers.
7. The flexible tubing shall be securely fastened to the corrugated metal pipe with metal strapping or watertight connecting collars.
8. The flexible tubing shall be securely anchored to the slope by staking at the grommets provided.
9. Where a pipe slope drain outlets into a sediment trapping device, it shall discharge at the riser crest or weir elevation.
10. A riprap apron shall be used below the pipe outlet where clean water is being discharged into a stabilized area. See Figures 5A.6 and 5A.7.
11. Inspection and any needed maintenance shall be performed after each storm.

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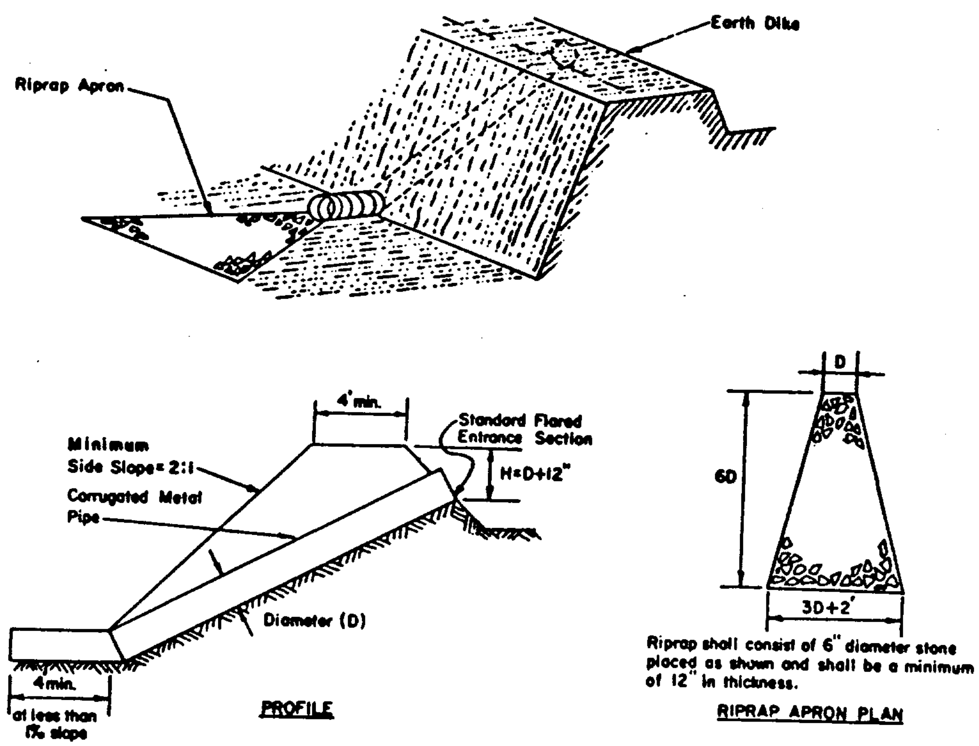
Figure 5A.6
Pipe Slope Drain - Rigid



Note: Size designation is: PSD-Pipe Diam.
(ex., PSD-12= Pipe Slope Drain with 12" diameter pipe)

CONSTRUCTION SPECIFICATIONS

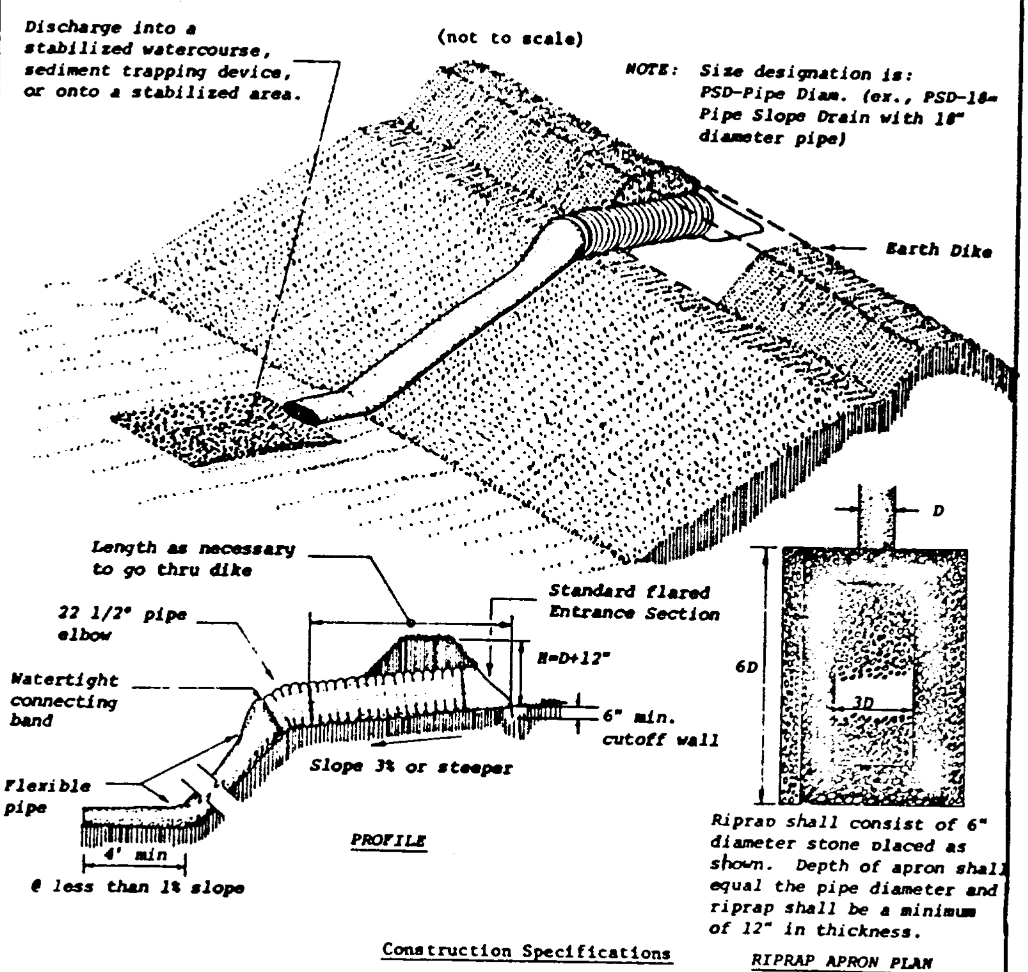
1. THE PIPE SLOPE DRAIN SHALL HAVE A SLOPE OF 3% OR STEEPER.
2. TOP OF THE EARTH DIKE OVER THE INLET PIPE AND ALL DIKES CARRYING WATER TO THE PIPE SHALL BE AT LEAST ONE FOOT HIGHER THAN THE TOP OF THE PIPE.
3. ADD 0.3 FOOT TO DIKE HEIGHT FOR SETTLEMENT.
4. SOIL AROUND AND UNDER THE SLOPE PIPE SHALL BE HAND TAMPED IN 4 INCH LIFTS.
5. THE PIPE SHALL BE CORRUGATED METAL PIPE WITH WATERTIGHT 12 INCH CONNECTING BANDS OR FLANGE CONNECTIONS.
6. RIP-RAP TO BE 6 INCHES IN A LAYER AT LEAST 12 INCHES THICKNESS AND PRESSED INTO THE SOIL.
7. PERIODIC INSPECTION AND REQUIRED MAINTENANCE MUST BE PROVIDED AFTER EACH RAIN EVENT.

Maximum Drainage Area: 5 Acres

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PIPE SLOPE DRAIN	STANDARD SYMBOL PSD

6066

Figure 5A.7
Pipe Slope Drain - Flexible



Construction Specifications

1. The inlet pipe shall have a slope of 3% or steeper.
2. The top of the earth dike over the inlet pipe and those dikes carrying water to the pipe shall be at least 1' higher at all points than the top of the inlet pipe.
3. The inlet pipe shall be corrugated metal pipe with watertight connecting bands.
4. The flexible tubing shall be the same diameter as the inlet pipe and shall be constructed of a durable material with hold-down grommets spaced 10' on centers.
5. The flexible tubing shall be securely fastened to the corrugated metal pipe with metal strapping or watertight connecting collars.
6. The flexible tubing shall be securely anchored to the slope by staking at the grommets provided.
7. A riprap apron shall be provided at the outlet. This shall consist of 6" diameter stone placed as shown.
8. The soil around and under the inlet pipe and entrance section shall be hand tamped in 4" lifts to the top of the earth dike.
9. Follow-up inspection and any needed maintenance shall be performed after each storm.

* Drainage area must not exceed 5 acres.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PIPE SLOPE DRAIN	STANDARD SYMBOL ⇒ PSD ⇒

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R0039375

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STANDARD AND SPECIFICATIONS FOR STRAW BALE DIKE

Definition

A temporary barrier of straw or similar material used to intercept sediment laden runoff from small drainage areas of disturbed soil.

Purpose

The purpose of a bale dike is to reduce runoff velocity and effect deposition of the transported sediment load. Straw bale dikes have an estimated design life of three (3) months.

Conditions Where Practice Applies

The straw bale dike is used where:

1. No other practice is feasible.
2. There is no concentration of water in a channel or other drainage way above the barrier.
3. Erosion would occur in the form of sheet erosion.
4. Length of slope above the straw bale dike does not exceed these limits.

Constructed Slope	Percent Slope	Slope Length (ft.)
2:1	50	25
2 -1/2:1	40	50
3:1	33	75
3-1/2:1	30	100
4:1	25	125

Where slope gradient changes through the drainage area, steepness refers to the steepest slope section contributing to the straw bale dike.

The practice may also be used for a single family lot if the slope is less than 15 percent. The contributing drainage area in this instance shall be less than one acre and the length of slope above the dike shall be less than 200 feet.

Design Criteria

A design is not required. All bales shall be placed on the contour with cut edge of bale adhering to the ground. See Figure 5A.8 on page 5A.18 or details.

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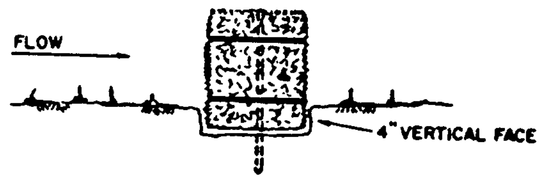
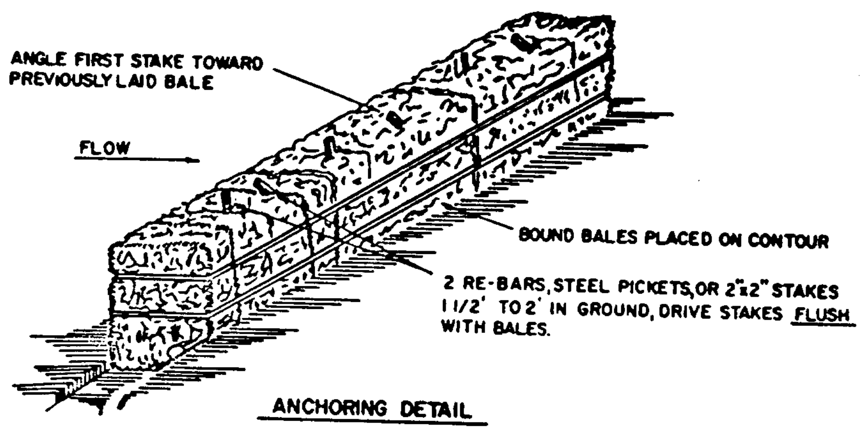
Figure 5A.8
Straw Bale Dike Details



BEDDING DETAIL

DRAINAGE AREA NO MORE THAN 1/4 ac. PER 100 FEET OF STRAW BALE DIKE FOR SLOPES LESS THAN 25%



ANCHORING DETAIL

CONSTRUCTION SPECIFICATIONS

1. BALES SHALL BE PLACED AT THE TOE OF A SLOPE OR ON THE CONTOUR AND IN A ROW WITH ENDS TIGHTLY ABUTTING THE ADJACENT BALES.
2. EACH BALE SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF (4) INCHES, AND PLACED SO THE BINDINGS ARE HORIZONTAL.
3. BALES SHALL BE SECURELY ANCHORED IN PLACE BY EITHER TWO STAKES OR RE-BARS DRIVEN THROUGH THE BALE. THE FIRST STAKE IN EACH BALE SHALL BE DRIVEN TOWARD THE PREVIOUSLY LAID BALE AT AN ANGLE TO FORCE THE BALES TOGETHER. STAKES SHALL BE DRIVEN FLUSH WITH THE BALE.
4. INSPECTION SHALL BE FREQUENT AND REPAIR REPLACEMENT SHALL BE MADE PROMPTLY AS NEEDED.
5. BALES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFULNESS SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STRAW BALE DIKE	STANDARD SYMBOL SBD

STANDARD AND SPECIFICATIONS FOR SILT FENCE

Definition

A temporary barrier of geotextile fabric (filter cloth) used to intercept sediment laden runoff from small drainage areas of disturbed soil.

Purpose

The purpose of a silt fence is to reduce runoff velocity and effect deposition of transported sediment load. Limits imposed by ultraviolet stability of the fabric will dictate the maximum period the silt fence may be used.

Conditions Where Practice Applies

A silt fence may be used subject to the following conditions:

1. Maximum allowable slope lengths contributing runoff to a silt fence are:

Slope Steepness	Maximum Slope Length (Ft)
2:1	50
3:1	75
4:1	125
5:1	175
Flatter than 5:1	200

2. Maximum drainage area for overland flow to a silt fence shall not exceed 1/2 acre per 100 feet of fence; and
3. Erosion would occur in the form of sheet erosion; and
4. There is no concentration of water flowing to the barrier.

Design Criteria

Design computations are not required. All silt fences shall be placed as close to the area as possible, and the area below the fence must be undisturbed or stabilized.

A detail of the silt fence shall be shown on the plan, and contain the following minimum requirements:

1. The type, size, and spacing of fence posts.
2. The size of woven wire support fences.
3. The type of filter cloth used.
4. The method of anchoring the filter cloth.
5. The method of fastening the filter cloth to the fencing support.

Where ends of filter cloth come together, they shall be overlapped, folded and stapled to prevent sediment bypass. See Figure 5A.9 on page 5A.20 for details.

Criteria for Silt Fence Materials

1. Silt Fence Fabric: The fabric shall meet the following specifications unless otherwise approved by the appropriate erosion and sediment control plan approval authority. Such approval shall not constitute statewide acceptance. Statewide acceptability shall depend on in field and/or laboratory observations and evaluations.

Fabric Properties	Minimum Acceptable Value	Test Method
Grab Tensile Strength (lbs)	90	ASTM D1682
Elongation at Failure (%)	50	ASTM D1682
Mullen Burst Strength (PSI)	190	ASTM D3786
Puncture Strength (lbs)	40	ASTM D751 (modified)
Slurry Flow Rate (gal/min/sf)	0.3	
Equivalent Opening Size	40-80	US Std Sieve CW-02215
Ultraviolet Radiation Stability (%)	90	ASTM G-26

2. Fence Posts (for fabricated units): The length shall be a minimum of 36 inches long. Wood posts will be of sound quality hardwood with a minimum cross sectional area of 3.0 square inches. Steel posts will be standard T and U section weighing not less than 1.00 pound per linear foot.
3. Wire Fence (for fabricated units): Wire fencing shall be a minimum 14-1/2 gage with a maximum 6 in. mesh opening, or as approved.
4. Prefabricated Units: Envirofence or approved equal may be used in lieu of the above method providing the unit is installed per details shown in Figure 5A.9.

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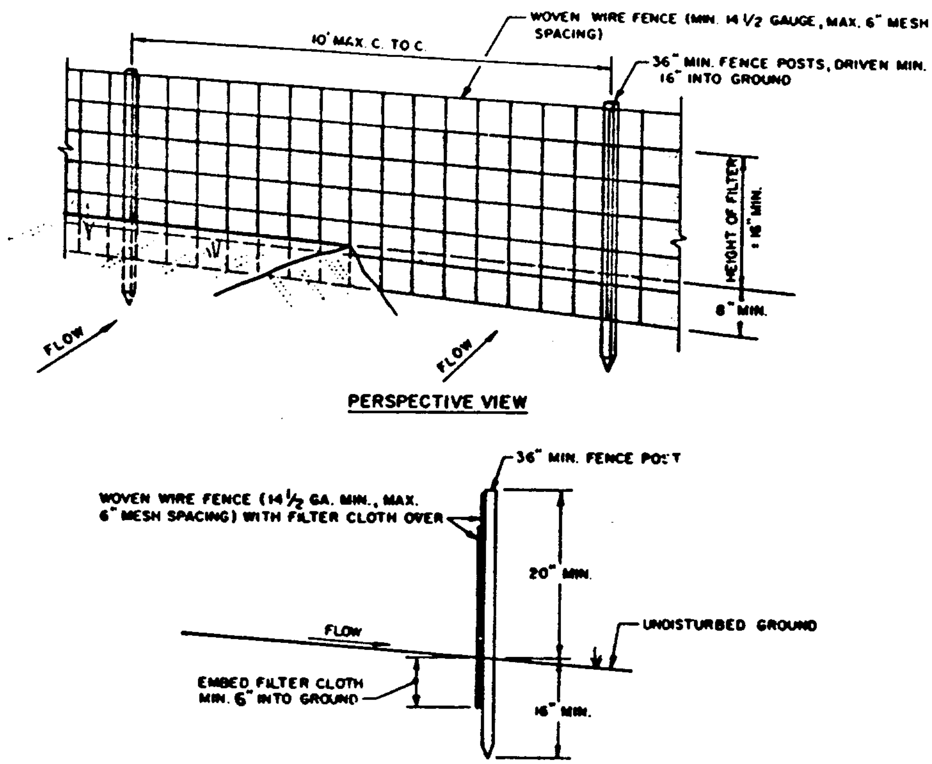
Figure 5A.9
Silt Fence Details



SECTION

CONSTRUCTION NOTES FOR FABRICATED SILT FENCE

1. WOVEN WIRE FENCE TO BE FASTENED SECURELY TO FENCE POSTS WITH WIRE TIES OR STAPLES.
2. FILTER CLOTH TO BE TO BE FASTENED SECURELY TO WOVEN WIRE FENCE WITH TIES SPACED EVERY 24" AT TOP AND MID SECTION.
3. WHEN TWO SECTIONS OF FILTER CLOTH ADJOIN EACH OTHER THEY SHALL BE OVERLAPPED BY SIX INCHES AND FOLDED.
4. MAINTENANCE SHALL BE PERFORMED AS NEEDED AND MATERIAL REMOVED WHEN "BULGES" DEVELOP IN THE SILT FENCE

POSTS: STEEL EITHER "T" OR "U" TYPE OR 2" HARDWOOD

FENCE: WOVEN WIRE, 14 1/2 GA. 6" MAX. MESH OPENING

FILTER CLOTH: FILTER X, MIRAFI 100X, STABILINKA T140N OR APPROVED EQUAL.

PREFABRICATED UNIT: GEOFAB, ENVIROFENCE, OR APPROVED EQUAL.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	SILT FENCE	STANDARD SYMBOL

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STANDARD AND SPECIFICATIONS FOR CHECK DAM

Definition

Small temporary stone dams constructed across a drainageway.

Purpose

To reduce erosion in a drainage channel by restricting the velocity of flow in the channel.

Condition Where Practice Applies

This practice is used as a temporary or emergency measure to limit erosion by reducing flow in small open channels that are degrading or subject to erosion; and where permanent stabilization is impractical due to short period of usefulness and time constraints of construction.

Design Criteria

Drainage Area: Maximum drainage area above the check dam shall not exceed two (2) acres.

Height: Not greater than 2 feet. Center shall be maintained 9 inches lower than abutments at natural ground elevation.

Side Slopes: Shall be 2:1 or flatter

Spacing: The check dams shall be spaced as necessary in the channel so that the crest of the downstream dam is at the elevation of the toe of the upstream dam.

Stone Size: Use graded stone 2 to 15 inches in size (NYS - DOT Light Stone Fill meets these requirements).

The overflow of the check dams will be stabilized to resist erosion that might be caused by the check dam. See Figure 5A.10 on page 5A.22 for details.

Maintenance

The check dams should be inspected after each runoff event. Correct all damage immediately. If significant erosion has occurred between structures a liner of stone or other suitable material should be installed in that portion of the channel.

Remove sediment accumulated behind the dam as needed to allow channel to drain through the stone check dam and prevent large flows from carrying sediment over the dam. Replace stones as needed to maintain the design cross section of the structures.

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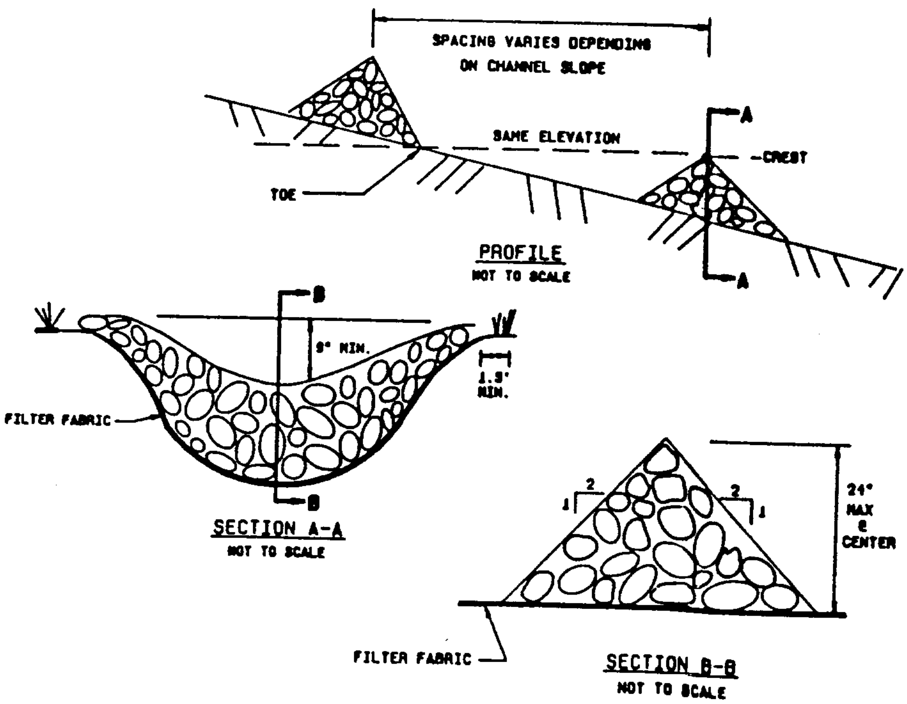
Figure 5A.10
Check Dam Details



CONSTRUCTION SPECIFICATIONS

1. STONE WILL BE PLACED ON A FILTER FABRIC FOUNDATION TO THE LINES, GRADES AND LOCATIONS SHOWN IN THE PLAN.
2. SET SPACING OF CHECK DAMS TO ASSUME THAT THE ELEVATIONS OF THE CREST OF THE DOWNSTREAM DAM IS AT THE SAME ELEVATION OF THE TOE OF THE UPSTREAM DAM.
3. EXTEND THE STONE A MINIMUM OF 1.5 FEET BEYOND THE DITCH BANKS TO PREVENT CUTTING AROUND THE DAM.
4. PROTECT THE CHANNEL DOWNSTREAM OF THE LOWEST CHECK DAM FROM SCOUR AND EROSION WITH STONE OR LINER AS APPROPRIATE.
5. ENSURE THAT CHANNEL APPURTENANCES SUCH AS CULVERT ENTRANCES BELOW CHECK DAMS ARE NOT SUBJECT TO DAMAGE OR BLOCKAGE FROM DISPLACED STONES.

MAXIMUM DRAINAGE AREA 2 ACRES.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	CHECK DAM	STANDARD SYMBOL —▶—▶

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R0039382

STANDARD AND SPECIFICATIONS FOR ROCK DAM

Definition

A rock embankment located to capture sediment.

Purpose

To retain sediment on the construction site and prevent sedimentation in off site water bodies.

Conditions Where Practice Applies

The rock dam may be used instead of the standard sediment basin with barrel and riser. The rock dam is preferred when it is difficult to construct a stable, earthen embankment and rock materials are readily available. The site should be accessible for periodic sediment removal. This rock dam should not be located in a live stream. The top of the dam will serve as the overflow outlet. The inside of the dam will be faced with smaller stone to reduce the rate of seepage so a sediment pool forms during runoff events.

Design Criteria

Drainage Area: The drainage area for this off stream structure is limited to 50 acres.

Location: The location of the dam should:

- provide a large area to trap sediment
- interrupt runoff from disturbed areas
- be accessible to remove sediment
- not interfere with construction activities

Storage Volume: The storage volume behind the dam should be at least 1,800 cubic feet based on the amount of disturbed area draining to the dam. This volume is measured one foot below the top of dam.

Dam Section:

Top Width	5 feet minimum @ crest
Side Slopes	2:1 upstream slope 3:1 downstream slope
Height	8' max to spillway crest

Length of Crest: The crest length should be designed to carry the 10 yr. peak runoff with a flow depth of 1 foot and 1 foot of freeboard.

Rock at the abutments should extend at least 2 feet above the spillway and be at least 2 feet thick. These rock abutments should extend at least one foot above the downstream slope to prevent abutment scour. A rock apron at least 1.5 feet thick should extend downstream from the toe of the dam a distance equal to the height of the dam to protect the outlet area from scour.

Rock Fill: The rockfill should be well graded, hard, erosion resistant stone with a minimum d_{50} size of 9 inches. A "key trench" lined with geotextile filter fabric should be installed in the soil foundation under the rockfill. The filter fabric must extend from the key trench to the downstream edge of the apron and abutments to prevent soil movement and piping under the dam.

The upstream face of the dam should be covered with a fine gravel (NYS-DOT #1 washed stone or equal) a minimum 1 foot thick to reduce the drainage rate.

Trapping Efficiency: To obtain maximum trapping efficiency, design for a long detention period. Usually a minimum of eight (8) hours before the basin is completely drained. Maximize the length of travel of sediment laden water from the inlet to the drain. Achieve a surface area equal to 0.01 acres per cfs (inflow) based on the 10-year storm.

See Figure 5A.11 on page 5A.24 for details.

Maintenance

Check the basin area after each rainfall event. Remove sediment and restore original volume when sediment accumulates to one-half the design volume. Check the structure for erosion, piping, and rock displacement after each significant event and replace immediately.

Remove the structure and any sediment immediately after the construction area has been permanently stabilized. All water should be removed from the basin prior to the removal of the rock dam. Sediment should be placed in designated disposal areas and not allowed to flow into streams or drainageways during structure removal.

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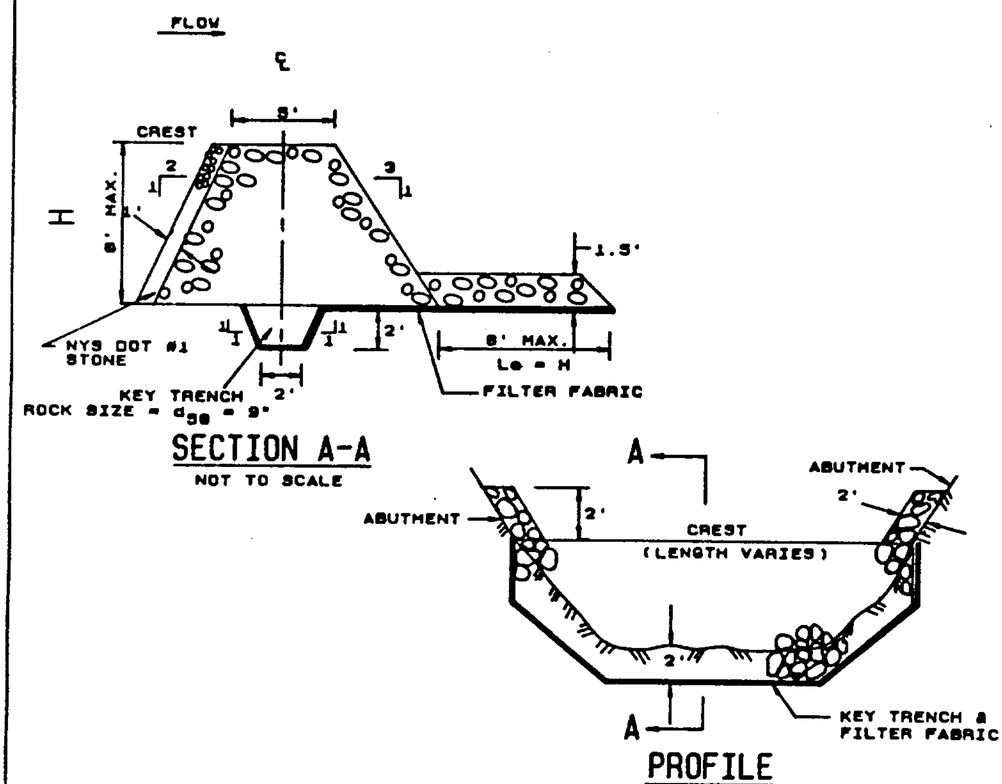
Figure 5A.11
Rock Dam Details



MAXIMUM DRAINAGE AREA: 50 ACRES

CONSTRUCTION SPECIFICATIONS

1. THE AREA UNDER THE ROCK DAM SHALL BE CLEARED AND STRIPPED OF ROOTS AND OTHER OBJECTIONABLE MATERIAL. THE RESERVOIR SHALL BE CLEARED AS NEEDED TO FACILITATE SEDIMENT REMOVAL.
2. DIMENSIONS SHOWN ARE MINIMUM. TRENCH SHALL BE EXCAVATED FROM ABUTMENT TO ABUTMENT ON THE DAM CENTERLINE. FILTER FABRIC SHALL BE PLACED FROM UPSTREAM EDGE OF KEYTRENCH TO DOWNSTREAM EDGE OF APRON. JOINTS WILL LAP A MINIMUM OF 1 FT. WITH UPSTREAM STRIP ON TOP.
3. CONSTRUCT THE ROCK EMBANKMENT TO THE DIMENSIONS SHOWN ON THE DRAWING. ROCK ABUTMENTS SHALL BE MAINTAINED 2 FT. ABOVE THE CREST.
4. THE ROCK DAM SHALL BE CONSTRUCTED PRIOR TO CLEARING THE BASIN AREA. STABLIZE ALL DISTURBED AREAS, EXCEPT THE BASIN AREA, WITH TEMPORARY SEEDING.
5. FENCES AND WARNING SIGNS SHOULD BE PLACED AS APPROPRIATE.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	ROCK DAM	STANDARD SYMBOL

STANDARD AND SPECIFICATIONS FOR STORM DRAIN INLET PROTECTION

Definition

A permeable barrier installed around inlets in the form of a fence, berm or excavation around an opening, thereby reducing sediment content of sediment laden water.

Purpose

To prevent sediment laden water from entering a storm drain system through inlets.

Conditions Where Practice Applies

This practice shall be used where the drainage area to an inlet is disturbed, it is not possible to temporarily divert the storm drain outfall into a trapping device and watertight blocking of inlets is not advisable. It is not to be used in place of sediment trapping devices. This may be used in conjunction with storm drain diversion to help prevent siltation of pipes installed with low slope angle.

Types of Storm Drain Inlet Practices

There are five (5) specific types of storm drain inlet protection practices that vary according to their function, location, drainage area and availability of materials:

I. Excavated Drop Inlet Protection
II. Fabric Drop Inlet Protection
III. Stone & Block Drop Inlet Protection
IV. Sod Drop Inlet Protection
V. Curb Drop Inlet Protection

Design Criteria

Drainage Area - The drainage area for storm drain inlets should be in accordance with the specific type of inlet used. (Type I through Type V).

Type I - Excavated Drop Inlet Protection

Limit the drainage area to the inlet device to 1 acre. Excavated side slopes shall be no steeper than 2:1. The minimum depth shall be 1 foot and the maximum depth 2 feet as measured from the crest of the inlet structure. Shape the excavated basin to fit conditions with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency. The capacity of the excavated basin should be established to contain 900 cubic feet per acre of disturbed area. Weep holes, protected by the fabric and stone, should be provided for draining the temporary pool.

Inspect and clean the excavated basin after every storm. Sediment should be removed when 50 percent of the storage volume is achieved. This material should be incorporated in the site in a stabilized manner.

See details for Excavated Drop Inlet Protection in Figure 5A.12 on page 5A.27.

Type II - Fabric Drop Inlet Protection

Limit the drainage area to 1 acre per inlet device. Land area slope immediately surrounding this device should not exceed 1 percent. The maximum height of the fabric above the inlet crest shall not exceed 1.5 feet.

The top of the barrier should be maintained to allow overflow to drop into the drop inlet and not bypass the inlet to unprotected lower areas. Support stakes for fabric shall be a minimum of 3 feet long, spaced a maximum 3 feet apart. They should be driven close to the inlet so any overflow drops into the inlet and not on the unprotected soil. Improved performance and sediment storage volume can be obtained by excavating the area.

Inspect the fabric barrier after each rain event and make repairs as needed. Remove sediment from the pool area as necessary with care not to undercut or damage the filter fabric. Upon stabilization of the drainage area remove all materials and unstable sediment and dispose of properly. Bring the adjacent area of the drop inlet to grade, smooth and compact and stabilize in the appropriate manner to the site.

See Figure 5A.13 for Details for Filter Fabric Drop Inlet Protection on page 5A.28.

Type III - Stone and Block Drop Inlet Protection

Limit the drainage area to 1 acre at the drop inlet. The stone barrier should have a minimum height of 1 foot and a maximum height of 2 feet. Do not use mortar. The height should be limited to prevent excess ponding and bypass flow.

Recess the first course of blocks at least 2 inches below the crest opening of the storm drain for lateral support. Subsequent courses can be supported laterally if needed by placing a 2x4 inch wood stud through the block openings perpendicular to the course. The bottom row should have a few blocks oriented so flow can drain through the block to dewater the basin area.

The stone should be placed just below the top of the blocks on slopes of 2:1 or flatter. Place hardware cloth or wire mesh with 1/2 inch openings over all block openings to hold stone in place.

As an optional design, the concrete blocks may be omitted and the entire structure constructed of stone, ringing the outlet ("doughnut"). The stone should be kept at a 3:1 slope toward the inlet to keep it from being washed into the inlet. A level area 1 foot wide and four inches below the crest will further prevent wash. Stone on the slope toward the inlet should be at least 3 inches in size for stability and 1 inch or smaller away from the inlet to control flow rate. The elevation of the top of the stone crest must be maintained 6 inches lower than the ground elevation downslope from the inlet to insure that all storm flows pass over the stone into the storm drain and not past the structure. Temporary diking should be used as necessary to prevent bypass flow.

The barrier should be inspected after each rain event and repairs made where needed. Remove sediment as necessary to provide for accurate storage volume for subsequent rains. Upon stabilization of contributing drainage area remove all materials and any unstable soil and dispose of properly. Bring the disturbed area to proper grade, smooth, compact and stabilize in a manner appropriate to the site.

See Figure 5A.14 for Details for Stone and Block Drop Inlet Protection on page 5A.29.

Type IV - Sod Drop Inlet Protection

The drainage area should be limited to 2 acres and the velocity over the sod kept below 5 feet per second. Place the sod to form a turf mat completely covering the soil surface for a minimum distance of 4 feet from each side of the drop inlet where runoff will enter. The slope of the sodden area should not exceed 4:1. (This can be a permanent practice).

During the first 4 weeks, water sod as often as necessary to maintain moist soil to a depth of 2 inches. Maintain a grass height of a least 2 inches with no more than 1/3 the shoot height (grass leaf) removed in any mowing. Apply fertilizer and lime as necessary to maintain the desired growth and sod density.

See figure 5A.15 Details for Sod Drop Inlet Protection on page 5A.30.

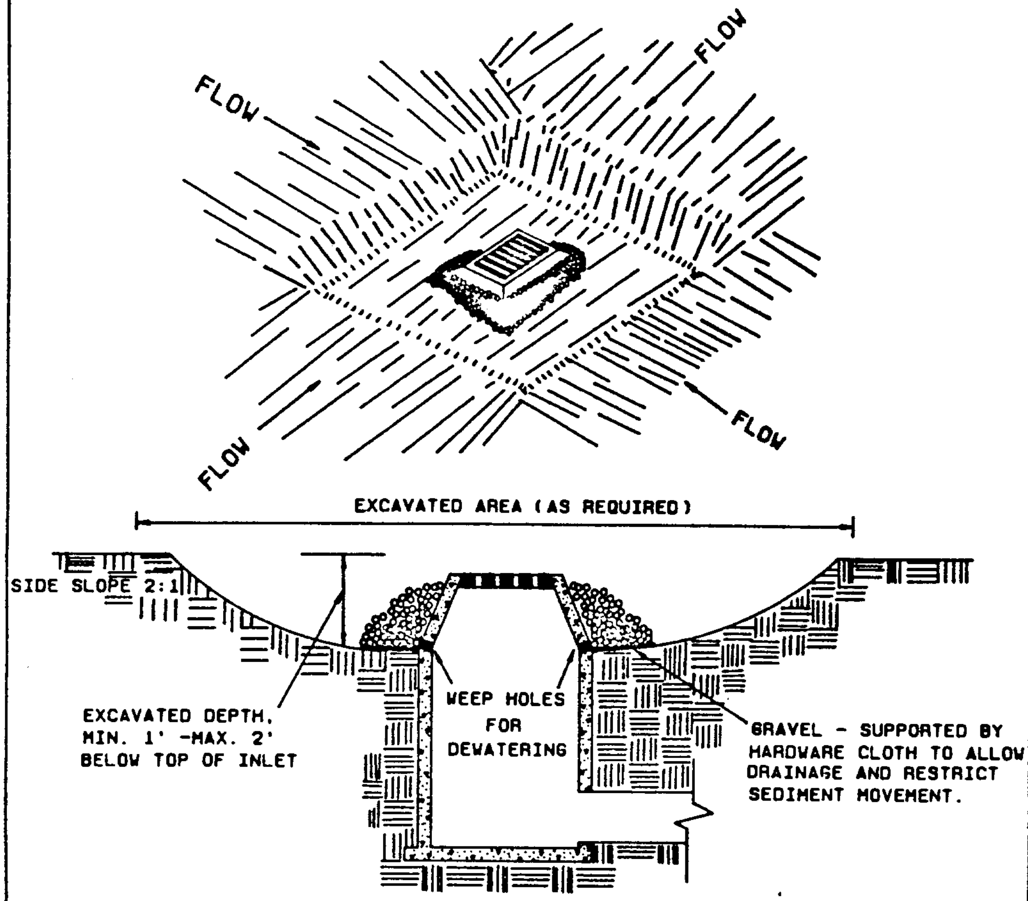
Type V - Curb Drop Inlet Protection

The drainage area should be limited to 1 acre at the drop inlet. The wire mesh must be of sufficient strength to support the filter fabric and stone with the water fully impounded against it. Stone is to be 2 inches in size and clean. The filter fabric must be of a type approved for this purpose with an equivalent opening size (EOS) of 40-85. The protective structure will be constructed to extend beyond the inlet 2 feet in both directions. Assure that storm flow does not bypass the inlet by installing temporary dikes directing flow into the inlet.

The structure should be inspected after every storm event. Any sediment should be removed and disposed of on the site. Any stone missing should be replaced. Check materials for proper anchorage and secure as necessary.

See Figure 5A.16 for Details for Curb Drop Inlet Protection on page 5A.31.

Figure 5A.12
Excavated Drop Inlet Protection Details



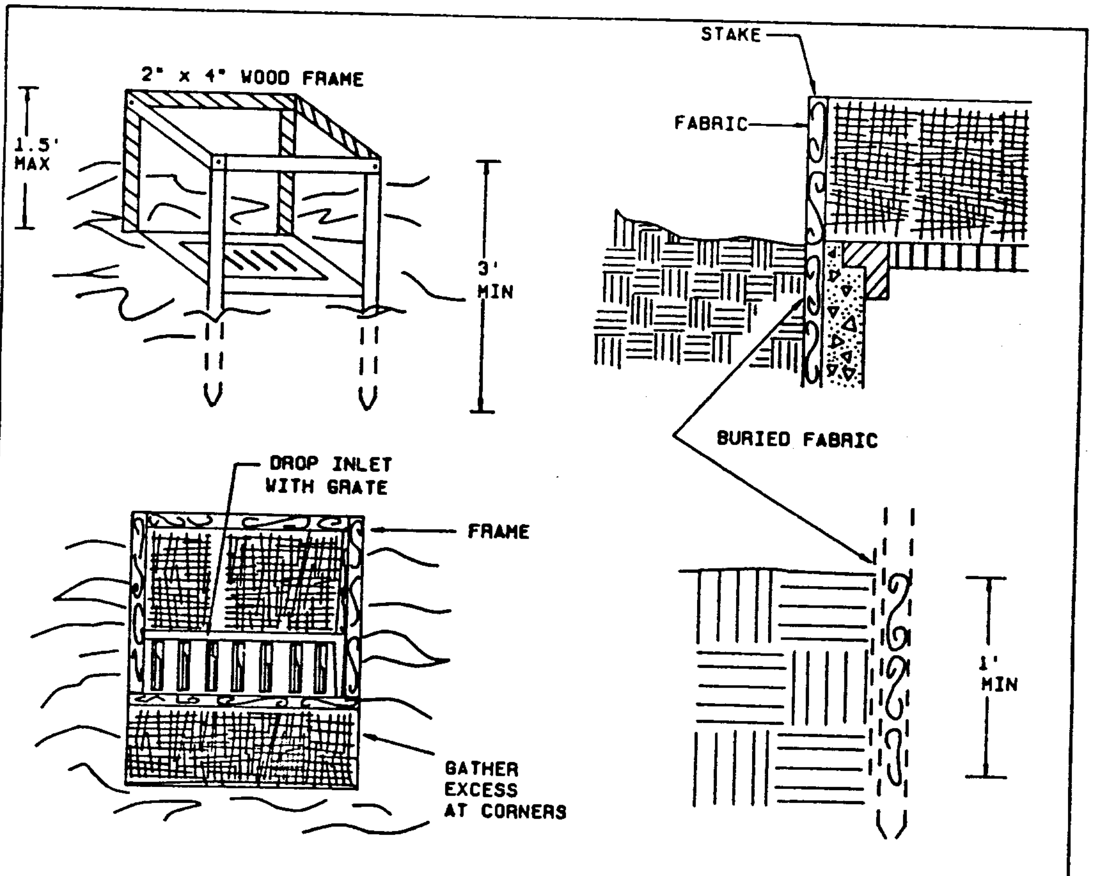
CONSTRUCTION SPECIFICATIONS

1. CLEAR THE AREA OF ALL DEBRIS THAT WILL HINDER EXCAVATION.
2. GRADE APPROACH TO THE INLET UNIFORMLY AROUND THE BASIN.
3. WEEP HOLES SHALL BE PROTECTED BY GRAVEL.
4. UPON STABLIZATION OF CONTRIBUTING DRAINAGE AREA, SEAL WEEP HOLES, FILL BASIN WITH STABLE SOIL TO FINAL GRADE, COMPACT IT PROPERLY AND STABLIZE WITH PERMANENT SEEDING.

MAXIMUM DRAINAGE AREA 1 ACRE

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	EXCAVATED DROP INLET PROTECTION	STANDARD SYMBOL 

Figure 5A.13
Filter Fabric Drop Inlet Protection Details



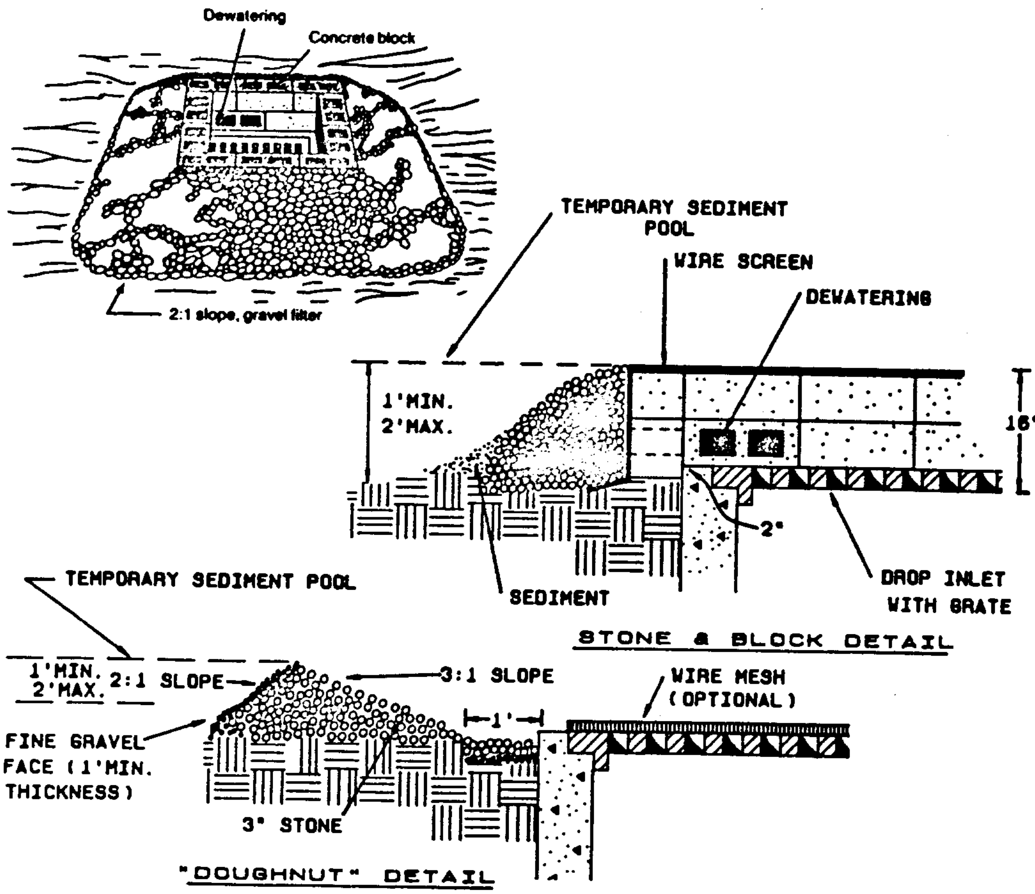
CONSTRUCTION SPECIFICATIONS

1. FILTER FABRIC SHALL HAVE AN EOS OF 40-85. BURLAP MAY BE USED FOR SHORT TERM APPLICATIONS.
2. CUT FABRIC FROM A CONTINUOUS ROLL TO ELIMINATE JOINTS. IF JOINTS ARE NEEDED THEY WILL BE OVERLAPPED TO THE NEXT STAKE.
3. STAKE MATERIALS WILL BE STANDARD 2" x 4" WOOD OR EQUIVALENT. METAL WITH A MINIMUM LENGTH OF 3 FEET.
4. SPACE STAKES EVENLY AROUND INLET 3 FEET APART AND DRIVE A MINIMUM 18 INCHES DEEP. SPANS GREATER THAN 3 FEET MAY BE BRIDGED WITH THE USE OF WIRE MESH BEHIND THE FILTER FABRIC FOR SUPPORT.
5. FABRIC SHALL BE EMBEDDED 1 FOOT MINIMUM BELOW GROUND AND BACKFILLED. IT SHALL BE SECURELY FASTENED TO THE STAKES AND FRAME.
6. A 2" x 4" WOOD FRAME SHALL BE COMPLETED AROUND THE CREST OF THE FABRIC FOR OVER FLOW STABILITY.

MAXIMUN DRAINAGE AREA 1 ACRE

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	FILTER FABRIC DROP INLET PROTECTION	STANDARD SYMBOL [IIII]

Figure 5A.14
Stone & Block Drop Inlet Protection Details



CONSTRUCTION SPECIFICATIONS

1. LAY ONE BLOCK ON EACH SIDE OF THE STRUCTURE ON ITS SIDE FOR DEWATERING. FOUNDATION SHALL BE 2 INCHES MINIMUM BELOW REST OF INLET AND BLOCKS SHALL BE PLACED AGAINST INLET FOR SUPPORT.
2. HARDWARE CLOTH OR 1/2" WIRE MESH SHALL BE PLACED OVER BLOCK OPENINGS TO SUPPORT STONE.
3. USE CLEAN STONE OR GRAVEL 1/2-3/4 INCH IN DIAMETER PLACED 2 INCHES BELOW THE TOP OF THE BLOCK ON A 2:1 SLOPE OR FLATTER.
4. FOR STONE STRUCTURES ONLY, A 1 FOOT THICK LAYER OF THE FILTER STONE WILL BE PLACED AGAINST THE 3 INCH STONE AS SHOWN ON THE DRAWINGS.

MAXIMUM DRAINAGE AREA 1 ACRE

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STONE & BLOCK DROP INLET PROTECTION STRUCTURE	STANDARD SYMBOL

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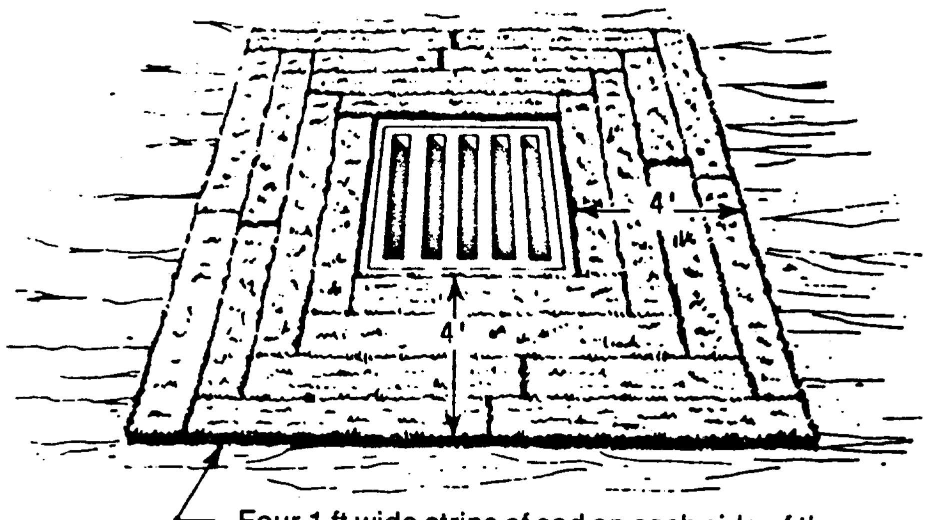
Figure 5A.15
Sod Drop Inlet Protection Details



CONSTRUCTION SPECIFICATIONS

1. BRING THE AREA TO BE SODDED TO FINAL GRADE ELEVATION WITH TOPSOIL. ADD FERTILIZER AND LIME AND INSTALL SOD IN ACCORDANCE WITH THE PRACTICE ON SODDING.
2. LAY ALL SOD STRIPS PERPENDICULAR TO THE DIRECTION OF FLOW.
3. MAINTAIN A MINIMUM WIDTH OF 4 FEET IN ALL FLOW DIRECTIONS.
4. SOD STRIPS SHALL BE STAGGERED SO ADJACENT STRIP ENDS ARE NOT ALIGNED.

MAXIMUM DRAINAGE AREA 2 ACRES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	SOD DROP INLET PROTECTION	STANDARD SYMBOL

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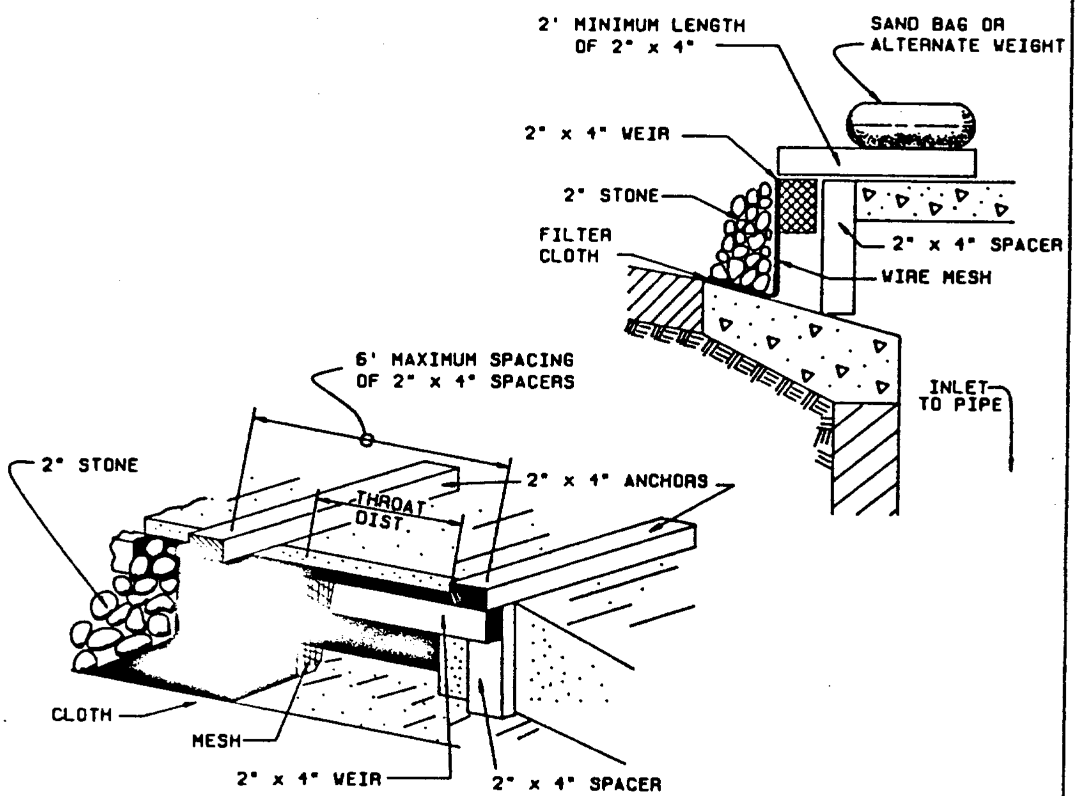
Figure 5A.16
Curb Drop Inlet Protection Details



CONSTRUCTION SPECIFICATIONS

1. FILTER FABRIC SHALL HAVE AN EOS OF 40-85.
2. WOODEN FRAME SHALL BE CONSTRUCTED OF 2" x 4" CONSTRUCTION GRADE LUMBER.
3. WIRE MESH ACROSS THROAT SHALL BE A CONTINUOUS PIECE 30 INCH MINIMUM WIDTH WITH A LENGTH 4 FEET LONGER THAN THE THROAT. IT SHALL BE SHAPED AND SECURELY NAILED TO A 2" x 4" WEIR.
4. THE WEIR SHALL BE SECURELY NAILED TO 2" x 4" SPACERS 9 INCHES LONG SPACED NO MORE THAN 6 FEET APART.
5. THE ASSEMBLY SHALL BE PLACED AGAINST THE INLET AND SECURED BY 2" x 4" ANCHORS 2 FEET LONG EXTENDING ACROSS THE TOP OF THE INLET AND HELD IN PLACE BY SANDBAGS OR ALTERNATE WEIGHTS.

MAXIMUM DRAINAGE AREA 1 ACRE

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	CURB GUTTER INLET PROTECTION STRUCTURE	STANDARD SYMBOL

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STANDARD AND SPECIFICATIONS FOR SEDIMENT TRAP

Definition

A temporary sediment control device formed by excavation and/or embankment to intercept sediment laden runoff and to retain the sediment.

Purpose

The purpose of the structure is to intercept sediment laden runoff and trap the sediment in order to protect drainage ways, properties, and right-of-way below the sediment trap from sedimentation.

Conditions Where Practice Applies

A sediment trap is usually installed in a drainage way, at a storm drain inlet, or other points of discharge from a disturbed area.

Sediment traps should not be used to artificially break up a natural drainage area into smaller sections where a larger device (sediment basin) would be better suited.

Design Criteria

If any of the design criteria presented here cannot be met, see Standard and Specifications for Sediment Basin on page 5A.47.

Drainage Area

The drainage area for sediment traps shall be in accordance with the specific type of sediment trap used (Type I through VI).

Location

Sediment traps shall be located so that they can be installed prior to grading or filling in the drainage area they are to protect. Traps must not be located any closer than 20 feet from a proposed building foundation if the trap is to function during building construction. Locate traps to obtain maximum storage benefit from the terrain, for ease of cleanout and disposal of the trapped sediment.

Trap Size

The volume of a sediment trap as measured at the elevation of the crest of the outlet shall be at least 1800 cubic feet per acre of drainage area. The volume of a constructed trap shall be calculated using standard mathematical procedures. The volume of a natural sediment trap may be approximated by the equation; Volume (cu. ft.) = 0.4 x surface area (sq. ft.) x maximum depth (ft.).

Trap Cleanout

Sediment shall be removed and the trap restored to the original dimensions when the sediment has accumulated to 1/2 of the design depth of the trap. Sediment removed from the trap shall be deposited in a protected area and in such a manner that it will not erode.

Embankment

All embankments for sediment traps shall not exceed five (5) feet in height as measured at the low point of the original ground along the centerline of the embankment. Embankments shall have a minimum four (4) foot wide top and side slopes of 2:1 or flatter. The embankment shall be compacted by traversing with equipment while it is being constructed.

The elevation of the top of any dike directing water to any sediment trap will equal or exceed the maximum height of the outlet structure along the entire length of the trap.

Excavation

All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimal. Excavated portions of sediment traps shall have 1:1 or flatter slopes.

Outlet

The outlet shall be designed, constructed and maintained in such a manner that sediment does not leave the trap and that erosion at or below the outlet does not occur.

Sediment traps must outlet onto stabilized (preferably undisturbed) ground, into a watercourse, stabilized channel, or into a storm drain system.

Trap Details Needed on Erosion and Sediment Control Plans

There is no standard symbol for a sediment trap. Each trap shall be delineated on the plans in such manner that it will not be confused with any other features. Each trap on a plan shall indicate all the information necessary to properly construct and maintain the structure. If the drawings are such that this information cannot be delineated on the drawings, then a table shall be developed. If a table is developed, then each trap on a plan shall have a number and the numbers shall be consecutive.

The following information shall be shown for each trap in a summary table form on the plans.

1. Trap number
2. Type of trap
3. Drainage area
4. Storage required
5. Storage provided (if applicable)
6. Outlet length or pipe sizes
7. Storage depth below outlet or cleanout elevation
8. Embankment height and elevation (if applicable)

Type of Sediment Traps

There are six (6) specific types of sediment traps which vary according to their function, location or drainage area.

I. Pipe Outlet Sediment Trap
II. Grass Outlet Sediment Trap
III. Storm Inlet Sediment Trap
IV. Swale Sediment Trap
V. Stone Outlet Sediment Trap
VI. Riprap Outlet Sediment Trap

I. Pipe Outlet Sediment Trap

A Pipe Outlet Sediment Trap consists of a trap formed by embankment or excavation. The outlet for the trap is through a perforated riser and a pipe through the embankment. The outlet pipe and riser shall be made of corrugated metal. The top of the embankment shall be at least 1 1/2 feet above the crest of the riser. The top 2/3 of the riser shall be perforated with one (1) inch nominal diameter holes or slits spaced six (6) inches vertically and horizontally placed in the concave portion of the corrugated pipe.

No holes or slits will be allowed within six (6) inches of the top of the horizontal barrel. All pipe connections shall be watertight. The riser shall be wrapped with 1/2 to 1/4 inch hardware clothwire then wrapped with filter cloth (Mirafi lOOX, Poly Filter GB or a filter cloth with an equivalent sieve size between #40-80) and secured with strapping or connecting band at the top and bottom of the cloth. The cloth shall cover an area at least six (6) inches above the highest hole and six (6) inches below the lowest hole. The top of the riser pipe shall not be covered with filter cloth. The riser shall have a base with sufficient weight to prevent flotation of the riser. Two approved bases are:

1. A concrete base 12 in. thick with the riser embedded 9 in. into the concrete base, or
2. One quarter inch, minimum, thick steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2.5 feet of stone, gravel, or earth placed on it to prevent flotation. In either case, each side of the square base measurement shall be the riser diameter plus 24 inches.

Pipe outlet sediment traps shall be limited to a five (5) acres maximum drainage area. Pipe outlet sediment traps may be interchangeable in the field with stone outlet or riprap sediment traps provided that these sediment traps are constructed in accordance with the detail and specifications for that trap.

Select pipe diameter from the following table:

Minimum Sizes Barrel Diameter[1] (in.)	Riser Diameter[1] (in.)	Maximum Drainage Area (ac.)
12	15	1
15	18	2
18	21	3
21	24	4
21	27	5

[1] Barrel diameter may be same size as riser diameter.

See details for Pipe Outlet Sediment Trap ST-I in Figure 5A.17 (1) and 5A.17 (2) on pages 5A.36 and 5A.37.

II. Grass Outlet Sediment Trap

A Grass Outlet Sediment Trap consists of a trap formed by excavating the earth to create a holding area. The trap has a discharge point over natural existing grass. The outlet length (feet) shall be equal to four (4) times the drainage area (acres) and a minimum length of four (4) feet. The outlet shall be free of any restrictions to flow. The outlet lip must remain undisturbed and level. The volume of this trap shall be computed at the elevation of the crest of the outlet. Grass outlet sediment traps shall be limited to a five (5) acre maximum drainage area.

See Details for Grass Outlet Sediment Trap ST-II in Figure 5A.18 on page 5A.38.

III. Storm Inlet Sediment Trap

A Storm Inlet Sediment Trap consists of a basin formed by excavation on natural ground that discharges through an opening in a storm drain inlet structure. This opening can either be the inlet opening or a temporary opening made by omitting bricks or blocks in the inlet.

A yard drain inlet or an inlet in the median strip of a dual highway could use the inlet opening for the tap outlet. The trap should be out of the roadway so as not to interfere with future compaction or construction. Placing the trap on the opposite side of the opening and diverting water from the roadway to the trap is one means of doing this. Storm inlet sediment traps shall be limited to a three (3) acre maximum drainage area. The volume of this trap is measured at the elevation of the crest of the outlet (invert of the inlet opening).

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See Details for Storm Inlet Sediment Trap ST-III in Figure 5A.19 on page 5A.39.

IV. Swale Sediment Trap

A Swale Sediment Trap consists of a trap formed by over excavating a swale or a drainage ditch. The outlet of the swale sediment trap is controlled by the invert of the downstream swale. Swale sediment traps are placed in surface drain ditches just before the runoff water leaves the property, enters a watercourse at the end of cut sections, or immediately preceding ditch inlets or stabilized outlets. Often a section of concrete liner is left out to construct the swale trap in that section. Once the contributory drainage area is stabilized, the trap may be removed and the swale or ditch reconstructed. The swale sediment trap shall be used only where no other device is feasible. The swale sediment trap shall be limited to a maximum drainage area of two (2) acres. The volume of this trap shall be computed at the elevation of the invert of the outlet.

See Details for Swale Sediment Trap ST-IV in Figure 5A.20 on Page 5A.40.

V. Stone Outlet Sediment Trap

A Stone Outlet Sediment Trap consists of a trap formed by an embankment or excavation. The outlet of this trap is over a stone section placed on level ground. The minimum length (feet) of the outlet shall be equal to four (4) times the drainage area (acres).

Required storage shall be 1,800 cubic feet per acre of drainage area.

The outlet crest (top of stone in weir section) shall be level, at least one (1) foot below top of embankment and no more than one (1) foot above ground beneath the outlet. Stone used in the outlet shall be small riprap (4 in. x 8 in.). To provide more efficient trapping effect, a layer of filter cloth should be embedded one (1) foot back into the upstream face of the outlet stone or a one (1) foot thick layer of two (2) inch or finer aggregate shall be placed on the upstream face of the outlet.

Stone Outlet Sediment Traps may be interchangeable in the field with pipe or riprap outlet sediment traps provided they are constructed in accordance with the detail and specifications for those traps. Stone outlet sediment traps shall be limited to a five (5) acre maximum drainage area.

See Details for Outlet Sediment Trap ST-V in Figure 5A.21 on page 5A.41.

VI. Riprap Outlet Sediment Trap

A Riprap Outlet Sediment Trap consists of a trap formed by an excavation and embankment. The outlet for this trap shall be through a partially excavated channel lined with riprap. This outlet channel shall discharge onto a stabilized area or to a stable watercourse. The riprap outlet sediment trap may be used for drainage areas of up to a maximum of 15 acres.

Design Criteria for Riprap Outlet Sediment Trap

1. The total contributing drainage area (disturbed or undisturbed either on or off the developing property) shall not exceed 15 acres.
2. The storage needs for this trap shall be computed using 1800 cubic feet of required storage for each acre of drainage area. The storage volume provided can be figured by computing the volume of storage area available behind the outlet structure up to an elevation of one (1) foot below the level weir crest.
3. The maximum height of embankment shall not exceed five (5) feet.
4. The elevation of the top of any dike directing water to a riprap outlet sediment trap will equal or exceed the minimum elevation of the embankment along the entire length of this trap.

Riprap Outlet Sediment Trap ST-VI
(for Stone Lined Channel)

Contributing Drainage Area (ac.)	Depth of Channel (a) (ft.)	Length of Weir (b) (ft.)
1	1.5	4.0
2	1.5	5.0
3	1.5	6.0
4	1.5	10.0
5	1.5	12.0
6	1.5	14.0
7	1.5	16.0
8	2.0	10.0
9	2.0	10.0
10	2.0	12.0
11	2.0	14.0
12	2.0	14.0
13	2.0	16.0
14	2.0	16.0
15	2.0	18.0

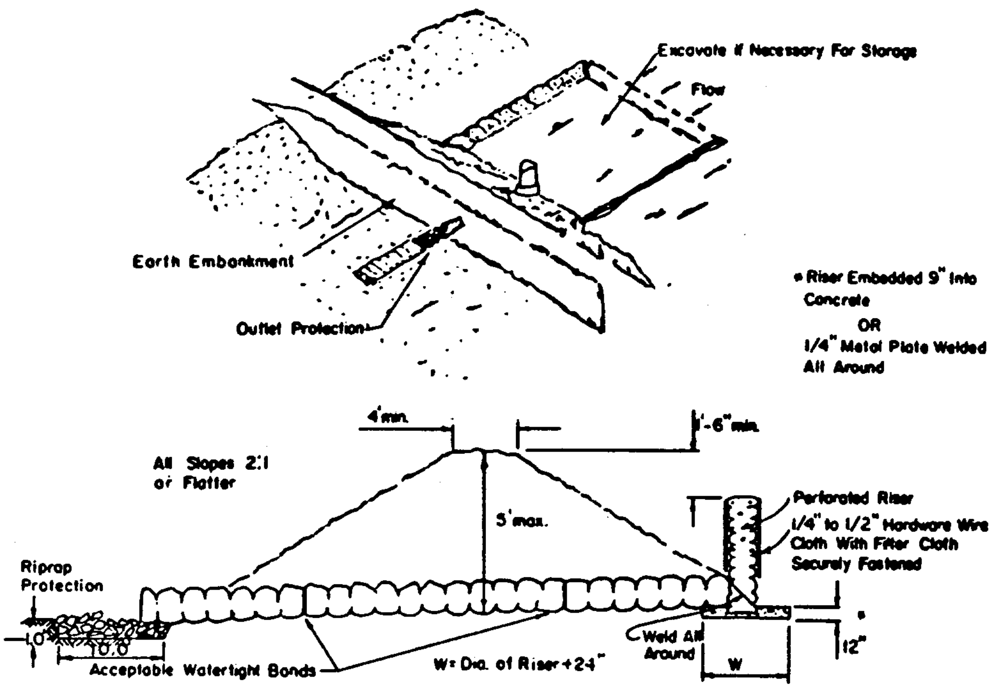
See Details for Riprap Outlet Sediment Trap ST-VI on Figure 5A.22 on page 5A.42.

Optional Dewatering Methods

Optional dewatering devices may be designed for use with sediment traps. Included are two methods which may be used. See Figure 5A.23 on page 5A.44 for details.

Figure 5A.17 (1)
Pipe Outlet Sediment Trap: ST-I

PIPE OUTLET SEDIMENT TRAP ST-I



EMBANKMENT SECTION THRU RISER

SIZES OF PIPE NEEDED

Barrel Diameter ________.

Riser Diameter ________.

Note:

Construction Specification should be attached to this detail to complete design.

Max. Drainage Area: 5 Acres

U.S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PIPE OUTLET SEDIMENT TRAP ST-I 1 of 2	STANDARD DRAWING

Figure 5A.17 (2)
Pipe Outlet Sediment Trap: ST-I - Construction Specifications

CONSTRUCTION SPECIFICATION FOR PIPE OUTLET TRAP: ST-1

1. AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS OR OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, ROCKS, ORGANIC MATERIAL, OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED.
3. VOLUME OF SEDIMENT STORAGE SHALL BE 1800 CUBIC FEET PER ACRE OF CONTRIBUTORY DRAINAGE.
4. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND IN SUCH A MANNER THAT IT WILL NOT ERODE.
5. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRS MADE AS NEEDED.
6. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION ARE MINIMIZED.
7. THE STRUCTURE SHALL BE REMOVED AND AREA STABILIZED WHEN THE DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.
8. ALL FILL SLOPES SHALL BE 2:1 OR FLATTER; CUT SLOPES 1:1 OR FLATTER.
9. ALL PIPE CONNECTIONS SHALL BE WATERTIGHT.
10. THE TOP 2/3 OF THE RISER SHALL BE PERFORATED WITH ONE (1) INCH DIAMETER HOLES OR SLITS SPACED SIX (6) INCHES VERTICALLY AND HORIZONTALLY AND PLACED IN THE CONCAVE PORTION OF PIPE. NO HOLES WILL BE ALLOWED WITHIN SIX (6) INCHES OF THE HORIZONTAL BARREL.
11. THE RISER SHALL BE WRAPPED WITH 1/4 TO 1/2 INCH HARDWARE CLOTH WIRE THEN WRAPPED WITH FILTER CLOTH (HAVING AN EQUIVALENT SIEVE SIZE OF 40-80). THE FILTER CLOTH SHALL EXTEND SIX (6) INCHES ABOVE THE HIGHEST HOLE AND SIX (6) INCHES BELOW THE LOWEST HOLE. WHERE ENDS OF FILTER CLOTH COME TOGETHER, THEY SHALL BE OVER-LAPPED, FOLDED AND STAPLED TO PREVENT BYPASS.
12. STRAPS OR CONNECTING BANDS SHALL BE USED TO HOLD THE FILTER CLOTH AND WIRE FABRIC IN PLACE. THEY SHALL BE PLACED AT THE TOP AND BOTTOM OF THE CLOTH.
13. FILL MATERIAL AROUND THE PIPE SPILLWAY SHALL BE HAND COMPACTED IN FOUR (4) INCH LAYERS. A MINIMUM OF TWO (2) FEET OF HAND COMPACTED BACKFILL SHALL BE PLACED OVER THE PIPE SPILLWAY BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.
14. THE RISER SHALL BE ANCHORED WITH EITHER A CONCRETE BASE OR STEEL PLATE BASE TO PREVENT FLOTATION. FOR CONCRETE BASED THE DEPTH SHALL BE 12 INCHES WITH THE RISER EMBEDDED NINE (9) INCHES. A 1/4 INCH MINIMUM THICKNESS STEEL PLATE SHALL BE ATTACHED TO THE RISER BY A CONTINUOUS WELD AROUND THE BOTTOM TO FORM A WATERTIGHT CONNECTION AND THEN PLACE TWO (2) FEET OF STONE, GRAVEL, OR TAMPED EARTH ON THE PLATER.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PIPE OUTLET SEDIMENT TRAP ST-1 2 of 2	STANDARD SYMBOL

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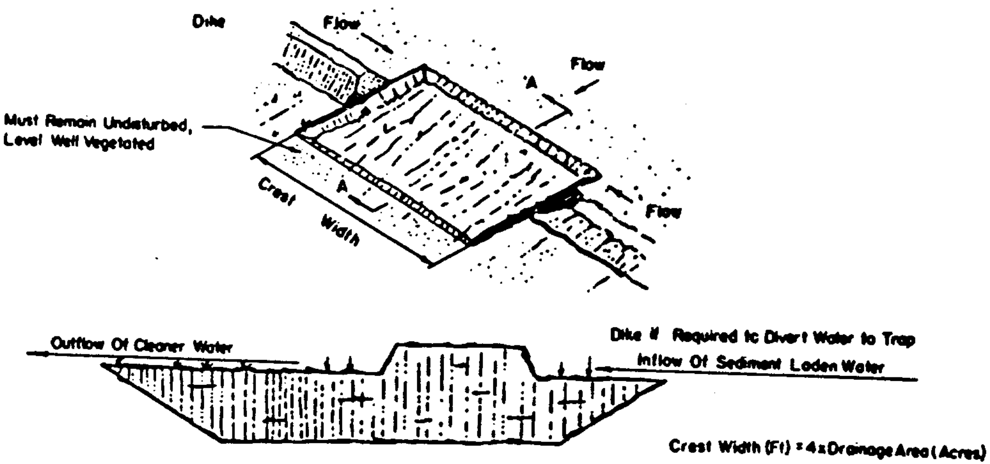
Figure 5A.18
Grass Outlet Sediment Trap: ST- II

GRASS OUTLET SEDIMENT TRAP ST-II



SECTION A-A

EXCAVATED GRASS OUTLET SEDIMENT TRAP

CONSTRUCTION SPECIFICATION FOR ST-II

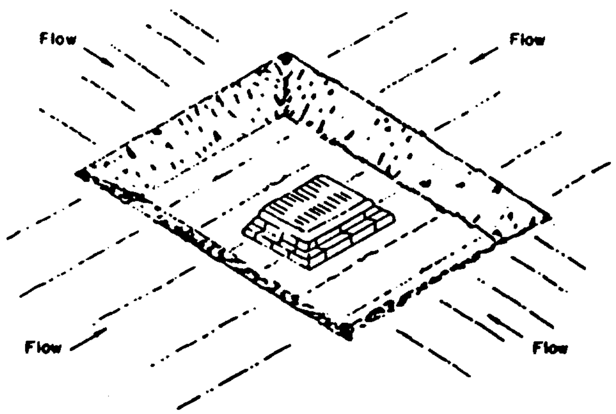
1. Volume of sediment storage shall be 1800 cubic feet per acre of contributory drainage area.
2. Minimum crest width shall be 4 X Drainage Area.
3. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to ½ the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.
4. The structure shall be inspected after each rain and repairs made as needed.
5. Construction operations shall be carried out in such a manner that erosion and water pollution shall be minimized.
6. The sediment trap shall be removed and area stabilized when the remaining drainage area has been properly stabilized.
7. All cut slopes shall be 1:1 or flatter.

Maximum Drainage Area: 5 Acres

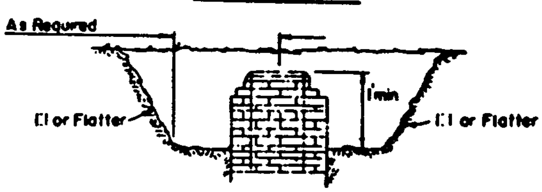
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	GRASS OUTLET SEDIMENT TRAP ST-II	STANDARD SYMBOL

Figure 5A.19
Storm Inlet Sediment Trap: ST-III

STORM INLET SEDIMENT TRAP ST-III



YARD DRAIN



CROSS SECTION

CONSTRUCTION SPECIFICATION FOR ST-III

1. Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to ½ the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

2. The volume of sediment storage shall be 1800 cubic feet per acre of contributory drainage.

3. The structure shall be inspected after each rain and repairs made as needed.

4. Construction operations shall be carried out in such a manner that erosion and water pollution shall be minimized.

5. The sediment trap shall be removed and the area stabilized when the constructed drainage area has been properly stabilized.

6. All cut slopes shall be 1:1 or flatter.

Maximum Drainage Area: 3 Acres

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STORM INLET SEDIMENT TRAP ST-III	STANDARD SYMBOL

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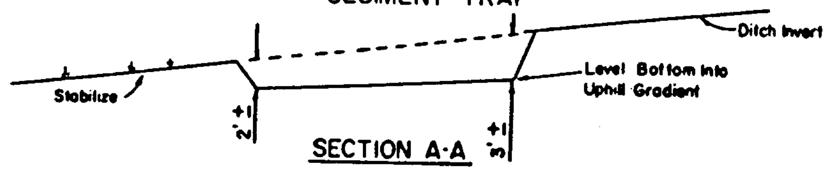
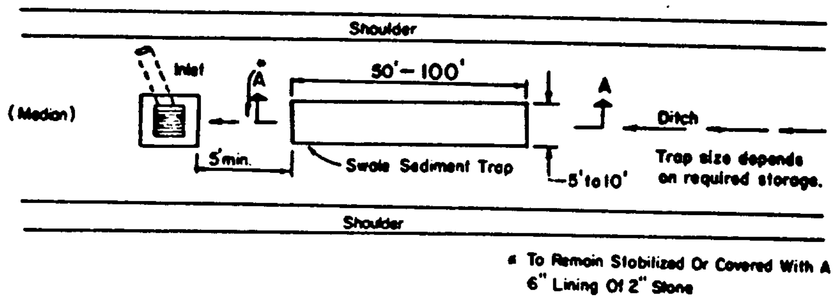
Figure 5A.20
Swale Outlet Sediment Trap: ST- IV

SEDIMENT TRAP



SWALE SEDIMENT TRAP



CONSTRUCTION SPECIFICATION FOR ST-IV

1. The swale sediment trap shall be constructed in accordance with the dimensions provided on the design drawings or sized to provide the minimum storage necessary 1800 cubic feet of storage for each acre of drainage area.

2. Sediment shall be removed and trap restored to its original dimensions when the sediment has accumulated to ½ the design depth of the trap. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

3. The structure shall be inspected after each rain and repairs made as needed.

4. Construction operations shall be carried out in such a manner that erosion and water pollution shall be minimized.

5. The sediment trap shall be removed and area stabilized when the contributory drainage area has been properly stabilized.

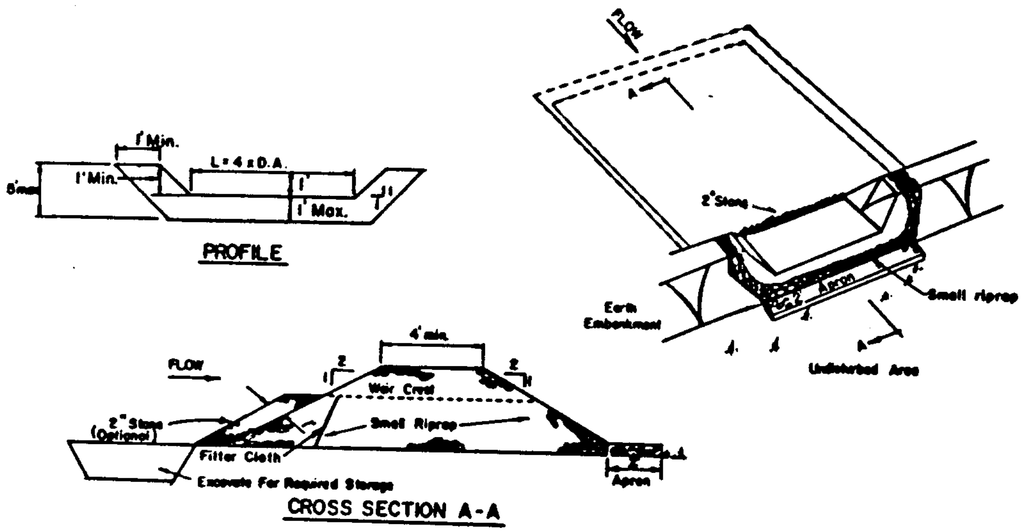
6. The swale sediment trap will be properly backfilled and the swale or ditch reconstructed.

Maximum Drainage Area: 2 Acres

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	SWALE SEDIMENT TRAP – ST IV	STANDARD SYMBOL

Figure 5A.21
Stone Outlet Sediment Trap: ST-V

STONE OUTLET SEDIMENT TRAP V



OPTION: A ONE FOOT LAYER OF 2" STONE MAY BE PLACED ON THE UPSTREAM SIDE OF THE RIPRAP IN PLACE OF THE EMBEDDED FILTER CLOTH.

CONSTRUCTION SPECIFICATIONS FOR ST-V

1. AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS AND OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, ROCKS, ORGANIC MATERIAL OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED.
3. ALL CUT AND FILL SLOPES SHALL BE 2:1 OR FLATTER.
4. THE STONE USED IN THE OUTLET SHALL BE SMALL RIPRAP 4"-8" ALONG WITH A 1' THICKNESS OF 2" AGGREGATE PLACED ON THE UP-GRADE SIDE ON THE SMALL RIPRAP OR EMBEDDED FILTER CLOTH IN THE RIPRAP.
5. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH TO THE TRAP.
6. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRS MADE AS NEEDED.
7. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION IS MINIMIZED.
8. THE STRUCTURE SHALL BE REMOVED AND THE AREA STABILIZED WHEN THE DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.

Maximum Drainage Area: 5 Acres

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STONE OUTLET SEDIMENT TRAP — V	STANDARD SYMBOL

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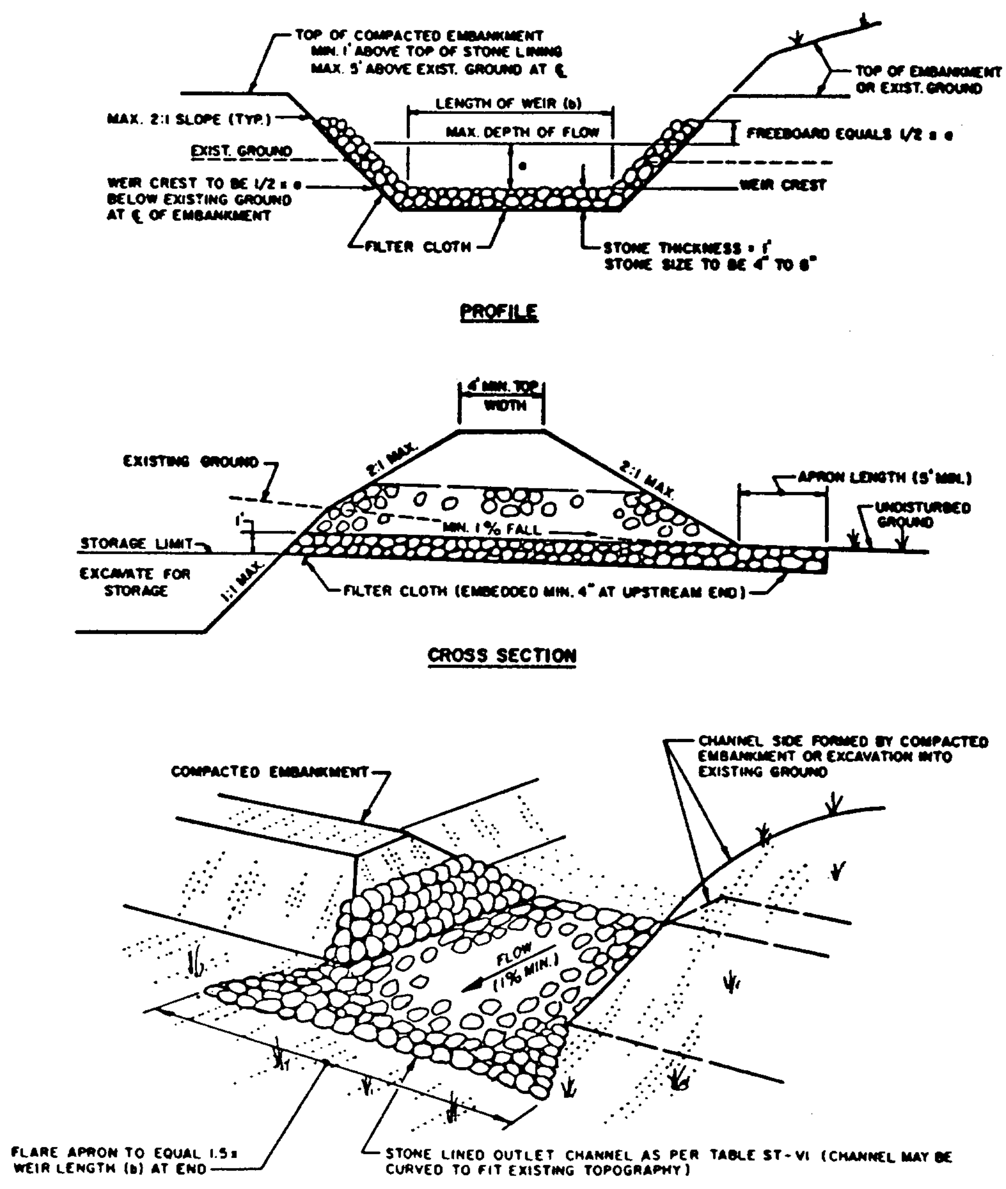
Fgure 5A.22 (1)
Riprap Outlet Sediment Trap: ST-VI

RIPRAP OUTLET SEDIMENT TRAP ST-VI



MAXIMUM DRAINAGE AREA = 15 ACRES

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	RIPRAP OUTLET SEDIMENT TRAP ST – VI 1 OF 2	STANDARD SYMBOL

Fgure 5A.22 (2)
Riprap Outlet Sediment Trap: ST-VI - Construction Specifications

CONSTRUCTION SPECIFICATION FOR RIPRAP OUTLET SEDIMENT TRAP = ST-VI

1. THE AREA UNDER EMBANKMENT SHALL BE CLEARED, GRUBBED AND STRIPPED OF ANY VEGETATION AND ROOT MAT. THE POOL AREA SHALL BE CLEARED.
2. THE FILL MATERIAL FOR THE EMBANKMENT SHALL BE FREE OF ROOTS OR OTHER WOODY VEGETATION AS WELL AS OVER-SIZED STONES, ROCKS, ORGANIC MATERIAL OR OTHER OBJECTIONABLE MATERIAL. THE EMBANKMENT SHALL BE COMPACTED BY TRAVERSING WITH EQUIPMENT WHILE IT IS BEING CONSTRUCTED. MAXIMUM HEIGHT OF EMBANKMENT SHALL BE FIVE (5) FEET, MEASURED AT CENTERLINE OF EMBANKMENT.
3. ALL FILL SLOPES SHALL BE 2:1 OR FLATTER, CUT SLOPES 1:1 OR FLATTER.
4. ELEVATION OF THE TOP OF ANY DIKE DIRECTING WATER INTO TRAP MUST EQUAL OR EXCEED THE HEIGHT OF EMBANKMENT.
5. STORAGE AREA PROVIDED SHALL BE FIGURED BY COMPUTING THE VOLUME AVAILABLE BEHIND THE OUTLET CHANNEL UP TO AN ELEVATION OF ONE (1) FOOT BELOW THE LEVEL WEIR CREST.
6. FILTER CLOTH SHALL BE PLACED OVER THE BOTTOM AND SIDES OF THE OUTLET CHANNEL PRIOR TO PLACEMENT OF STONE. SECTIONS OF FABRIC MUST OVERLAP AT LEAST ONE (1) FOOT WITH SECTION NEAREST THE ENTRANCE PLACED ON TOP. FABRIC SHALL BE EMBEDDED AT LEAST SIX (6) INCHES INTO EXISTING GROUND AT ENTRANCE OF OUTLET CHANNEL.
7. STONE USED IN THE OUTLET CHANNEL SHALL BE FOUR (4) TO EIGHT (8) INCHES (RIPRAP). TO PROVIDE A FILTERING EFFECT, A LAYER OF FILTER CLOTH SHALL BE EMBEDDED ONE (1) FOOT WITH SECTION NEAREST ENTRANCE PLACED ON TOP. FABRIC SHALL BE EMBEDDED AT LEAST SIX (6) INCHES INTO EXISTING GROUND AT ENTRANCE OF OUTLET CHANNEL.
8. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA AND IN SUCH A MANNER THAT IT WILL NOT ERODE.
9. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRED AS NEEDED.
10. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION ARE MINIMIZED.
11. THE STRUCTURE SHALL BE REMOVED AND THE AREA STABILIZED WHEN DRAINAGE AREA HAS BEEN PROPERLY STABILIZED.
12. DRAINAGE AREA FOR THIS PRACTICE IS LIMITED TO 15 ACRES OR LESS.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	RIPRAP OUTLET SEDIMENT TRAP ST-VI 2of2	STANDARD SYMBOL

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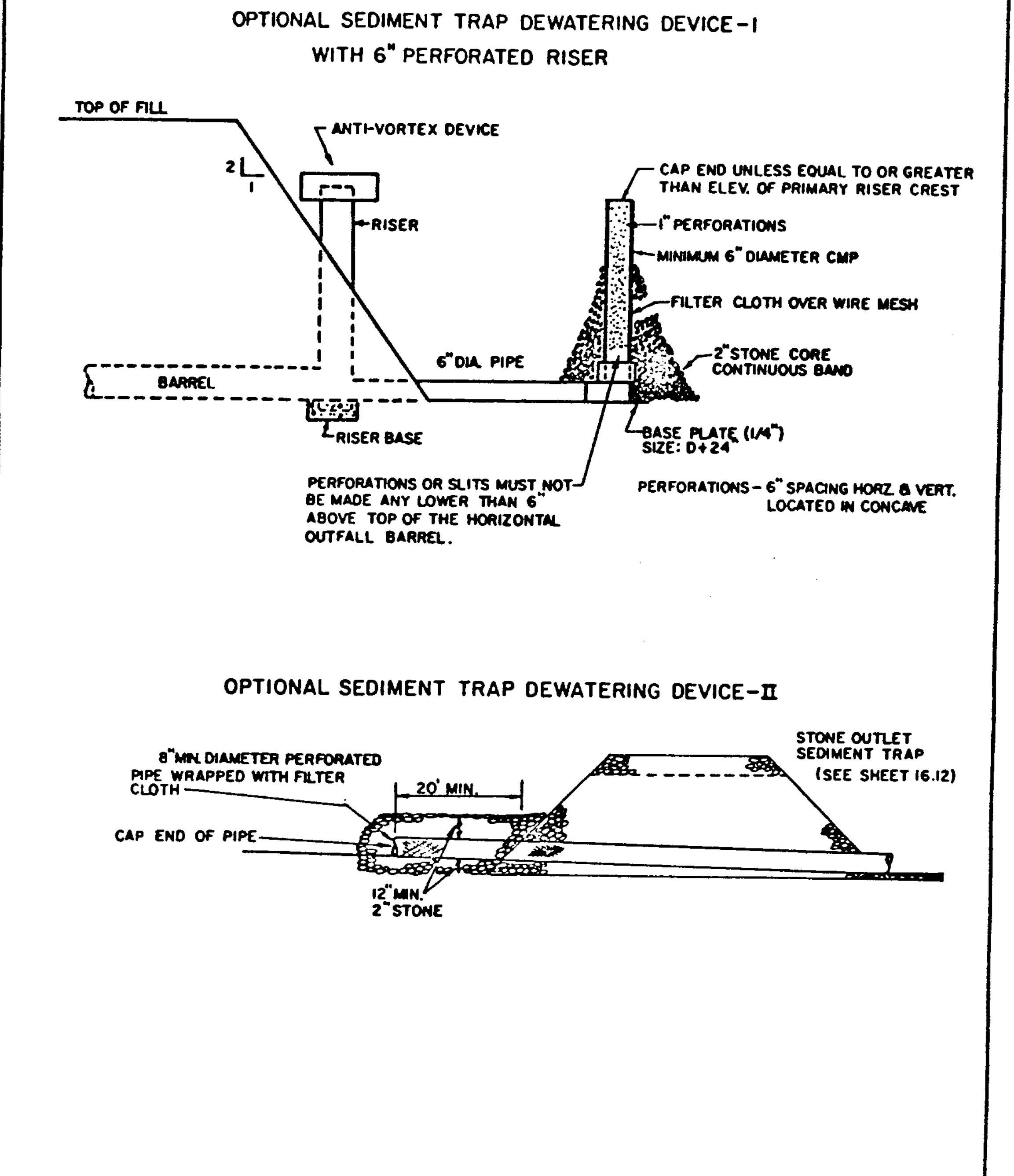
Figure 5A.23
Optional Sediment Trap Dewatering Devices



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	OPTIONAL SEDIMENT TRAP DEWATERING DEVICES	STANDARD SYMBOL

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R0039404

STANDARD AND SPECIFICATIONS FOR PORTABLE SEDIMENT TANK

Definition

A sediment tank is a compartmented tank container through which sediment laden water is pumped to trap and retain the sediment.

Purpose

To trap and retain sediment prior to pumping the water to drainageways, adjoining properities, and rights-of-way below the sediment tank site.

Conditions Where Practice Applies

A sediment tank is to be used on sites where excavations are deep, and space is limited, such as urban construction, where direct discharge of sediment laden water to stream and storm drainage systems is to be avoided.

Design Criteria

Location

The sediment tank shall be located for ease of clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities and pedestrian traffic.

Tank Size

The following formula should be used in determining the storage volume of the sediment tank; pump discharge (G.P.M.) x 16 = Cubic Foot Storage

An example of a typical sediment tank is shown on Figure 5A.24 on page 5A.46. Other container designs can be used if the storage volume is adequate and approval is obtained from the local approving agency.

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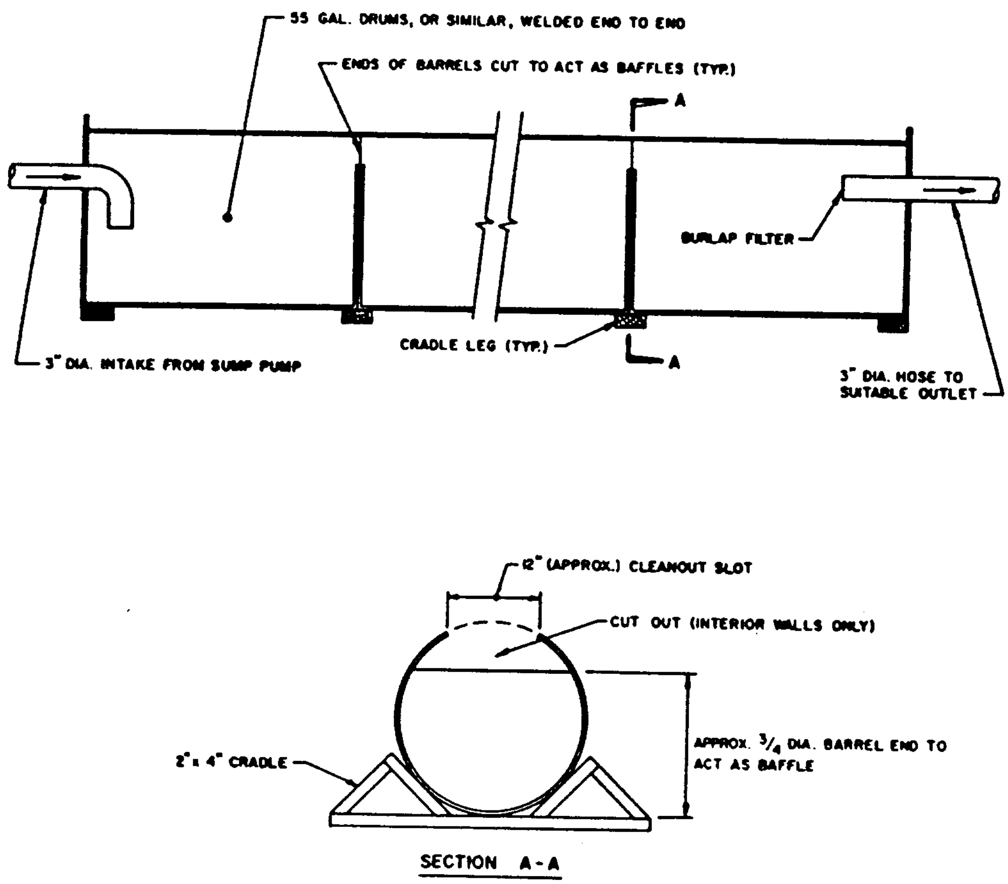
Figure 5A.24
Portable Sediment Tank

PORTABLE SEDIMENT TANK



CONSTRUCTION NOTES

1. CLEAN OUT THE SEDIMENT TANK WHEN ONE THIRD (1/3) FILLED WITH SILT.
2. STEEL DRUMS ARE USED AS AN EXAMPLE DUE TO THEIR READY AVAILABILITY ANY TANKS MAY BE USED, PROVINDING THAT THE VOLUME REQUIREMENTS ARE MET.
3. ALL SEDIMENT COLLECTED IN THE TANK SHALL BE DISPOSED OF IN A SEDIMENT TRAPPING DEVICE OR AS APPROVED BY THE INSPECTOR.

U S DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PORTABLE SEDIMENT TANK	STANDARD SYMBOL

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STANDARD AND SPECIFICATIONS FOR SEDIMENT BASIN

Definition

A temporary barrier or dam constructed across a drainage way or at other suitable locations to intercept sediment laden runoff and to trap and retain the sediment.

Scope

This standard applies to the installation of temporary sediment basins on sites where: (a) failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities; (b) the drainage area does not exceed 100 acres; and (c) the basin is to be removed within 36 months after the beginning of construction of the basin.

Permanent (to function more than 36 months) sediment basins, or temporary basins exceeding the classification requirements for class 1 and 2, or structures that temporarily function as a sediment basin but are intended for use as a permanent pool shall be classified as permanent structures and shall conform to criteria appropriate for permanent structures. These structures shall be designed and constructed to conform to SCS Standard and Specification No. 378 for Ponds in the National Handbook of Conservation Practices. The total volume of permanent sediment basins shall equal or exceed the capacity requirements for temporary basins contained herein.

Standard sediment basin designs can be used for drainage area of 10 or 20 acres. See Figures 5A.25 and 5A.26 on pages 5A.55 and 5A.56 for details.

Classification of Temporary Sediment Basins

For the purpose of this standard, temporary sediment basins are classified as follows:

Class	1	2
Max. Drainage Area (acres)	100	100
Max. Height[1] of Dam (ft.)	10	15
Min. Embankment Top Width (ft)	8	10
Embankment Side Slopes	2:1 or Flatter	2 1/2:1 or Flatter
Anti-Seep Collar Required	Yes	Yes

[1] Height is measured from the low point of original ground along the centerline of dam to the top of the dam.

Purpose

The purpose of a sediment basin is to intercept sediment laden runoff and reduce the amount of sediment leaving the disturbed area in order to protect drainage ways, properties, and rights-of-way below the sediment basin.

Conditions Where Practice Applies

A sediment basis is appropriate where physical site conditions or land ownership restrictions preclude the installation of other erosion control measures to adequately control runoff, erosion, and sedimentation. It may be used below construction operations which expose critical areas to soil erosion. The basin shall be maintained until the disturbed area is protected against erosion by permanent stabilization.

Design Criteria

Compliance with Laws and Regulations

Design and construction shall comply with state and local laws, ordinances, rules and regulations.

Location

The sediment basin should be located to obtain the maximum storage benefit from the terrain and for ease of cleanout of the trapped sediment. It should be located to minimize interference with construction activities and construction of utilities. Whenever possible, sediment basins should be located so that storm drains may outfall or be diverted into the basin. Do not locate basins in perennial streams.

Size of the Basin

The sediment storage volume of the basin, as measured from the bottom of the basin to the elevation of the crest of the principal spillway shall be at least 1,800 cubic feet per acre of distrubed area draining to the basin. This 1,800 cubic feet is equivalent to 1/2 inch of sediment per acre of drainage area. where possible, the entire drainage area is used for this computation, rather than the distrubed area above, to maximize trapping efficiency.

Sediment basins shall be cleaned out when the volume remaining as described above is reduced by sedimentation to 900 cubic feet per acre of drainage area (50 percent full), except in no case shall the sediment level be permitted to build up higher than one foot below the principal spillway crest. At this elevation cleanout shall be performed to restore the original design volume to the sediment basin.

The elevation corresponding to the maximum allowable sediment level shall be determined and shall be stated in the design data as a distance below the top of the riser and shall be clearly marked on the riser.

The basin dimensions necessary to obtain the required basin volume as stated above shall be clearly shown on the plans to facilitate plan review, construction and inspection.

Shape of the Basin

It is recommended that the designer of a sediment basin strive to incorporate the following features:

1. Length to width ratio greater than 2:1, where length is the distance between the inlet and outlet.
2. A wedge shape with the inlet located at the narrow end.

Spillway Design

Runoff shall be computed by the method outlined in Chapter 2, Estimating Runoff, Engineering Field Manual for Conservation Practices available in the Soil Conservation Service offices, Section 10 of this manual, or by TR-55, Urban Hydrology for Small Watersheds. Runoff computations shall be based upon the worst soil cover conditions expected to prevail in the contributing drainage area during the anticipated effective life of the structure. The combined capacities of the principal and emergency spillway shall be sufficient to pass the peak rate of runoff from a ten year frequency storm.

1. Principal spillway: A spillway consisting of a vertical pipe or box type riser joined (watertight connection) to a pipe (barrel) which shall extend through the embankment and outlet beyond the downstream toe of the fill. The minimum capacity of the principal spillway shall be 0.2 cfs per acre of drainage area when the water surface is at the emergency spillway crest elevation. For those basins with no emergency spillway, the principal spillway shall have the capacity to handle the peak flow from a ten year frequency rainfall event. The minimum size of the barrel shall be 8 inches in diameter. See Figures 5A.27, 5A.28 and 5A.29 on pages 5A.57, 5A.58 and 5A.59 for principal spillway sizes and capacities.

   A. Crest elevation: When used in combination with an emergency spill way, the crest elevation of the riser shall be a minimum one foot below the elevation of the control section of the emergency spillway.

   B. Watertight riser and barrel assembly: The riser and all pipe connection shall be completely watertight except for the inlet opening at the top or a dewatering opening and shall not have any other holes, leaks, rips or perforations in it.

   C. Dewatering the basin: There are two stages of dewatering the basin: (1) the detention pool which is below the crest of the riser and above the surface of the trapped sediment; and (2) the sediment itself which will have a high water content to the point of being "soupy".

      1) Individual dewatering methods may be dictated by the intended use of the basin, i.e., sediment, flyash, or other special materials, that are to be trapped and retained within the basin. If a dewatering device is needed it shall be included in the sediment basin plans submitted for approval and shall be installed during construction of the basin.

      Dewatering shall be done in such a manner as to remove the relatively clean water without removing any of the sediment that has settled out and without removing any appreciable quantities of floating debris. Dewatering sediments trapped in a basin are often advantageous to the developer or contractor. Relatively dry material can be handled with on-site equipment rather than the expensive draglines often needed to handle wet (undewatered) sediments. Usually, the detention pool may be dewatered by a siphon installed on the riser, mechanical pumping, and surface or subsurface drains. For details on these methods of dewatering, see Figure 5A.30 on page 5A.60.

      2) Dewatering the sediment is not required but some local ordinances may require some methods to dewater the basin and facilitate the cleanout process. One very successful means of doing this is by use of a dewatering device.

   D. Anti-vortex device and trash rack: An anti-vortex device and trash rack shall be securely installed on top of the riser and shall be the concentric type as shown in Figure 5A.31 on pages 5A.61 and 5A.62.

   E. Base: The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two approved bases for risers ten feet or less in height are: 1) a concrete base 18 in. thick with the riser embedded 9 in. in the base, and 2) a 1/4 in. minimum thickness steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have 2.5 feet of stone, gravel, or compacted earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter.

   For risers greater than ten feet high computations shall be made to design a base which will prevent flotation. The minimum factor of safety shall be 1.20 (Downward forces = 1.20 x upward forces). See Figure 5A.32 on page 5A.63 for details.

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F. Anti-Seep Collars: Anti-seep collars shall be installed around all conduits through earth fills of impoundment structures according to the following criteria:

1) Collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.

2) Collar spacing shall be between 5 and 14 times the vertical projection of each collar.

3) All collars shall be placed within the saturation zone.

4) The assumed normal saturation zone (phreatic line) shall be determined by projecting a line at a slope of 4 horizontal to 1 vertical from the point where the normal water (riser crest) elevation touches the upstream slope of the fill to a point where this line intersects the invert of the pipe conduit. All fill located within this line may be assumed as saturated.

When anti-seep collars are used, the equation for revised seepage length becomes:

$$2(N)(P) = 1.15(L_s) \text{ or } N = (0.075)(L_s)/P$$

Where: L_s = Saturated length is length, in feet, of pipe between riser and intersection of phreatic line and pipe invert.

N = number of anti-seep collars.

P = vertical projection of collar from pipe, in feet.

5) All anti-seep collars and their connections shall be watertight.

See Figure 5A.33 on pages 5A.64 and 5A.65 for anti-seep collar design and Figure 5A.34 on page 5A.66 for construction details.

G. Outlet: An outlet shall be provided, including a means of conveying the discharge in an erosion free manner to an existing stable channel. Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references will be shown on the erosion and sediment control plan.

Protection against scour at the discharge end of the pipe spillway shall be provided. Measures may include impact basin, riprap, revetment, excavated plunge pools, or other approved methods. See Standard and Specifications for Rock Outlet Protection, page 5B.21.

2. Emergency Spillways: The entire flow area of the emergency spillway shall be constructed in undisturbed ground (not fill). The emergency spillway cross-section shall be trapezoidal with a minimum bottom width of eight feet. This spillway channel shall have a straight control section of at least 20 feet in length; and a straight outlet section for a minimum distance equal to 25 feet.

A. Capacity: The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the 10 year 24-hour frequency storm, less any reduction due to flow in the pipe spillway. Emergency spillway dimensions may be determined by using the method described in Figure 5A.35 on page 5A.67.

B. Velocities: The velocity of flow in the exit channel shall not exceed 5 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the non-erosive range for the type of protection used.

C. Erosion Protection: Erosion protection shall be provided for by vegetation as prescribed in this publication or by other suitable means such as riprap, asphalt or concrete.

D. Freeboard: Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the settled embankment. If there is no emergency spillway it is the difference between the water surface elevation required to pass the design flow through the pipe and the top of the settled embankment. Freeboard shall be at least one foot.

Embankment Cross-Section

Class 1 Basins: The minimum top width shall be eight feet. The side slopes shall not be steeper than 2:1.

Class 2 Basins: The minimum top width shall be ten feet. The side slopes shall not be steeper than 2 1/2:1.

Entrance of Runoff Into Basin

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion. Considerable care should be given to the major points of inflow into basins. In many cases the difference in elevation of the inflow and the bottom of the basin is considerable, thus creating a potential for severe gullying and sediment generation. Often a riprap drop at major points of inflow would eliminate gullying and sediment generation.

Diversions, grade stabilization structures or other water control devices shall be installed as necessary to insure direction of runoff and protect points of entry into the basin. Points of entry should be located so as to insure

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maximum travel distance of entering runoff to point of exit (the riser) from the basin.

Disposal

The sediment basin plans shall indicate the method(s) of disposing of the sediment removed from the basin. The sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the basin, adjacent to a stream or floodplain. Disposal sites will be covered by an approved sediment control plan.

The sediment basis plans shall also show the method of disposing of the sediment basin after the drainage area is stabilized, and shall include the stabilization of the sediment basin site. Water contained within the storage area shall be removed from the basin by pumping, cutting the top of the riser, or other appropriate method prior to removing or breaching the embankment. Sediment shall not be allowed to flush into a stream or drainage way.

Safety

Sediment basins are attractive to children and can be very dangerous. Local ordinances and regulations must be adhered to regarding health and safety. The developer or owner shall check with local building officials on applicable safety requirements. If fencing of sediment basins is required, the location of and type of fence shall be shown on the plans.

Construction Specifications

Site Preparation

Areas under the embankment shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots or other objectionable material. In order to facilitate cleanout and restoration, the pool area (measured at the top of the pipe spillway) will be cleared of all brush, trees, and other objectionable materials.

Cutoff-Trench

A cutoff trench shall be excavated along the centerline of earth fill embankments. The minimum depth shall be two feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be four feet, but wide enough to permit operation of excavation and compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for embankment. The trench shall be dewatered during the backfilling/compaction operations.

Embankment

The fill material shall be taken from approved areas shown on the plans. It shall be clean mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable material. Relatively pervious materials such as said or gravel (Unified Soil Classes GW, GP, SW & SP) shall not be placed in the embankment. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain sufficient moisture so that it can be formed by hand into a ball without crumbling. If water can be squeezed out of a ball, it is too wet for proper compaction. Fill material shall be placed six inch to eight inch thick continuous layers over the entire length of the fill. Compaction shall be obtained by routing and hauling the construction equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement.

Pipe Spillway

The riser shall be securely attached to the barrel or barrel stub by welding the full circumference making a watertight structural connection. The barrel stub must be attached to the riser at the same percent (angle) of grade as the outlet conduit. The connection between the riser and the riser base shall be watertight. All connections between barrel sections must be achieved by approved watertight bank assemblies (See Figure 5A.36 on page 5A.69 for details). The barrel and riser shall be placed on a firm, smooth foundation of impervious soil. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the pipe or anti-seep collars. The fill material around the pipe spillway shall be placed in four inch layers and compacted under and around the pipe to at least the same density as the adjacent embankment.

A minimum depth of two feet of hand compacted backfill shall be placed over the pipe spillway before crossing it with construction equipment. Steel base plates on risers shall have at least 2 1/2 feet of compacted earth, stone or gravel placed over it to prevent flotation.

Emergency Spillway

The emergency spillway shall be installed in undisturbed ground. The achievement of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of +/- 0.2.

Vegetative Treatment

Stabilize the embankment and emergency spillway in accordance with the appropriate vegetative standard and specification immediately following construction. In no case shall the embankment remain unstabilized for more than seven (7) days.

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Erosion and Pollution Control

Construction operations shall be carried out in such a manner that erosion and water pollution will be minimized. State and local laws shall be complied with concerning pollution abatement.

Safety

State and local requirements shall be met concerning fencing and signs, warning the public of hazards of soft sediment and floodwater.

Maintenance

1. Repair all damages caused by soil erosion and construction equipment at or before the end of each working day.
2. Sediment shall be removed from the basin when it reaches the specified distance below the top of the riser. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain.

Final Disposal

When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the approved sediment control plan. The proposed use of a sediment basin site will often dictate final disposition of the basis and any sediment contained therein. If the site is scheduled for future construction, then the basin material and trapped sediments must be removed, safely disposed of, and backfilled with a structural fill.

When the basin area is to remain open space the pond may be pumped dry, graded and back filled.

Information to be Submitted

Sediment Basin designs and construction plans submitted for review to a local Soil and Water Conservation District, or other agency shall include the following:

1. Specific location of the basin.
2. Plan view of the storage basin and emergency spillway, showing existing and proposed contours.
3. Cross section of dam, principal spillway and emergency spillway and profile of emergency spillway.
4. Details of pipe connections, riser to pipe connections, riser base, anti-seep collars, trash rack cleanout elevation and anti-vortex device.
5. Runoff calculations for 10 year frequency storm, if required.
6. Storage Computation
   A. Total required
   B. Total available
   C. Level of sediment at which cleanout shall be required; to be stated as a distance from the riser crest to the sediment surface.
7. Calculations showing design of pipe and emergency spillway.

Note: Items 5 through 7 above may be submitted using the design data sheet on pages 5A.52 through 5A.55.

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TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET

Computed by____________ Date________ Checked by____________ Date________
Project ________________________________ Basin # ____________
Location ______________ Total Area draining to basin, ________________ Acres.

BASIN VOLUME DESIGN

1. Min. req'd vol. = 67 cu. yds. x ____ ac. drainage = _____ cu.yds.
2. Vol. of basin = ______________________ = _____ cu.yds.
3. Excavate ____________ cu. yds. to obtain required capacity

   Min. vol. before cleanout = 27 cu. yds. x ______ Ac. drainage = __________ Cu. yds.

   Elevation corresponding to scheduled time to clean out _______

   Distance below top of riser _______________.

DESIGN OF SPILLWAYS

Runoff

4. $Q_{p(10)}$ = _______________ cfs

   (EFM, Ch. 2, TR-55 or Section 10, attach runoff computation sheet).

Pipe Spillway (Q_{ps})

5. Min. pipe spillway cap., Q_{ps} = 0.2 x ___ ac. drainage = ____ cfs

   Note: If there is no emergency spillway, then req'd Q_{ps} = Q_p = ____ cfs.

6. H = ____ ft. Barrel length = ______ ft.
7. Barrel: Diam. ____ inches; Q_{ps} = (Q) ______ x (cor. fac.) ____ = _____ cfs.
8. Riser: Diam. ____ inches; Length ____ ft.; h = ____ ft.
9. Trash Rack: Diam. ____ inches; H = _____ inches.

Emergency Spillway Design

10. Emergency Spillway Flow, Q_{es} = Q_p - Q_{ps} = _____ - _____ = _____ cfs.
11. Width ___ ft.; H_p _____ ft.

    Entrance channel slope _________________ %

    Exit channel slope ____________________ %

ANTI-SEEP COLLAR DESIGN (If Required)

12. y = ____ ft.; z = ____ :1; pipe slope = _____ %, L_s = ____ ft.

    Use ____ collars, ____ - _____ inches square; projection = ____ ft.

DESIGN ELEVATIONS

13. Riser Crest = _______ Design High Water = _______

    Em. Spwy. Crest = _______ Top of Dam = _________

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TEMPORARY SEDIMENT BASIN DESIGN DATA SHEET INSTRUCTIONS FOR USE OF FORM

1. Minimum required detention volume is 67 cubic yards per acre from each acre of drainage area. Values larger than 67 cubic yards per acre may be used for greater protection. Compute volume using entire drainage area although only part may be disturbed.
2. The volume of a naturally shaped (no excavation in basin) basin may be approximated by the formula $V = (0.4)(A)(d)$, where V is in cubic feet, A is the surface area of the basin, in square feet, and d is the maximum depth of the basin, in feet. Volume may be computed from contour information or other suitable methods.
3. If volume of basin is not adequate for required storage, excavate to obtain the required volume.
4. The method described in Section 10 - TR-55 or the SCS Engineering Field Manual for Conservation Practices, Chapter 2, are the preferred methods for runoff computation. If rational method is used to compute runoff, obtain appropriate values for "I" and "C", depending on watershed conditions during development.
5. Required discharge from pipe spillway equals 0.2 cfs/ac. times total drainage area. (This is equivalent to a uniform runoff of 5 in. per 24 hours). The pipe shall be designed to carry Q_p if site conditions preclude installation of an emergency spillway to protect the structure.
6. Determine value of "H" from field conditions; "H" is interval between the centerline of the outlet pipe and the emergency spillway crest or if there is no emergency spillway, to the design high water.
7. See Pipe Spillway Design Charts, Figures 5A.28 and 5A.29 on pages 5A.58 and 5A.59.
8. See Riser Inflow Curves, Figure 5A.27 on page 5A.57.
9. See Trash Rack and Anti-Vortex Device Design, Figures 5A.31 on page 5A.61.
10. Compute Q_{es} by subtracting actual flow carried by the pipe spillway from the total inflow, Q_p.
11. Use appropriate tables to obtain values of H_p, bottom width, and actual Q_{es}. If no emergency spillway is to be used, so state, giving reason(s).
12. See Anti-Seep Collar Design.
13. Fill in design elevations. The emergency spillway crest must be set no closer to riser crest than value of h which causes pipe spillway to carry the minimum required Q. Therefore, the elevation difference between spillways shall be equal to the value of h, or one foot, whichever is greater. Design high water is the elevation of the emergency spillway crest plus the value of Hp, or if there is no emergency spillway, it is the elevation of the riser crest plus h required to handle the 10 year storm. Minimum top of dam elevation requires 1.0 ft. of freeboard above design high water.

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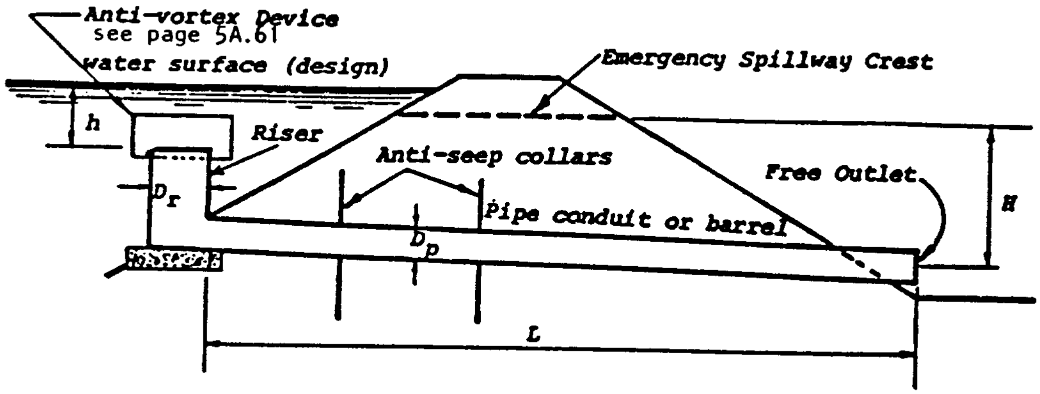
PIPE SPILLWAY DESIGN



H = Head on pipe spillway (pipe flow), ft. (centerline of outlet to emergency spillway crest or to design high water if no emergency spillway)

h = Head over riser crest, ft.

L = Length of pipe in ft.

D_p = Diameter of pipe conduit (barrel)

Dr = Diameter of riser

To use charts for pipe spillway design:

- Enter chart, Figures 5A.28 and 5A.29 on pages 5A.58 and 5A.59 with H and required discharge.
- Find diameter of pipe conduit that provides equal or greater discharge
- Enter chart, Figure 5A.27 on page 5A.57 with actual pipe discharge. Read across to select smallest riser that provides discharge within weir flow portion of rating curve. Read down to find corresponding h required.

Example:

Given: Q (required) = 5.8 cfs, L = 60 ft., H = 9 ft. to centerline of pipe = Free outlet

Find: Pipe size, actual Q and size of riser

Q of 12 in. pipe = 6.0 cfs x (correction factor) 1.07 = 6.4 cfs from the Pipe Flow Chart

From Riser Inflow Curves (Figure 5A.27 on page 5A.57), smallest riser = 18 in. (@ h = 0.6)

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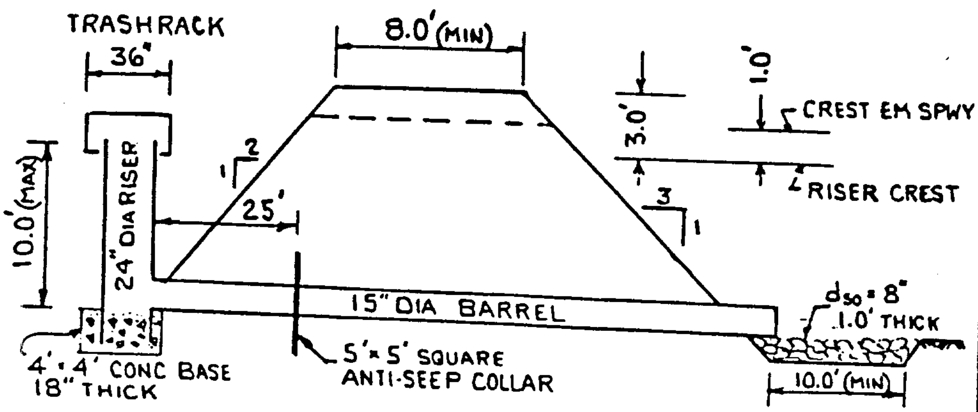
Figure 5A.25
Sediment Basin I

STANDARD SEDIMENT BASIN I

CONDITIONS WHERE PRACTICE APPLIES

1. Drainage area to the basin is 10 acres or less.
2. An emergency spillway is required.
3. One anti-seep collar shall be used and placed 25 feet from the riser.
4. Watertight bands shall be used.
5. All pipe material shall be of good quality with no holes.
6. Volume of storage computed as 1,800 C.F./acre of drainage area.



EMERGENCY SPILLWAY DESIGN

$Q_{ES} = Q_{PEAK} - Q_{PIPE}$ = 52 - 11 = 41 CFS

SIZE: WIDTH 12 FT : H_p = 1.2 FT

ENTRANCE SLOPE - POSITIVE

EXIT SLOPE - 2.8 % V = 4.4 FPS

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STANDARD SEDIMENT BASIN	STANDARD SYMBOL

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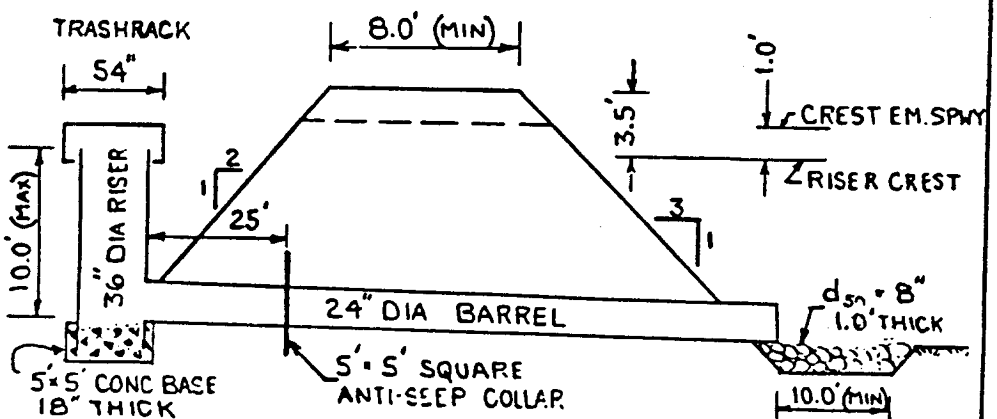
Figure 5A.26
Sediment Basin II

STANDARD SEDIMENT BASIN II

CONDITIONS WHERE PRACTICE APPLIES

1. Drainage area to the basin is 20 acres or less.
2. An emergency spillway is required.
3. One anti-seep collar shall be used, and placed 25 feet from the riser.
4. Watertight bands shall be used.
5. All pipe material shall be of good quality with no holes.
6. Volume of storage computed as 1,800 C.F./acre of drainage area.



EMERGENCY SPILLWAY DESIGN

$Q_{ES} = Q_{PEAK} - Q_{PIPE}$ = 88 - 35 = 53 CFS

SIZE: WIDTH 14 FT : H_P = 1.3 FT

ENTRANCE SLOPE - POSITIVE

EXIT SLOPE - 3.0% V = 4.6 FPS

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STANDARD SEDIMENT BASIN	STANDARD SYMBOL

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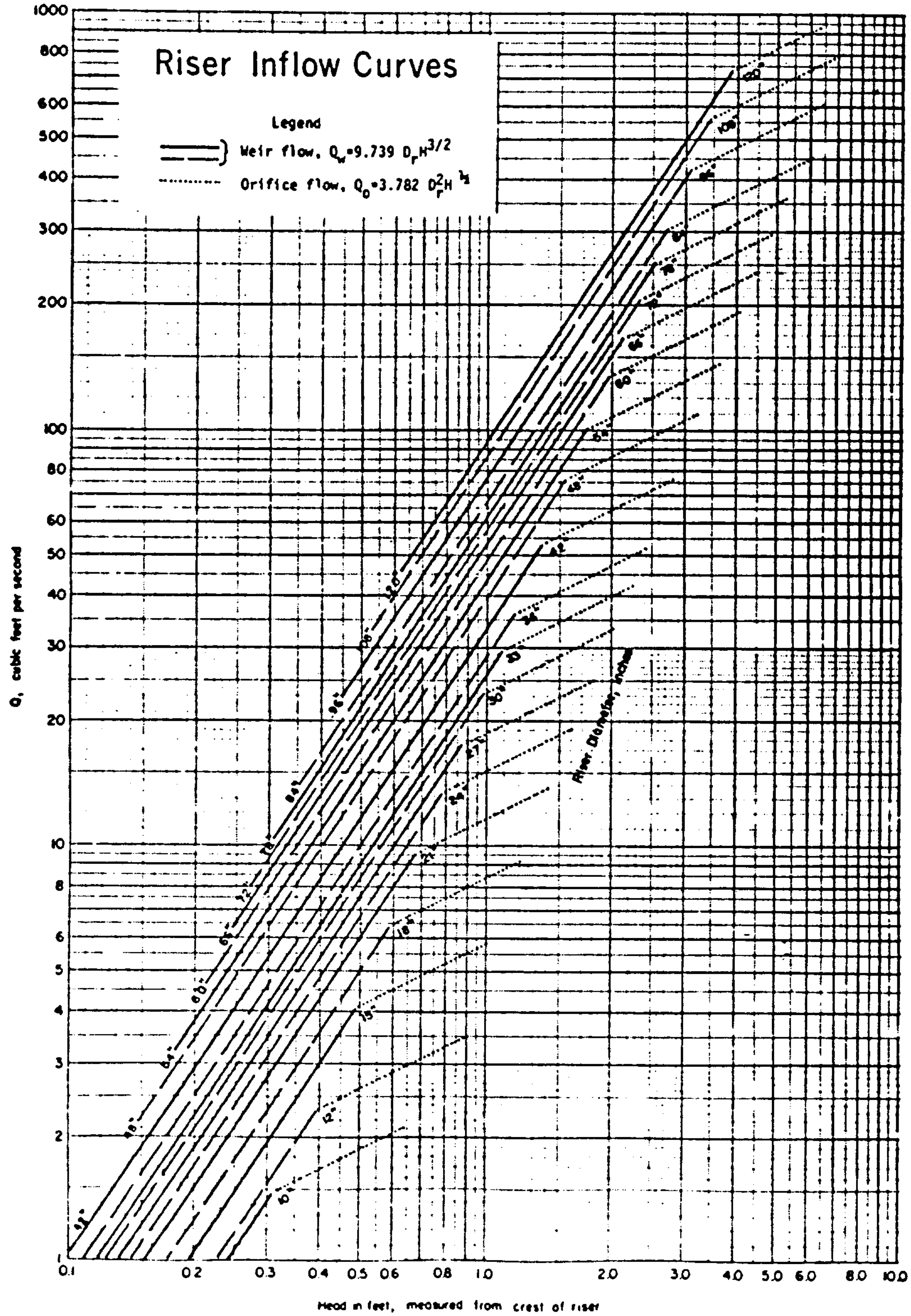
Figure 5A.27
Riser Inflow Chart



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PIPE FLOW CHART n = 0.025

FOR CORRUGATED METAL PIPE INLET $K_m = K_e + K_b = 1.0$ AND 70 FEET OF CORRUGATED METAL PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

diameter of pipe in inches

H, in feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
1	0.33	0.70	1.25	1.90	3.48	5.47	7.99	11.0	18.8	28.8	41.1	55.7	72.6	91.8	113	137	163	191	222	255	290
2	0.47	0.99	1.76	2.80	4.92	7.74	11.3	15.6	26.6	40.8	58.2	78.8	103	130	160	194	231	271	314	360	410
3	0.58	1.22	2.16	3.43	6.02	9.48	13.8	19.1	32.6	49.9	71.2	96.5	126	159	196	237	282	331	384	441	502
4	0.67	1.40	2.49	3.97	6.96	10.9	16.0	22.1	37.6	57.7	82.3	111	145	184	226	274	326	383	444	510	580
5	0.74	1.57	2.79	4.43	7.78	12.2	17.9	24.7	42.1	64.5	92.0	125	162	205	253	306	365	428	496	570	648
6	0.82	1.72	3.05	4.86	8.52	13.4	19.6	27.0	46.1	70.6	101	136	178	225	277	336	399	469	544	624	710
7	0.88	1.86	3.30	5.25	9.20	14.5	21.1	29.2	49.8	76.3	109	147	192	243	300	362	431	506	587	674	767
8	0.94	1.99	3.53	5.61	9.84	15.5	22.6	31.2	53.2	81.5	116	158	205	260	320	388	461	541	628	721	820
9	1.00	2.11	3.74	5.95	10.4	16.4	24.0	33.1	56.4	86.5	123	167	218	275	340	411	489	574	666	764	870
10	1.05	2.22	3.94	6.27	11.0	17.3	25.3	34.9	59.5	91.2	130	176	230	290	358	433	516	605	702	806	917
11	1.10	2.33	4.13	6.58	11.5	18.2	26.5	36.6	62.4	95.6	136	185	241	304	376	454	541	635	736	845	962
12	1.15	2.43	4.32	6.87	12.1	19.0	27.7	38.2	65.2	99.9	142	193	252	318	392	475	565	663	769	883	1004
13	1.20	2.53	4.49	7.15	12.6	19.7	28.8	39.8	67.8	104	148	201	262	331	408	494	588	690	800	919	1045
14	1.25	2.63	4.66	7.42	13.0	20.5	29.9	41.3	70.4	108	154	208	272	343	424	513	610	716	830	953	1085
15	1.29	2.72	4.83	7.60	13.5	21.2	30.9	42.8	72.8	112	159	216	281	355	439	531	631	741	860	987	1123
16	1.33	2.81	4.99	7.93	13.9	21.9	32.0	44.2	75.2	115	165	223	290	367	453	548	652	765	888	1019	1160
17	1.37	2.90	5.14	8.18	14.3	22.6	32.9	45.5	77.5	119	170	230	229	378	467	565	672	789	915	1051	1195
18	1.41	2.98	5.29	8.41	14.8	23.2	33.9	46.8	79.8	120	174	236	308	389	480	581	692	812	942	1081	1230
19	1.45	3.06	5.43	8.64	15.2	23.9	34.8	48.1	82.0	126	179	243	316	400	494	597	711	834	967	1111	1264
20	1.49	3.14	5.57	8.87	15.6	24.5	35.7	49.4	84.1	129	184	249	325	410	506	613	729	856	993	1139	1297
21	1.53	3.22	5.71	9.09	15.9	25.1	36.6	50.6	86.2	132	188	255	333	421	519	628	747	877	1017	1168	1329
22	1.56	3.29	5.85	9.30	16.3	25.7	37.5	51.8	88.2	135	193	261	341	430	531	643	765	898	1041	1195	1360
23	1.60	3.37	5.98	9.51	16.7	26.2	38.3	53.0	90.2	138	197	267	348	440	543	657	782	918	1064	1222	1390
24	1.63	3.44	6.11	9.72	17.0	26.8	39.1	54.1	92.1	141	201	273	356	450	555	671	799	937	1087	1248	1420
25	1.66	3.51	6.23	9.92	17.4	27.4	39.9	55.2	94.0	144	206	279	363	459	566	685	815	957	1110	1274	1450
26	1.70	3.58	6.36	10.1	17.7	27.9	40.7	56.3	95.9	147	210	284	370	468	577	699	831	976	1132	1299	1478
27	1.73	3.65	6.48	10.3	18.1	28.4	41.5	57.4	97.7	150	214	290	377	477	588	712	847	994	1153	1324	1507
28	1.76	3.72	6.60	10.5	18.4	29.0	42.3	58.4	99.5	153	218	295	384	486	599	725	863	1013	1174	1348	1534
29	1.79	3.78	6.71	10.7	18.7	29.5	43.0	59.5	101	155	221	300	391	494	610	738	878	1030	1195	1372	1561
30	1.82	3.85	6.83	10.9	19.1	30.0	43.7	60.5	103	158	225	305	398	503	620	750	893	1048	1216	1396	1588

Correction Factors For Other Pipe Lengths

L, in feet	6"	8"	10"	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
20	1.69	1.63	1.58	1.53	1.47	1.42	1.37	1.34	1.28	1.24	1.20	1.18	1.16	1.14	1.13	1.11	1.10	1.10	1.09	1.08	1.08
30	1.44	1.41	1.39	1.36	1.32	1.29	1,27	1.24	1.21	1.18	1.15	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.07	1.06	1.06
40	1.26	1.27	1.25	1.23	1.21	1.20	1.18	1.17	1.14	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.05	1.04
50	1.16	1.16	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03
60	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.94	.94	.95	.95	.95	.95	.96	.96	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99	.99	.99
90	.89	.89	.90	.90	.91	.91	.92	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97	.97	.97	.97	.94
100	.85	.85	.86	.86	.87	.88	.89	.89	.90	.91	.92	.93	.93	.94	.94	.95	.95	.95	.96	.96	.94
120	.78	.79	.79	.90	.81	.82	.83	.83	.85	.86	.87	.89	.89	.90	.91	.89	.92	.93	.93	.94	.92
140	.72	.73	.74	.75	.76	.77	.78	.79	.81	.82	.84	.85	.86	.87	.88	.86	.89	.90	.91	.91	.90
160	.68	.69	.69	.70	.71	.73	.74	.75	.77	.79	.80	.82	.83	.84	.85	.92	.87	.88	.89	.89	

Figure 5A.28
Pipe Flow Chart; "n" = 0.025

PIPE FLOW CHART n = 0.013

FOR REINFORCED CONCRETE PIPE INLET $K_m = K_e + K_b = 1.00$ AND 70 FEET OF REINFORCED CONCRETE PIPE CONDUIT (full flow assumed)

Note correction factors for pipe lengths other than 70 feet

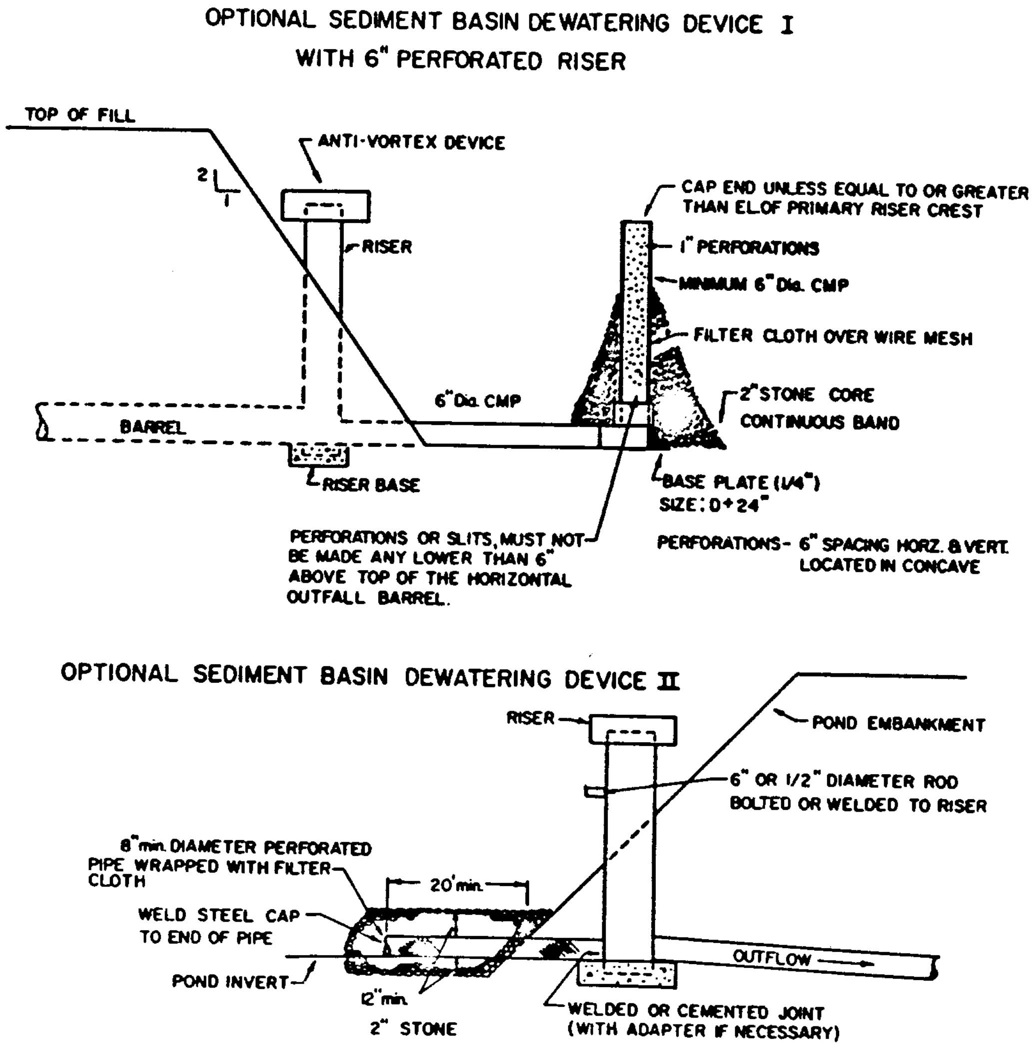
H, in feet	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
	diameter of pipe in inches																	
1	3.22	5.44	8.29	11.8	15.9	26.0	38.6	53.8	71.4	91.5	114	139	167	197	229	264	302	342
2	4.55	7.69	11.7	16.7	22.5	36.8	54.6	76.0	101	129	161	197	236	278	324	374	427	483
3	5.57	9.42	14.4	20.4	27.5	45.0	66.9	93.1	124	159	198	241	289	341	397	458	523	592
4	6.43	10.9	16.6	23.5	31.8	52.0	77.3	108	143	183	228	278	334	394	459	529	604	683
5	7.19	12.2	18.5	26.3	35.5	58.1	86.4	120	160	205	255	311	373	440	513	591	675	764
6	7.88	13.3	20.3	28.8	38.9	63.7	94.6	132	175	224	280	341	409	482	562	647	739	837
7	8.51	14.4	21.9	31.1	42.0	68.8	102	142	189	242	302	368	441	521	607	699	798	904
8	9.10	15.4	23.5	33.3	44.9	73.5	109	152	202	259	323	394	472	557	685	748	854	966
9	9.65	16.3	24.9	35.3	47.7	78.0	116	161	214	275	342	418	500	590	688	793	905	1025
10	10.2	17.2	26.2	37.2	50.2	82.2	122	170	226	289	361	440	527	622	725	836	954	1080
11	10.7	18.0	27.5	39.0	52.7	86.2	128	178	237	304	379	462	553	653	761	877	1001	1133
12	11.1	18.9	28.7	40.8	55.0	90.1	134	186	247	317	395	482	578	682	794	916	1045	1104
13	11.6	19.6	29.9	42.4	57.3	93.7	139	194	257	330	411	502	601	710	827	953	1088	1232
14	12.0	20.4	31.0	44.1	59.4	97.3	145	201	267	342	427	521	624	736	858	989	1129	1278
15	12.5	21.1	32.1	45.6	61.5	101	150	208	277	354	442	539	646	762	888	1024	1169	1323
16	12.9	21.8	33.2	47.1	63.5	104	155	215	286	366	457	557	667	787	917	1057	1207	1367
17	13.3	22.4	34.2	48.5	65.5	107	159	222	294	377	471	574	688	812	946	1090	1244	1409
18	13.7	23.1	35.2	49.9	67.4	110	164	228	303	388	484	591	708	835	973	1121	1280	1450
19	14.0	23.7	36.1	51.3	69.2	113	168	234	311	399	497	607	727	858	1000	1152	1315	1489
20	14.4	24.3	37.1	52.6	71.0	116	173	240	319	409	510	623	746	880	1026	1182	1350	1528
21	14.7	24.9	38.0	53.9	72.8	119	177	246	327	419	523	638	764	902	1051	1211	1383	1566
22	15.1	25.5	38.9	55.2	74.5	122	181	252	335	429	535	653	782	923	1076	1240	1415	1603
23	15.4	26.1	39.8	56.5	76.2	125	186	258	342	439	547	668	800	944	1100	1268	1447	1639
24	15.8	26.7	40.6	57.7	77.8	127	189	263	350	448	559	682	817	964	1123	1295	1478	1674
25	16.1	27.2	41.5	58.9	79.4	130	193	269	357	458	571	696	834	984	1147	1322	1509	1708
26	16.4	27.7	42.3	60.0	81.0	133	197	274	364	467	582	710	850	1004	1169	1348	1539	1742
27	16.7	28.3	43.1	61.2	82.5	135	201	279	371	476	593	723	867	1023	1192	1373	1568	1775
28	17.0	28.8	43.9	62.3	84.1	138	204	285	378	484	604	737	883	1041	1214	1399	1597	1808
29	17.3	29.3	44.7	63.4	85.5	140	208	290	384	493	615	750	898	1060	1235	1423	1625	1840
30	17.6	29.8	45.4	64.5	87.0	142	212	294	391	501	625	763	913	1078	1256	1448	1653	1871

Correction Factors For Other Pipe Lengths

L, in feet	12"	15"	18"	21"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"	90"	96"	102"
20	1.30	1.24	1.21	1.18	1.15	1.12	1.10	1.08	1.07	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.03
30	1.22	1.18	1.15	1.13	1.12	1,09	1.08	1.06	1.05	1.05	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02
40	1.15	1.13	1.11	1.10	1.08	1.07	1.05	1.05	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.02
50	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01
60	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	.96	.97	.97	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99	.99
90	.93	.94	.94	.95	.95	.96	.97	.97	.98	.98	.98	.98	.98	.99	.99	.99	.99	.99
100	.90	.91	.92	.93	.93	.95	.95	.96	.97	.97	.97	.98	.98	.98	.98	.98	.98	.99
120	.84	.86	.87	.89	.90	.91	.93	.94	.94	.95	.96	.96	.96	.97	.97	.97	.97	.98
140	.80	.82	.83	.85	.86	.88	.90	.91	.92	.93	.94	.94	.95	.95	.96	.96	.96	.97
160	.76	.78	.80	.82	.83	.86	.88	.89	.90	.91	.92	.93	.94	.94	.95	.95	.95	.96

Figure 5A.29
Pipe Flow Chart; "n" = 0.013

Figure 5A.30
Optional Sediment Basin Dewatering Methods



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	OPTIONAL SEDIMENT BASIN DEWATERING DEVICES	STANDARD SYMBOL O

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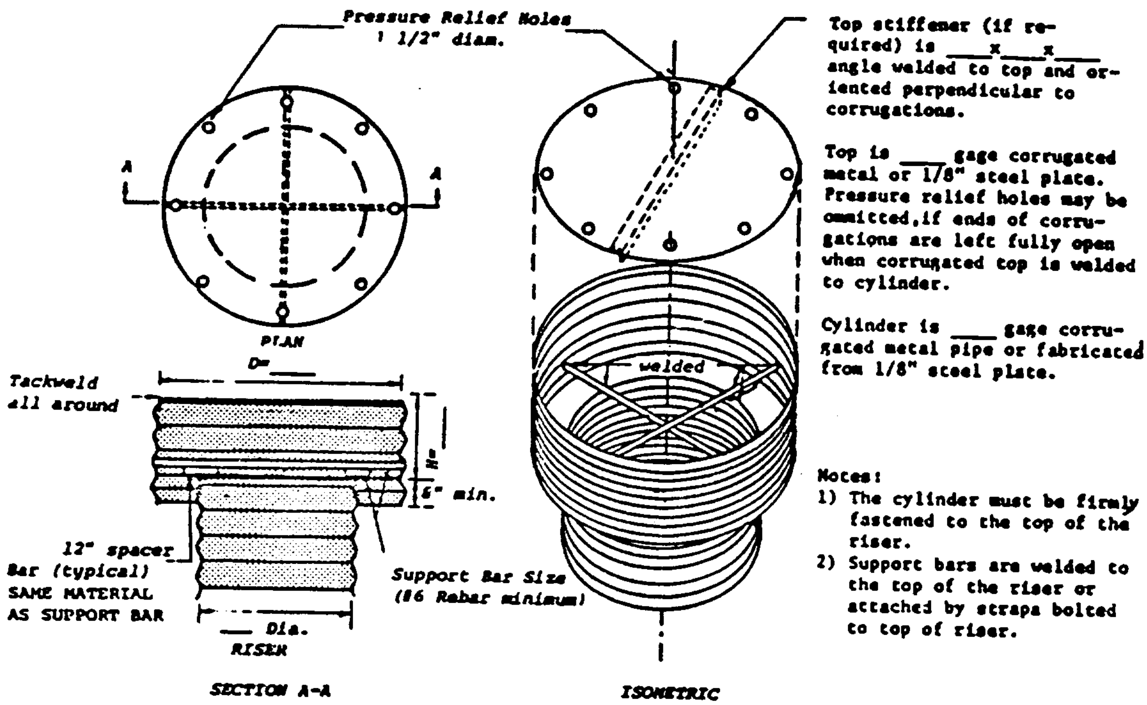
Figure 5A.31 (1)
Concentric Trash Rack and Anti-Vortex Device



CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE
(not to scale)

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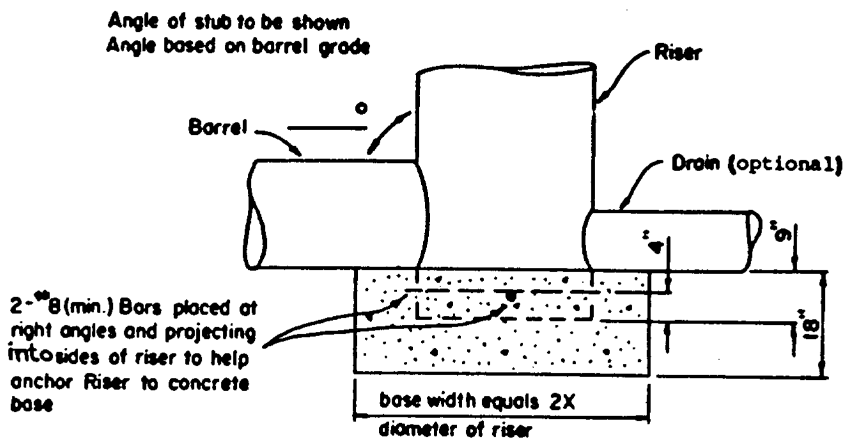
Figure 5A.31 (2)
CONCENTRIC TRASH RACK AND ANTI-VORTEX DEVICE DESIGN TABLE

Riser Diam.(in)	Cylinder Diam.(in.)	Thick. Gage	H (in.)	Minimum Size Support Bar	Minimum Top Thickness	Minimum Top Stiffener
12	18	16	6	#6 Rebar	16 ga.	--
15	21	16	7	#6 Rebar	16 ga.	--
18	27	16	8	#6 Rebar	16 ga.	--
21	30	16	11	#6 Rebar	16 ga.	--
24	36	16	13	#6 Rebar	14 ga.	--
27	42	16	15	#6 Rebar	14 ga.	--
36	54	14	17	#8 Rebar	12 ga.	--
42	60	14	19	#8 Rebar	12 ga.	--
48	72	12	21	1 1/4" pipe or 1 1/4x1 1/4x1/4 angle	10 ga.	--
54	78	12	25	See 48" Riser	10 ga.	--
60	90	12	29	1 1/2" pipe or 1 1/2x1 1/2x1/2 angle	8 ga.	--
66	96	10	33	2" pipe or 2x2x3/16 angle	8 ga. w/stiffener	2x2x1/4 angle
72	102	10	36	——See 66" Riser——		2 1/2x2 1/2x1/4 angle
78	114	10	39	2 1/2" pipe or 2x2x1/4 angle	See 72" Riser	See 72" Riser
84	120	10	42	2 1/2" pipe or 2 1/2x2 1/2x1/4 angle	See 72" Riser	2 1/2x 2 1/2x 5/16 angle

Note: The criteria for sizing the cylinder is that the area between the inside of the cylinder and the outside of the riser is equal to or greater than the area inside the riser. Therefore, the above table is invalid for use with concrete pipe risers.

Figure 5A.32
Riser Base Details



RISER BASE DETAIL

NOTES:

1. The concrete base shall be poured in such a manner to insure that the concrete fills the bottom of the riser to the invert of the outlet pipe to prevent the riser from breaking away from the base.

2. With aluminum or aluminized pipe, the embedded section must be painted with zinc chromate or equivalent.

3. Riser baser may be sized as computed using floatation with a factor of safety of 1.2.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	RISER BASE DETAIL SEDIMENT BASIN

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Figure 5A.33 (1)
Anti-Seep Collar Design

This procedure provides the anti-seep collar dimensions for only temporary sediment basins to increase the seepage length by 15% for various pipe slopes, embankment slopes and riser heights.

The first step in designing anti-seep collars is to determine the length of pipe within the saturated zone of the embankment. This can be done graphically or by the following equation, assuming that the upstream slope of the embankment intersects the invert of the pipe at its upstream end. (See embankment-invert intersection on the drawing below:

$$L_s = y\,(z + 4)\left[1 + \frac{\text{pipe slope}}{0.25-\text{pipe slope}}\right]$$

Where: L_s = length of pipe in the saturated zone (ft.)

y = distance in feet from upstream invert of pipe to highest normal water level expected to occur during the life of the structure, usually the top of the riser.

z = slope of upstream embankment as a ratio of z ft. horizontal to one ft. vertical.

pipe slope = slope of pipe in feet per foot.

This procedure is based on the approximation of the phreatic line as shown in the drawing below:

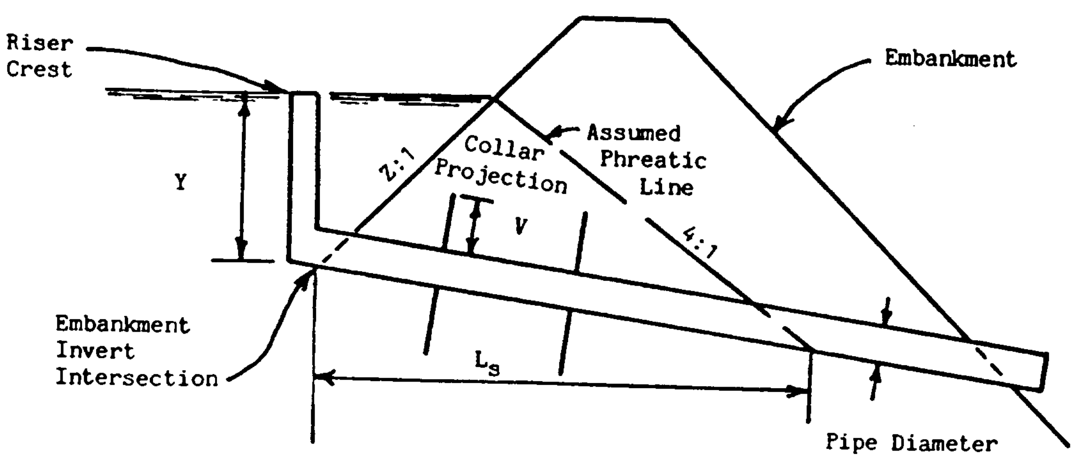

Figure 5A.33 (2)
Anti-Seep Collar Design Charts

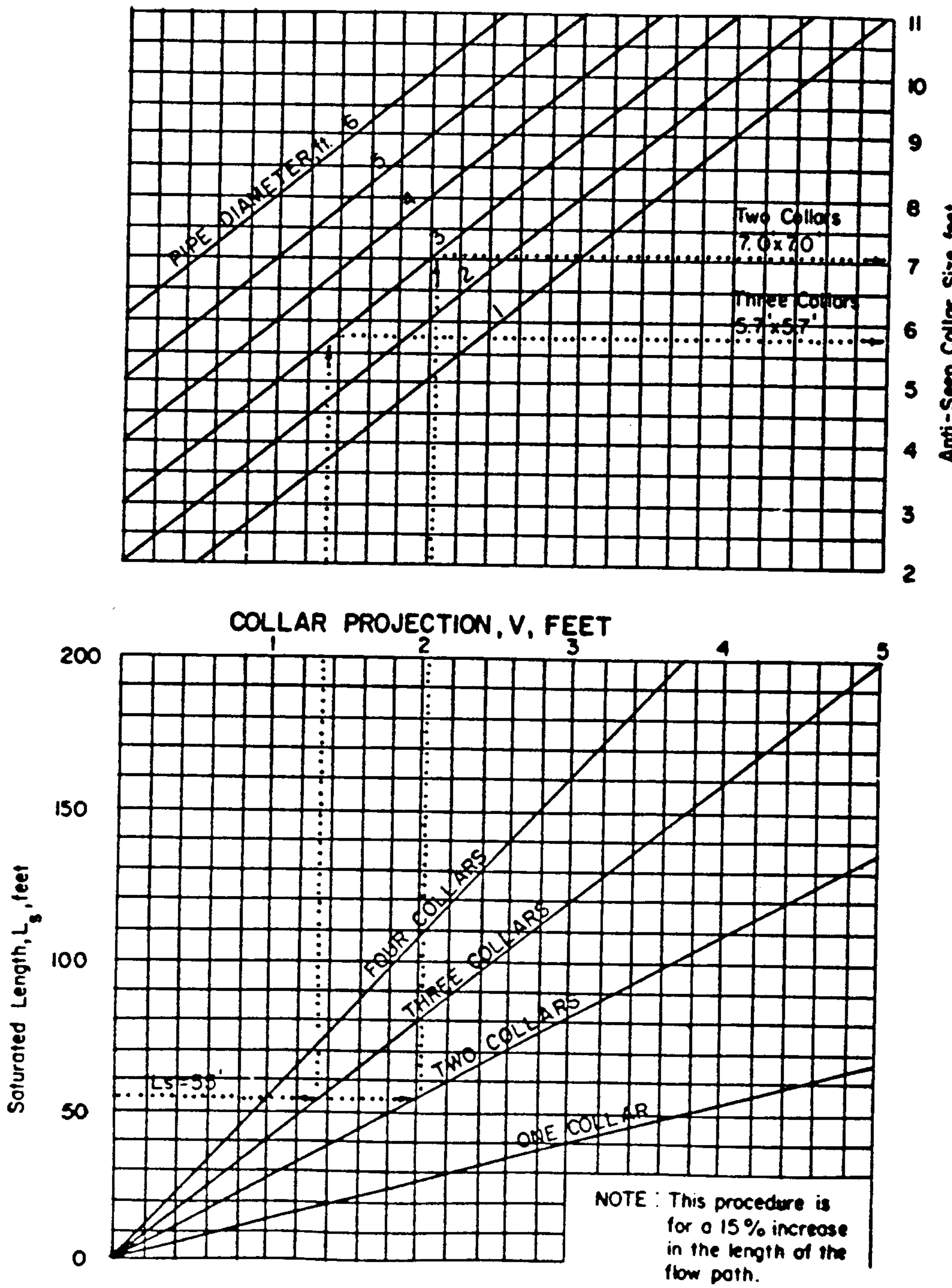

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Figure 5A.34
Anti-Seep Collar Design Details

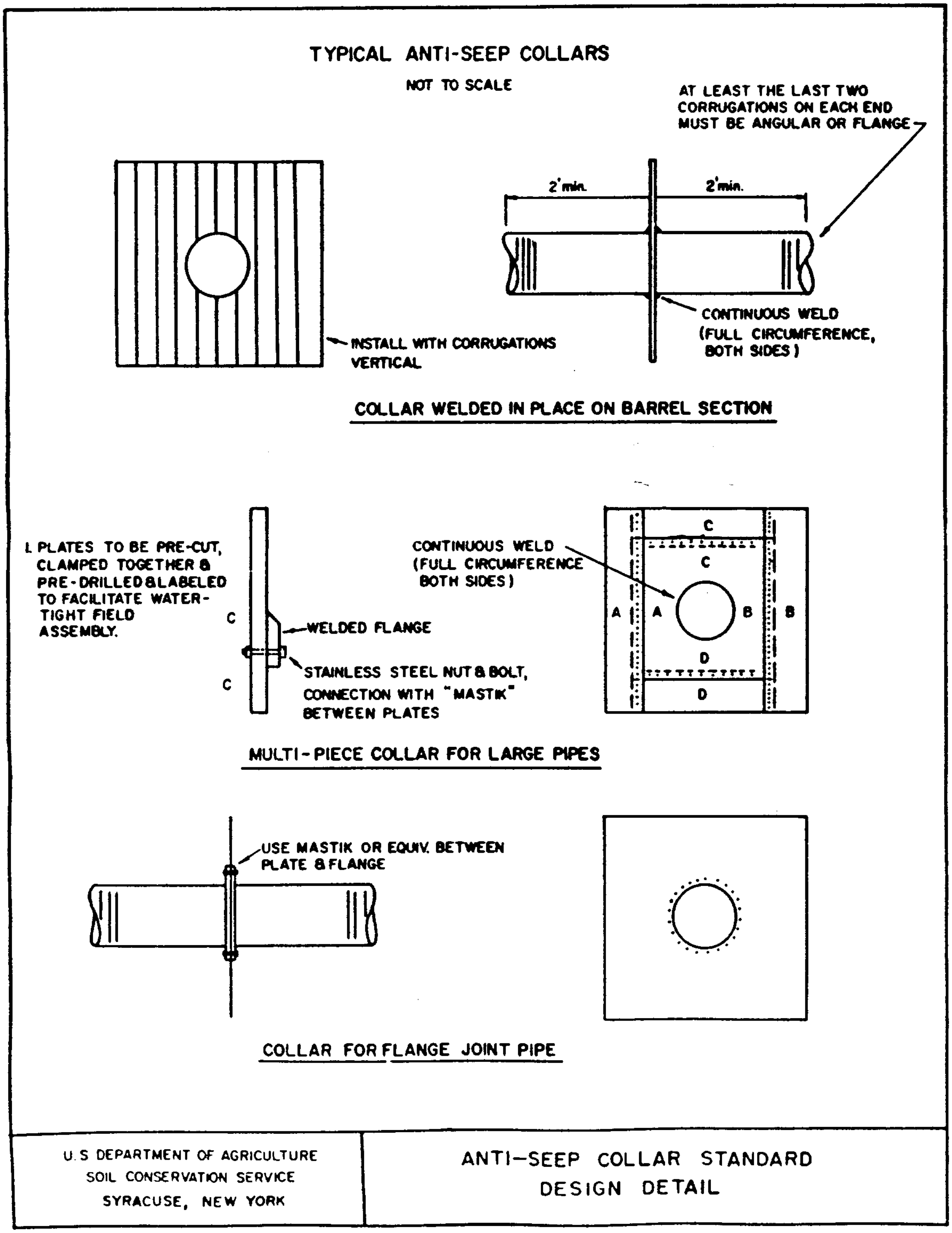

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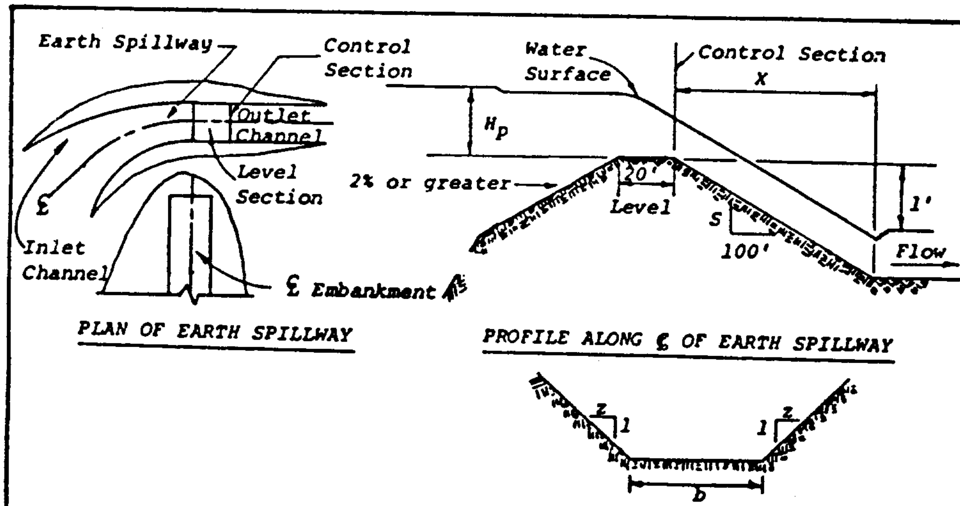
Figure 5A.35 (1)
Design Data for Earth Spillways



PLAN OF EARTH SPILLWAY

PROFILE ALONG ℄ OF EARTH SPILLWAY

CROSS SECTION OF EARTH SPILLWAY AT CONTROL SECTION

LEGEND

n = Manning's Coefficient of Roughness.
H_p = Difference in Elevation between Crest of Earth Spillway at the Control Section and Water Surface in Reservoir, in feet.
b = Bottom Width of Earth Spillway at the Control Section, in feet.
Q = Total Discharge, in cfs.
V = Velocity, in feet per second, that will exist in Channel below Control Section, at Design Q, if constructed to slope (S) that is shown.
S = Flattest Slope (S), in %, allowable for Channel below Control Section.
X = Minimum Length of Channel below Control Section, in feet.
z = Side Slope Ratio.

NOTES:

1) For a given H_p a decrease in the exit slope from S as given in the table decreases spillway discharge but increasing the exit slope from S does not increase discharge. If an exit slope (S_e) steeper than S is used, then velocity (V_e) in the exit channel will increase according to the following relationship:

$$V_e = V\left(\frac{S_e}{S}\right)^{0.3}$$

2) Data to right of heavy vertical lines on drawings should be used with caution, as the resulting sections will be either poorly proportioned or have velocities in excess of 6 ft/sec.

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	DESIGN DATA FOR EARTH SPILLWAYS	Ref: Engineering Field Manual

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Figure 5A.35 (2)
Design Data for Earth Spillways

DESIGN DATA FOR EARTH SPILLWAYS

SIDE SLOPE 2:1
VEGETATED n=0.040

STAGE (Hp) IN FEET	SPILLWAY VARIABLES	BOTTOM WIDTH (b) IN FEET																
		8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
0.5	Q	6	7	8	10	11	13	14	15	17	18	20	21	22	24	25	27	28
	V	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	S	3.9	3.9	3.9	3.9	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	X	32	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
0.6	Q	8	10	12	14	16	18	20	22	24	26	28	30	32	34	35	37	39
	V	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	S	3.7	3.7	3.7	3.7	3.6	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	X	36	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37
0.7	Q	11	13	16	18	20	23	25	28	30	33	35	38	41	43	44	46	48
	V	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
	S	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	X	39	40	40	40	[illegible]	41	[illegible]	41	41	[illegible]	41	41	41	41	41	41	41
0.8	Q	13	16	19	22	26	29	32	35	39	42	45	46	48	51	54	57	60
	V	3.5	3.5	3.5	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
	S	3.3	3.3	3.3	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	X	44	44	44	44	45	45	45	45	45	45	45	45	45	45	45	45	45
0.9	Q	17	20	24	28	32	35	39	43	47	51	53	57	60	64	68	71	75
	V	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	S	3.2	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	X	47	[illegible]	48	48	48	48	48	48	48	48	49	49	49	49	49	49	49
1.0	Q	20	[illegible]	29	33	38	42	[illegible]	51	56	[illegible]	63	68	72	77	81	86	90
	V	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	S	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	X	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52
1.1	Q	23	28	34	39	44	49	54	60	65	70	74	79	84	89	95	100	105
	V	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	S	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	55	55	55	55	55	55	55	56	56	56	56	56	56	56	56	56	56
1.2	Q	28	33	40	45	51	58	64	69	76	80	86	92	98	104	110	116	122
	V	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	S	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
	X	58	58	59	59	59	59	59	59	60	60	60	60	60	60	60	60	60
1.3	Q	32	38	46	53	58	65	73	80	86	[illegible]	99	106	112	119	125	133	140
	V	4.5	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	S	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
	X	62	62	62	63	63	63	63	63	63	63	63	64	64	64	64	64	64
1.4	Q	37	44	[illegible]	59	66	74	82	90	96	103	111	119	127	134	142	150	158
	V	4.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
	S	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	X	65	66	66	66	66	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	68	68	68	68	68	69
1.5	Q	[illegible]	[illegible]	58	66	75	85	[illegible]	[illegible]	108	116	125	133	142	150	160	169	178
	V	4.8	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.1	5.1
	S	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5
	X	69	69	70	70	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	72	72	72	72	72	72
1.6	Q	[illegible]	56	65	75	84	94	104	[illegible]	122	132	142	149	158	168	178	187	197
	V	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	S	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	X	72	74	74	75	75	76	76	76	76	76	76	76	76	76	76	76	76
1.7	Q	52	62	72	83	94	105	115	126	135	145	156	167	175	187	196	206	217
	V	5.2	5.2	5.2	5.3	5.3	5.3	5.3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	S	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.3	2.3
	X	76	78	79	80	80	80	80	80	80	80	80	80	80	80	80	80	80
1.8	Q	56	69	81	93	104	116	127	138	150	160	[illegible]	182	194	204	214	226	233
	V	5.3	5.4	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6	5.6	5.6
	S	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	80	82	83	84	84	84	84	84	84	84	84	84	84	84	84	84	84
1.9	Q	64	76	88	102	114	127	140	152	164	175	188	201	213	225	235	248	260
	V	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	S	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
	X	84	85	86	87	88	88	88	88	88	88	88	88	88	88	88	88	88
2.0	Q	71	83	97	111	125	138	153	164	178	193	204	218	232	245	256	269	283
	V	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9
	S	2.5	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	86	[illegible]	91	[illegible]	[illegible]	[illegible]	92	92	[illegible]	92	92	92	92	92	92	92	92
2.1	Q	77	[illegible]	107	122	135	149	162	177	192	[illegible]	220	234	250	267	276	291	305
	V	5.7	5.8	5.9	5.9	5.9	5.9	5.9	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	S	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	92	93	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96
2.2	Q	84	100	[illegible]	131	146	163	177	194	210	224	238	253	269	288	301	314	330
	V	5.9	5.9	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2
	S	2.4	2.4	2.4	2.3	[illegible]	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	X	96	[illegible]	99	95	99	99	99	100	100	100	100	100	100	100	100	100	100
2.3	Q	90	108	124	140	156	175	193	208	226	243	258	275	292	306	323	341	354
	V	6.0	[illegible]	[illegible]	[illegible]	6.2	[illegible]	[illegible]	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
	S	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	100	[illegible]	102	103	103	103	104	104	104	105	105	105	105	105	105	105	105
2.4	Q	99	116	136	152	170	189	206	224	[illegible]	260	275	294	312	327	346	364	378
	V	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
	S	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	X	105	[illegible]	106	107	107	108	108	108	108	109	109	109	109	109	109	109	109

REFERENCE		
Engineering Field Manual	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING & WATERSHED PLANNING UNIT UPPER DARBY, PENNSYLVANIA	RTSC-NE-ENG. 1110 SHEET 4 OF 11

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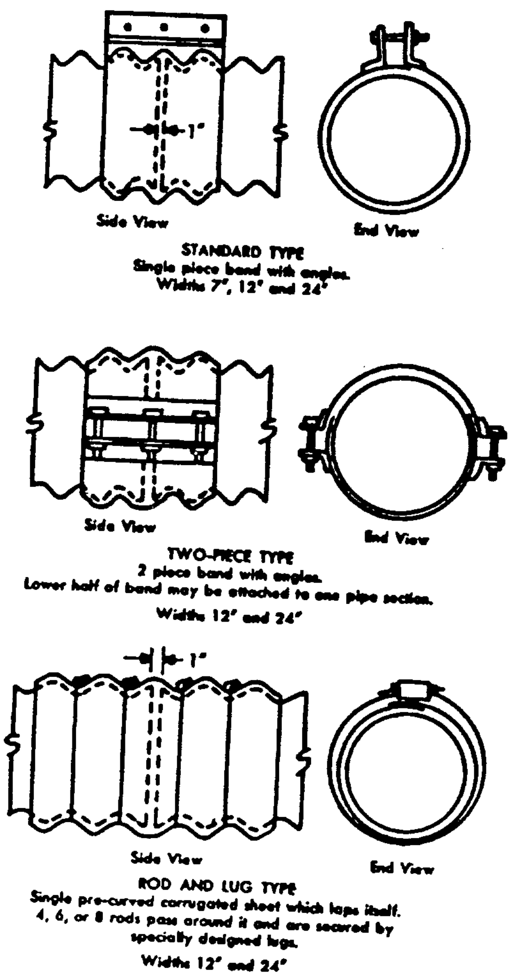
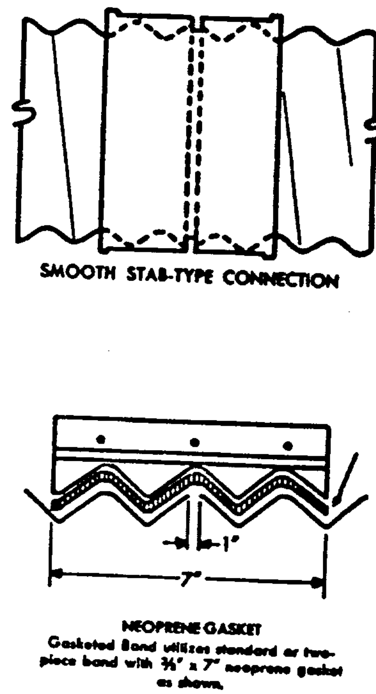
Figure 5A.36
Corrugated Steel Pipe Couplers





Note: Under no circumstance will the dimple (universal) connector be acceptable for use in any sediment control or stormwater management structure.

(All connector bands require neoprene gaskets.)

Procedure for Determining or Altering Sediment Basin Shape

As specified in the Standard and Specification, the pool area at the elevation of crest of the principal spillway shall have a length to width ratio of at least 2.0 to 1. The purpose of this requirement is to minimize the "short circuiting" effect of the sediment laden inflow to the riser and thereby increase the effectiveness of the sediment basin. The purpose of this procedure is to prescribe the parameters, procedures and methods of determining and modifying the shape of the basin.

The length of the flow path (L) is the distance from the point of inflow to the riser (outflow point). The point of inflow is the point that the stream enters the normal pool (pool level at the riser crest elevation). The pool area (A) is the area of the normal pool. The effective width (W_e) is found by the equation:

$$We = A/L \text{ and } L:W \text{ ratio} = L/W_e$$

In the event there is more than one inflow point, any inflow point which conveys more than 30 percent of the total peak inflow rate shall meet the length to width ratio criteria.

The required basin shape may be obtained by proper site selection, by excavation or by constructing a baffle in the basin. The purpose of the baffle is to increase the effective flow length from the inflow point to the riser. Baffles shall be placed midway between the inflow point and the riser. The baffle length shall be as required to provide the minimum 2:1 length width ratio. The effective length (L_e) shall be the shortest distance the water must flow from the inflow point around the end of the baffle to the outflow point. Then:

$$W_e = A/L_e \text{ and } L:W \text{ ratio} = L_e/W_e$$

Three examples are shown on the following page. Note that for the special case in example C the water is allowed to go around both ends of the baffle and the effective length, $L_e = L_1 + L_2$. Otherwise, the length to width ratio computations are the same as shown above. This special case procedure for computing Le is allowable only when the two flow paths are equal, i.e., when $L_1 = L_2$. A baffle detail is also shown in Figure 5A.37 on page 5A.71.

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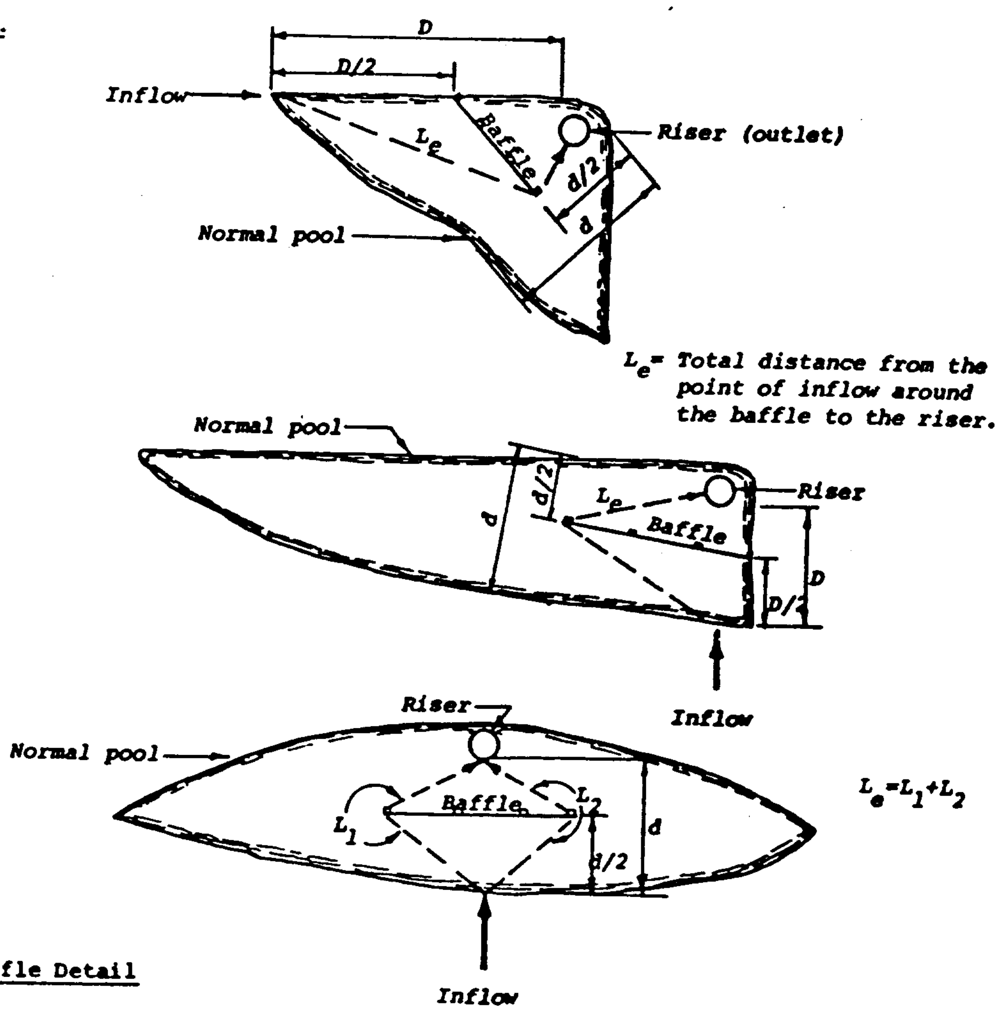
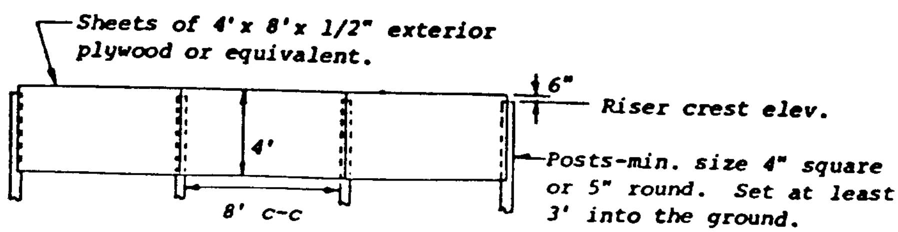
Figure 5A.37
Sediment Basin Baffle Details

Examples: Plan Views - not to scale



Baffle Detail



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STANDARD AND SPECIFICATIONS FOR STABILIZED CONSTRUCTION ENTRANCE

Definition

A stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving a construction site to or from a public right-of-way, street, alley, sidewalk or parking area.

Purpose

The purpose of stabilized construction entrance is to reduce or eliminate the tracking of sediment onto public rights-of-way or streets.

Conditions Where Practice Applies

A stabilized construction entrance shall be used at all points of construction ingress and egress.

Design Criteria

See Figure 5A.38 on page 5A.74 for details.

Aggregate Size: Use 2 in. stone, or reclaimed or recycled concrete equivalent.

Thickness: Not less than six (6) inches.

Width: 12 foot minimum but not less than the full width of points where ingress or egress occurs. 24 foot minimum if there is only one access to the site.

Length: As required, but not less than 50 feet (except on a single residence lot where a 30 foot minimum would apply).

Filter cloth: To be placed over the entire area to be covered with aggregate. Filter cloth will not be required on a single family residence lot. Piping of surface water under entrance shall be provided as required. If piping is impossible, a mountable berm with 5:1 slopes will be permitted.

Criteria for Filter Cloth

The filter cloth shall be woven or nonwoven fabric consisting only of continuous chain polymeric filaments or yarns of polyester. The fabric shall be inert to commonly encountered chemicals, hydro-carbons, mildew, rot resistant, and conform to the fabric properties as shown:

Fabric Properties[3]	Light Duty[1] Roads Grade Subgrade	Heavy Duty[2] Haul Roads Rough Graded	Test Method
Grab Tensile Strength (lbs)	200	220	ASTM D1682
Elongation at Failure (%)	50	60	ASTM D1682
Mullen Brust Strength (lbs)	190	430	ASTM D3786
Puncture Strength (lbs)	40	125	ASTM D751 modified
Equivalent	40-80	40-80	US Std Sieve
Openning Size			CW-02215
Aggregate Depth (in)	6	10	–

[1] Light Duty Road: Area sites that have been graded to subgrade and where most travel would be single axle vehicles and an occasional multi-axle truck. Acceptable materials are Trevira Spunbond 1115, Mirafi IOOX, Typar 3401, or equivalent.

[2] Heavy Duty Road: Area sites with only rough grading, and where most travel would be multi-axle vehicles. Acceptable materials are Trevira Spunbond 1135, Miraft 600X, or equivalent.

[3] Fabrics not meeting these specifications may be used only when design procedure and supporting documentation are supplied to determine aggregate depth and fabric strength.

Maintenance

The entrance shall be maintained in a condition which will prevent tracking of sediment onto public rights-of-way or streets. This may require periodic top dressing with additional aggregate. All sediment spilled, dropped, or washed onto public rights-of-way must be removed immediately.

When necessary, wheels must be cleaned to remove sediment prior to entrance onto public rights-of-way. When washing is required, it shall be done on an area stabilized with aggregate which drains into an approved sediment trapping device. All sediment shall be prevented from entering storm drains, ditches, or watercourses.

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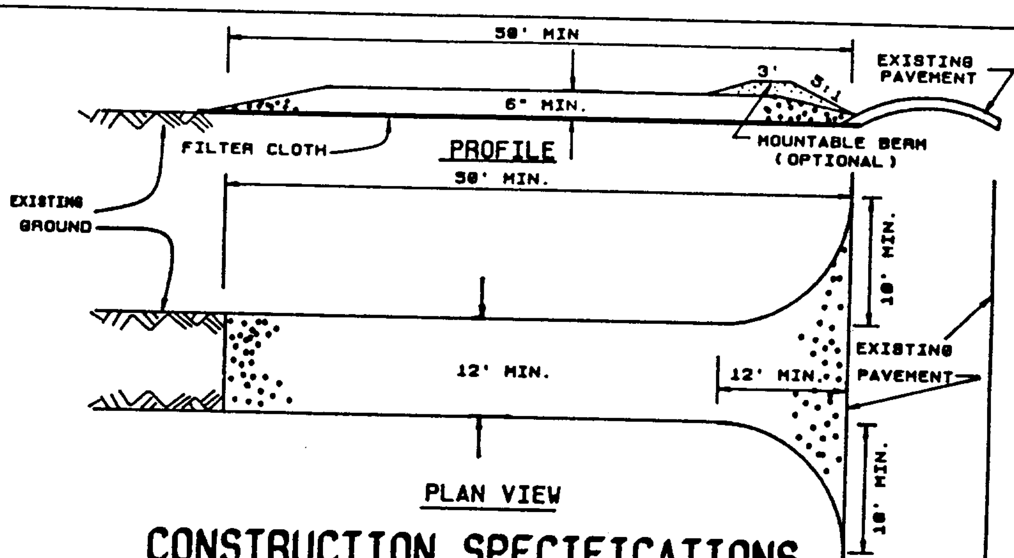
Figure 5A.38
Stabilized Construction Entrance Details



CONSTRUCTION SPECIFICATIONS

1. STONE SIZE - USE 2" STONE, OR RECLAIMED OR RECYCLED CONCRETE EQUIVALENT.

2. LENGTH - NOT LESS THAN 50 FEET (EXCEPT ON A SINGLE RESIDENCE LOT WHERE A 30 FOOT MINIMUM LENGTH WOULD APPLY).

3. THICKNESS - NOT LESS THAN SIX (6) INCHES.

4. WIDTH - TWELVE (12) FOOT MINIMUM, BUT NOT LESS THAN THE FULL WIDTH AT POINTS WHERE INGRESS OR EGRESS OCCURS. TWENTY-FOUR (24) FOOT IF SINGLE ENTRANCE TO SITE.

5. FILTER CLOTH - WILL BE PLACED OVER THE ENTIRE AREA PRIOR TO PLACING OF STONE.

6. SURFACE WATER - ALL SURFACE WATER FLOWING OR DIVERTED TOWARD CONSTRUCTION ENTRANCES SHALL BE PIPED ACROSS THE ENTRANCE. IF PIPING IS IMPRACTICAL, A MOUNTABLE BERM WITH 5:1 SLOPES WILL BE PERMITTED.

7. MAINTENANCE - THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHTS-OF-WAY. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACTED ONTO PUBLIC RIGHTS-OF-WAY MUST BE REMOVED IMMEDIATELY.

8. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH STONE AND WHICH DRAINS INTO AN APPROVED SEDIMENT TRAPPING DEVICE.

9. PERIODIC INSPECTION AND NEEDED MAINTENANCE SHALL BE PROVIDED AFTER EACH RAIN.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	STABLIZED CONSTRUCTION ENTRANCE	STANDARD SYMBOL

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STANDARD AND SPECIFICATIONS FOR CONSTRUCTION ROAD STABILIZATION

Definition

The stabilization of temporary construction access routes, on-site vehicle transportation routes and construction parking areas.

Purpose

To control erosion on temporary construction routes and parking areas.

Condition Where Practice Applies

All traffic routes and parking areas for temporary use by construction traffic.

Design Criteria

Construction roads should be located to reduce erosion potential, minimize impact on existing site resources and maintain operations in a safe manner. Highly erosive soils, wet or rocky areas, and steep slopes should be avoided. Roads should be routed where seasonal water tables are deeper than 18 inches. Surface runoff and control should be in accordance with other standards.

Road Grade - A maximum grade of 12% is recommended, although grades up to 15% are possible for short distances.

Road Width - 14 foot minimum for one-way traffic or 24 foot minimum for two-way traffic

Side Slope of Road Embankment - 2:1 or flatter

Ditch capacity - On site roadside ditch and culvert capacities shall be the 10 yr. peak runoff.

Stone surface - Use a 6-inch course of NYS DOT base course or equivalent as specified in NYS - Standards and Specifications for Highways.

Construction Specifications

1. Clear and strip roadbed and parking areas of all vegetation, roots, and other objectionable material.
2. Locate parking areas on naturally flat areas as available. Keep grades sufficient for drainage but not more than 2 to 3%.
3. Provide surface drainage and divert excess runoff to stabilized areas.
4. Maintain cut and fill slopes to 2:1 or flatter and stabilize with vegetation as soon as grading is accomplished.
5. Spread 6-inch course of crushed stone evenly over the full width of the road smooth to avoid depressions.
6. Provide appropriate sediment control measures to prevent offsite sedimentation.

Maintenance

Inspect construction roads and parking areas periodically for condition of surface. Topdress with new gravel as needed. Check ditches for erosion and sedimentation after rainfall events. Maintain vegetation in a healthy, vigorous condition. Areas producing sediment should be treated immediately.

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STANDARD AND SPECIFICATIONS FOR TEMPORARY ACCESS WATERWAY CROSSING

V O L 1 2

6 / 2 9

Definition

A temporary access waterway crossing is a structure placed across a waterway to provide access for construction purposes for a period of less than one year. Temporary access crossings shall not be utilized to maintain traffic for the general public.

Purpose

The purpose of the temporary access waterway crossing is to provide safe, environmentally sound access across a waterway for construction equipment by establishing minimum standards and specifications for the design, construction, maintenance, and removal of the structure. Temporary access waterway crossings are necessary to prevent construction equipment from damaging the waterway, blocking fish migration, and tracking sediment and other pollutants into the waterway. This standard and specification may represent a channel constriction thus the temporary nature of waterway access crossings must be stressed. They should be planned to be in service for the shortest practical period of time and removed as soon as their function is completed.

Conditions Where Practice Applies

The following standard and specification for temporary access waterway crossings are applicable in non-tidal waterways. These standard and specifications provide designs based on waterway geometry rather than the drainage area contributing to the point of crossing.

The principal consideration for development of the standard and specifications is concern for erosion and sediment control. Structural utility and safety must also be considered when designing temporary access waterway crossings to withstand expected loads.

The three types of standard temporary access waterway crossings are bridges, culverts, and fords.

General Requirements

1. In-Stream Excavation: In-Stream excavation shall be limited to only that necessary to allow installation of the standard methods as presented in Subsection "Temporary Access Waterway Crossing Methods."
2. Elimination of Fish Migration Barriers: Of the three basic methods presented in Subsection "Temporary Access Waterway Crossing Methods", bridges pose the least potential for creating barriers to aquatic migration. The construction of any specific crossing method as presented in Subsection "Temporary Access Waterway Crossing Methods", shall not cause a significant water level difference between the upstream and downstream water surface elevations. Fish spawning or migration within waterways is from October 1 to April 30 for water classified for trout and from March 15 to June 15 for other streams.
3. Crossing Alignment: The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15 degrees from a line drawn perpendicular to the centerline of the stream at the intended crossing location.
4. Road Approaches: The centerline of both roadway approaches shall coincide with the crossing alignment centerline for a minimum distance of 50 feet from each bank of the waterway being crossed. If physical or right-of-way restraints preclude the 50 feet minimum, a shorter distance may be provided. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing flood plain elevation.
5. Surface Water Diverting Structure: A water diverting structure such as a swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. Design criteria for this diverting structure shall be in accordance with the "Standard and Specification" for the individual design standard of choice. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.
6. Road Width: All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.
7. Time of Operation: All temporary crossings shall be removed within 14 calendar days after the structure is no longer needed. Unless prior written approval is obtained, all structures shall be removed within one year from the date of the installation.
8. Materials

   A. Aggregate: There shall be no earth or soil materials used for construction within the waterway channel. New York State Department of Transportation specifications coarse aggregate designation No. 4 (3/4" to 4") also referenced as AASHTO designation No. 1 shall be the minimum acceptable aggregate size for temporary crossings. Larger aggregates will be allowed.

B. Filter Cloth: Filter cloth is a fabric consisting of either woven or nonwoven plastic, polypropylene, or nylon used to distribute the load, retain fines, allow increased drainage of the aggregate and reduce mixing of the aggregate with the subgrade soil. Filter cloths such as Mirafi, Typar, Adva Filter, Polyfilter X, or approved equivalent shall be used, as required by the specific method.

Temporary Access Waterway Crossing Methods

The following criteria for erosion and sediment control shall be considered when selecting a specific temporary access waterway crossing standard method:

1. Site aesthetics: Select a standard design method that will least disrupt the existing terrain of the stream reach. Consider the effort that will be required to restore the area after the temporary crossing is removed.
2. Site location: Locate the temporary crossing where there will be the least disturbance to the soils of the existing waterway banks. When possible locate the crossing at a point receiving minimal surface runoff.
3. Physical site constraints: The physical constraints of a site may preclude the selection of one or more of the standard methods.
4. Time of year: The time of year may preclude the selection of one or more of the standard methods due to fish spawning or migration restrictions.
5. Vehicular loads and traffic patterns: Vehicular loads, traffic patterns, and frequency of crossings should be considered in choosing a specific method.
6. Maintenance of crossing: The standard methods will require various amounts of maintenance. The bridge method should require the least maintenance whereas the ford method will probably require more intensive maintenance.
7. Removal of the structure: Ease of removal and subsequent damage to the waterway should be primary factors in considering the choice of a standard method.

Temporary Access Bridge (Figure 5A.39 on page 5A.82)

A temporary access bridge is a structure made of wood, metal, or other materials which provides access across a stream or waterway.

Considerations

1. Preferred Method. This is the preferred method for temporary access waterway crossings. Normally, bridge construction causes the least disturbance to the waterway bed and banks when compared to the other access waterway crossings.
2. Most bridges can be quickly removed and reused.
3. Temporary access bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings.
4. Restrictions and Permits: A permit from the New York State department of Environmental Conservation, Division of Regulatory Affairs, Regional Permit Administrator, will be needed to install and remove temporary access culverts in streams with a classification of C(T) and higher. Installation and removal may not be permitted during the period of time from the start of trout spawning until the eggs have hatched. In some instances, restrictions may also be applied to bass spawning waters.

Construction Specifications

1. Restriction: Construction, use, or removal of a temporary access bridge will not normally have any time of year restrictions since construction, use or removal should not affect the stream or its banks.
2. Bridge Placement: A temporary bridge structure shall be constructed at or above bank elevation to prevent the entrapment of floating materials and debris.
3. Abutments: Abutments shall be placed parallel to and on stable banks.
4. Bridge Span: Bridges shall be constructed to span the entire channel. If the channel width exceeds 8 feet (as measured from top-of-bank to top-of-bank) then a footing, pier or bridge support may be constructed within the waterway. One additional footing, pier or bridge support will be permitted for each additional 8 foot width of the channel. However, no footing, pier or bridge support will be permitted within the channel for waterways less than 8 feet wide.
5. Stringers: Stringers shall either be logs, sawn timber, prestressed concrete beams, metal beams, or other approved materials.
6. Deck Material: Decking shall be of sufficient strength to support the anticipated load. All decking members shall be placed perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Decking materials must be butted tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
7. Run Planks (optional): Run planking shall be securely fastened to the length of the span. One run plank shall be provided for each track of the equipment wheels.

Although run planks are optional, they may be necessary to properly distribute loads.

8. Curbs or Fenders: Curbs or fenders may be installed along the outer sides of the deck. Curbs or fenders are an option which will provide additional safety.

9. Bridge Anchors: Bridges shall be securely anchored at only one end using steel cable or chain. Anchoring at only one end will prevent channel obstruction in the event that floodwaters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.

10. Stabilization: All areas disturbed during installation shall be stabilized within 14 calendar days of that disturbance in accordance with the Standard and Specifications for Critical Area Seeding on page 3.3.

Bridge Maintenance Requirements

1. Inspection: Periodic inspection shall be performed by the user to ensure that the bridge, streambed and stream banks are maintained and not damaged.
2. Maintenance: Maintenance shall be performed, as needed to ensure that the structure compiles with the standard and specifications. This shall include removal and disposal of any trapped sediment or debris. Sediment shall be disposed of outside of the flood plain and stabilized.

Bridge Removal and Clean-Up Requirements

1. Removal: When the temporary bridge is no longer needed, all structures including abutments and other bridging materials shall be removed within 14 calendar days. In all cases, the bridge materials shall be removed within one year of installation.
2. Final Clean-Up: Final clean-up shall consist of removal of the temporary bridge from the waterway, protection of banks from erosion, and removal of all construction materials. All removed materials shall be stored outside the waterway flood plain.
3. Method: Removal of the bridge and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.
4. Final Stabilization: All areas disturbed during removal shall be stabilized within 14 calendar days of that disturbance in accordance with the Standard and Specifications for Critical Area Seedings on page 3.3.

Temporary Access Culvert (Figure 5A.40 on page 5A.83)

A temporary access culvert is a structure consisting of a section(s) of circular pipe, pipe arches, or oval pipes of reinforcing concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossing.

Considerations

1. Temporary culverts are used where a) the channel is too wide for normal bridge construction, b) anticipated loading may prove unsafe for single span bridges, or c) access is not needed from bank to bank.
2. This temporary waterway crossing method is normally preferred over a ford type of crossing, since disturbance to the waterway is only during construction and removal of the culvert.
3. Temporary culverts can be salvaged and reused.

Construction Specifications

1. Restrictions and Permits: A permit from the New York State department of Environmental Conservation, Division of Regulatory Affairs, Regional Permit Administrator, will be needed to install and remove temporary access culverts in streams with a classification of C(T) and higher. Installation and removal may not be permitted during the period of time from the start of trout spawning until the eggs have hatched. In some instances, restrictions may also be applied to bass spawning waters.

   Critical periods are as follows:

   Rainbow Trout: Early spring to early summer (March 15 - July 1)[1]

   Brook and Brown Trout: Early fall to late spring (Oct. 1 - June 1)[1]

   Bass: Late spring to midsummer (May 15 - July 30)[1]

[1] Dates cover Statewide application. Locally, the period may be shorter.

2. Culvert Strength: All culverts shall be strong enough to support their cross sectional area under maximum expected loads.
3. Culvert Size: The size of the culvert pipe shall be the largest pipe diameter that will fit into the existing channel without major excavation of the waterway channel or without major approach fills. If a channel width exceeds 3 feet, additional pipes may be used until the cross sectional area of the pipes is greater than 60 percent of the cross sectional area of the existing channel. The minimum size culvert that may be used is 12 inch diameter pipe.
4. Culvert Length: The culvert(s) shall extend a minimum of one foot beyond the upstream and downstream toe of the aggregate placed around the culvert. In no case shall the culvert exceed 40 feet in length.

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5. Filter Cloth: Filter cloth shall be placed on the streambed and streambanks prior to placement of the pipe culvert(s) and aggregate. The filter cloth shall cover the streambed and extend a minimum six inches and a maximum one foot beyond the end of the culvert and bedding material. Filter cloth reduces settlement and improves crossing stability.

6. Culvert Placement: The invert elevation of the culvert shall be installed on the natural streambed grade to minimize interference with fish migration (free passage of fish).

7. Culvert Protection: The culvert(s) shall be covered with a minimum of one foot of aggregate. If multiple culverts are used they shall be separated by at least 12 in. of compacted aggregate fill. At the minimum, the bedding and fill material used in the construction of the temporary access culvert crossings shall conform with the aggregate requirements cited in the General Requirements subsection.

8. Stabilization: All areas disturbed during culvert installation shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Area Stabilization With Permanent Seeding."

Culvert Maintenance Requirements

1. Inspection: Periodic inspection shall be performed to ensure that the culverts, streambed, and streambanks are not damaged, and that sediment is not entering the stream or blocking fish passage or migration.

2. Maintenance: Maintenance shall be performed, as needed in a timely manner to ensure that structures are in compliance with this standard and specification. This shall include removal and disposal of any trapped sediment or debris. Sediment shall be disposed of and stabilized outside the waterway flood plain.

Culvert Removal and Clean-Up Requirements

1. Removal: When the crossing has served its purpose, all structures including culverts, bedding and filter cloth materials shall be removed within 14 calendar days. In all cases, the culvert materials shall be removed within one year of installation. No structure shall be removed during the spawning season (March 15 through June 15).

2. Final Clean-up: Final clean-up shall consist of removal of the temporary structure from the waterway, removal of all construction materials, restoration of original stream channel cross section, and protection of the streambanks from erosion. Removed material shall be stored outside of the waterway flood plain.

3. Method: Removal of the structure and clean-up of the area shall be accomplished without construction equipment working in the waterway channel.

4. Final Stabilization: All areas disturbed during culvert removal shall be stabilized within 14 calendar days of the disturbance in accordance with the Standard for "Critical Area Stabilization with Permanent Seeding."

Temporary Access Ford (Figure 5A.41 on page 5A.84)

A temporary access ford is a shallow structure placed in the bottom of a waterway over which the water flows while still allowing traffic to cross the waterway.

Considerations

Temporary fords may be used when the streambanks are less than four (4) feet above the invert of the stream, and the streambed is armored with naturally occurring bedrock, or can be protected with an aggregate layer in conformance with these specifications.

Construction Specifications

1. Restrictions and Permits: A permit from New York State department of Environmental Conservation, Division of Regulatory Affairs, Regional Permit Administrator, will be needed to install, use, and remove temporary fords in streams with a classification of C(T) or higher. Installation, use and removal may not be permitted during the period of time from the start of trout spawning until the eggs have hatched. In some instances, restrictions may also be applied to bass spawning waters.

   Current periods are as follows:

   Rainbow Trout: Early spring to early summer (March 15 - July 1)[1]

   Brook and Brown Trout: Early fall to late spring (Oct. 1 - June 1)[1]

   Bass: Late spring to midsummer (May 15 - July 30)[1]

[1] Dates cover Statewide application. Locally, the period may be shorter.

2. The approaches to the structure shall consist of stone pads constructed to comply with the aggregate requirements of the General Requirements subsection.

   The entire ford approach (where banks were cut) shall be covered with filter cloth and protected with aggregate to a depth of four (4) inches.

3. Fords shall be prohibited when the stream banks are four (4) feet or more in height above the invert of the stream.

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4. The approach roads at the cut banks shall be no steeper than 5:1. Spoil material from the banks shall be stored out of the flood plain and stabilized.

5. One layer of filter cloth shall be placed on the streambed, streambanks and road approaches prior to placing the bedding material on the stream channel or approaches. The filter cloth will be a minimum of six (6) inches and a maximum one foot beyond bedding material.

6. The bedding material shall be coarse aggregate or gabion mattresses filled with coarse aggregate.

7. Aggregate used in ford construction shall meet the minimum requirements of the General Requirements subsection.

8. All fords shall be constructed to minimize the blockage of stream flow and shall allow free flow over the ford. The placing of any material in the waterway bed will cause some upstream ponding. The depth of this ponding will be equivalent to the depth of the material placed within the stream and therefore should be kept to a minimum height. However, in no case will the bedding material be placed deeper than 12 inches or one-half (1/2) the height of the existing banks whichever is smaller.

9. Stabilization: All areas disturbed during ford installation shall be stabilized within 14 calendar days of that disturbance in accordance with the Standard and Specifications for Critical Area Seeding on page 3.3.

10. Ford Removal and Clean-Up Requirements

A. Removal: When the temporary structure has served its purpose, excess material used for this structure need not be removed. Care should be taken so that any aggregate left does not create an impoundment or restrict fish passage.

B. Final Clean-Up: Final clean-up shall consist of removal of excess temporary ford materials from the waterway. All materials shall be stored outside the waterway flood plain.

C. Method: Clean up shall be accomplished without construction equipment working in the stream channel.

D. Approach Disposition: The approach slopes of the cut banks shall not be backfilled.

E. Final Stabilization: All areas disturbed during ford removal shall be stabilized within 14 calendar days of that disturbance in accordance with the Standard and Specifications for Critical Area Seeding on page 3.3.

NOTE: Any temporary access crossing shall conform to the technical requirements of this Standard and Specifications as well as any specific requirement imposed by the New York State Department of Environmental Conservation.

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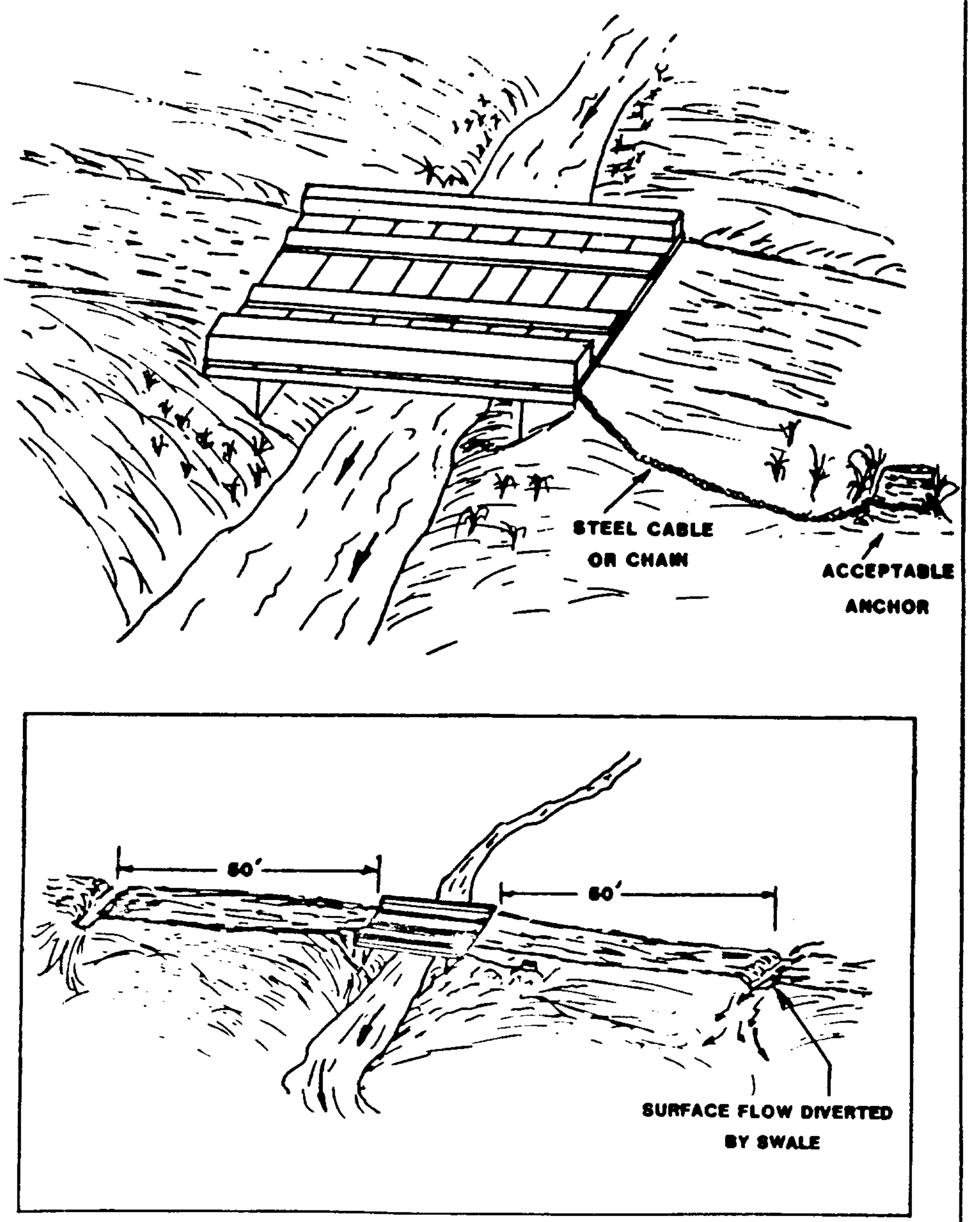
Figure 5A.39
Temporary Access Bridge

TEMPORARY ACCESS BRIDGE



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	TEMPORARY ACCESS BRIDGE	STANDARD SYMBOL ⟩T⟨

Figure 5A.40
Temporary Access Culvert

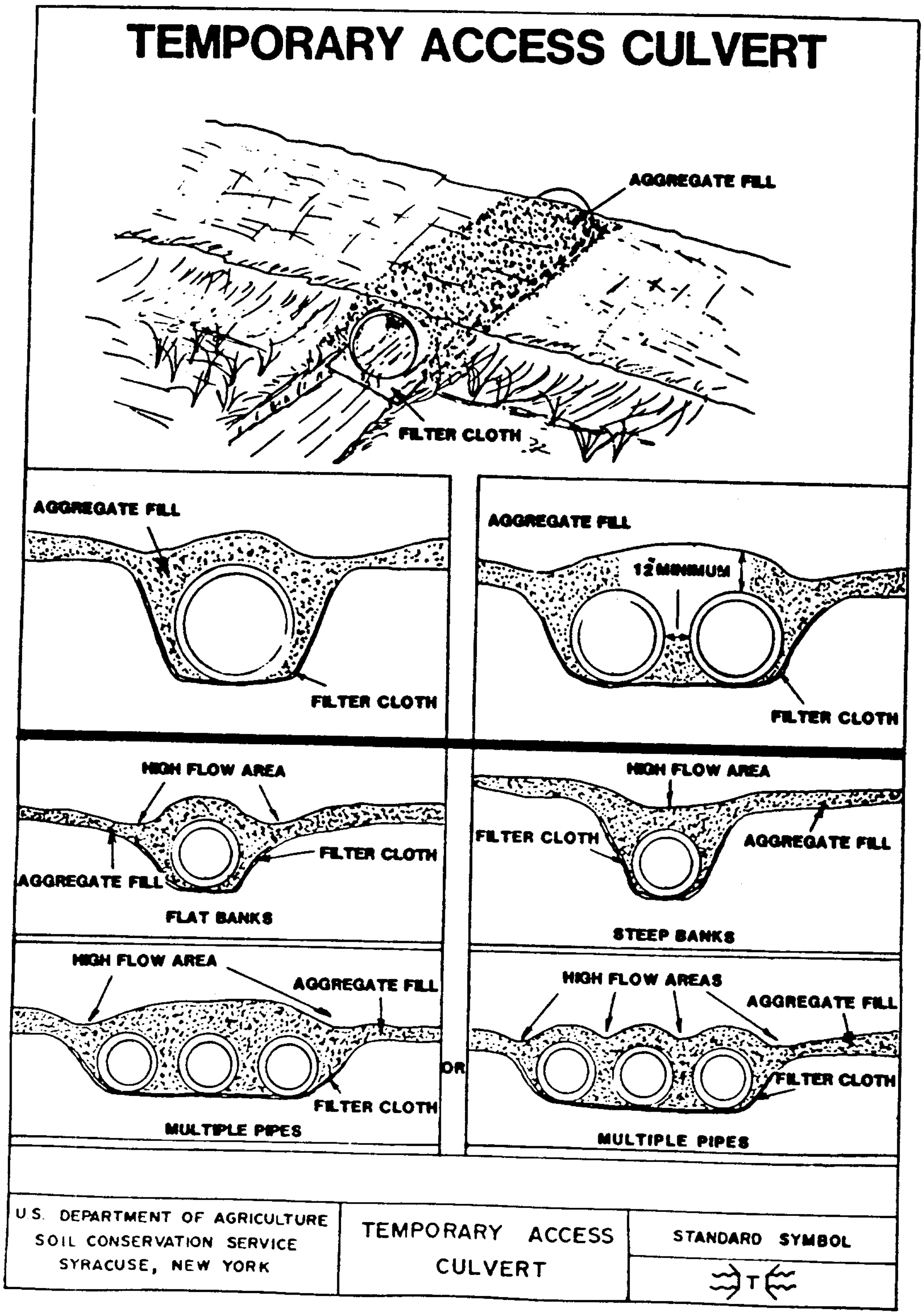


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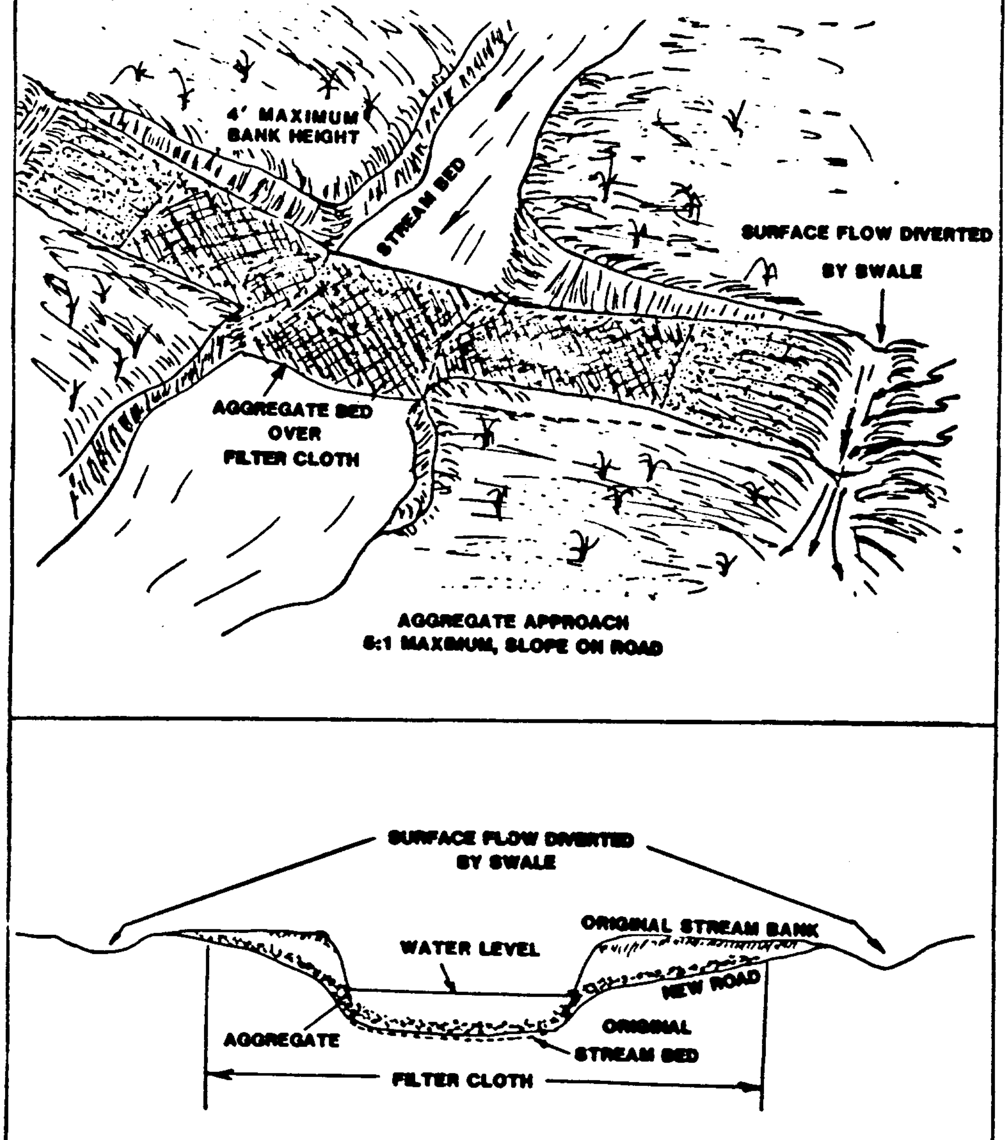
Figure 5A.41
Temporary Access Ford



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	TEMPORARY ACCESS FORD	STANDARD SYMBOL

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STANDARD AND SPECIFICATIONS FOR DUST CONTROL

Definition

The control of dust resulting from land-disturbing activities.

Purpose

To prevent surface and air movement of dust from disturbed soil surfaces that may cause off-site damage, health hazards, and traffic safety problems.

Conditions Where Practice Applies

On construction roads, access points, and other disturbed areas subject to surface dust movement and dust blowing where off-site damage may occur if dust is not controlled.

Design Criteria

Construction operations should be scheduled to minimize the amount of area disturbed at one time. Buffer areas of vegetation should be left where practical. Temporary or permanent stabilization measures should be installed. No specific design criteria is given; see construction specifications below for common methods of dust control.

Construction Specifications

Vegetative Cover - For disturbed areas not subject to traffic; vegetation provides the most practical method of dust control (see section 3).

Mulch (including gravel mulch) - Mulch offers a fast effective means of controlling dust.

Spray adhesives - Examples of spray adhesives for use on mineral soils are shown in the following table:

Material	Water Dilution	Type of Nozzle	Apply Gallons/Acre
Acrylic polymer	9:1	coarse spray	500
Latex emulsion	12.5:1	fine spray	235
Resin in water	4:1	fine spray	300

Water quality should be considered when materials are selected for dust control.

Sprinkling - The site may be sprayed until the surface is wet. This is especially effective on haul roads and access routes.

Stone used for construction roads is also effective for dust control.

Barriers - a fence or similar barrier can control air currents at intervals equal to fifteen times the barrier height. Preserve existing wind barrier vegetation as much as practical.

Maintenance

Maintain dust control measures through dry weather periods until all disturbed areas are stabilized.

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STANDARD AND SPECIFICATIONS FOR SUMP PIT

Definition

A temporary pit which is constructed to trap and filter water for pumping to a suitable discharge area.

Purpose

To remove excessive water from excavations.

Conditions Where Practice Applies

Sump pits are constructed when water collects during the excavation phase of construction. This practice is particularly useful in urban areas during excavation for building foundations.

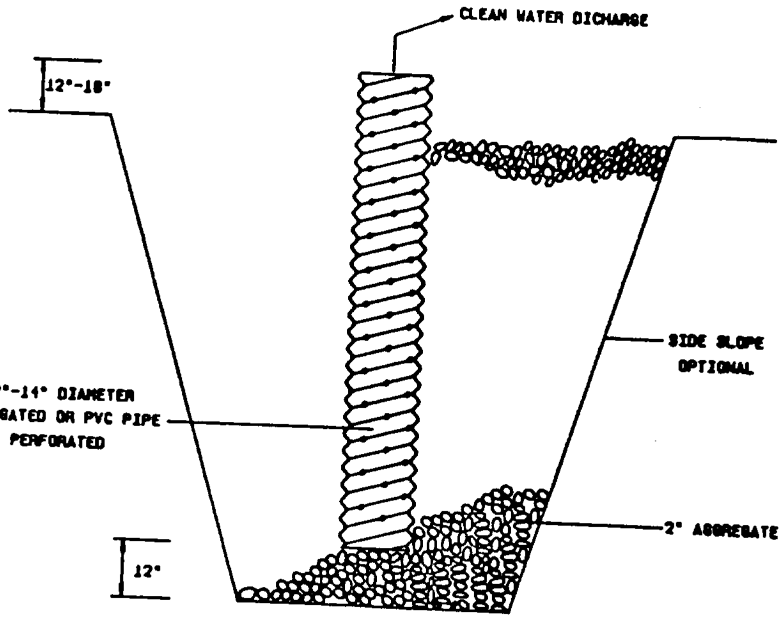
Design Criteria

The number of sump pits and their locations shall be determined by the contractor. A design is not required but construction should conform to the general criteria outlined on Figure 5A.42 on page 5A.88.

A perforated vertical standpipe is placed in the center of the pit to collect filtered water. Water is then pumped from the center of the pipe to a suitable discharge area.

Discharge of water pumped from the standpipe should be to a sediment trap, sediment basin or stabilized area. If water from the sump pit will be pumped directly to a storm drain system, filter cloth (Mirafi 100 X, Poly Filter GB or a filter cloth with an equivalent sieve size between 40-80) should be wrapped around the standpipe to ensure clean water discharge. It is recommended that 1/4 to 1/2 inch hardware cloth be wrapped around and secured to the standpipe prior to attaching the filter cloth. This will increase the rate of water seepage into the standpipe.

Figure 5A.42
Sump Pit Details



CONSTRUCTION SPECIFICATIONS

1. PIT DIMENSIONS ARE OPTIONAL.
2. THE STANDPIPE SHOULD BE CONSTRUCTED BY PERFORATING A 12"-24" DIAMETER CORREGATED OR PVC PIPE.
3. A BASE OF 2" AGGREGATE SHOULD BE PLACED IN THE PIT TO A DEPTH OF 12". AFTER INSTALLING THE STANDPIPE, THE PIT SURROUNDING THE STANDPIPE SHOULD THEN BE BACKFILLED WITH 2" AGGREGATE.
4. THE STAND PIPE SHOULD EXTEND 12"-18" ABOVE THE LIP OF THE PIT.
5. IF DISCHARGE WILL BE PUMPED DIRECTLY TO A STORM DRAINAGE SYSTEM, THE STANDPIPE SHOULD BE WRAPPED WITH FILTERCLOTH BEFORE INSTALLATION.

   IF DESIRED, 1/4"-1/2" HARDWARE CLOTH MAY BE PLACED AROUND THE STANDPIPE, PRIOR TO ATTACHING THE FILTERCLOTH. THIS WILL INCREASE THE RATE OF WATER SEEPAGE INTO THE PIPE.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	SUMP PIT	STANDARD SYMBOL

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SECTION 5B
PERMANENT STRUCTURAL MEASURES FOR EROSION AND SEDIMENT CONTROL IN URBAN AREAS

CONTENTS

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Section prepared by:
Donald W. Lake, Jr., State Conservation Engineer
USDA - Soil Conservation Service
Syracuse, New York

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STANDARD AND SPECIFICATIONS FOR DIVERSION

Definition

A drainage way of parabolic or trapezoidal cross-section with a supporting ridge on the lower side that is constructed across the slope.

Purpose

The purpose of a diversion is to intercept and convey runoff to stable outlets at non-erosive velocities.

Conditions Where Practice Applies

Diversions are used where:

1. Runoff from higher areas is or has potential for damaging properties causing erosion, or interfering with or preventing the establishment of vegetation on lower areas.
2. Surface and/or shallow subsurface flow is damaging sloping upland.
3. The length of slopes needs to be reduced so that soil loss will be reduced to a minimum.

Diversions are only applicable below stabilized or protected areas. Avoid establishment on slopes greater than fifteen percent. Diversions should be used with caution on soils subject to slippage. Construction of diversions shall be in compliance with state drainage and water laws.

Design Criteria

Location

Diversion location shall be determined by considering outlet conditions topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout.

Capacity

Peak rates of runoff values used in determining the capacity requirements shall be as outlined in Chapter 2, Estimating Runoff, Engineering Field Manual for Conservation Practices, Section 10 of this manual or by TR-55, Urban Hydrology for Small Watersheds.

The constructed diversion shall have capacity to carry, as a minimum, the peak discharge from a ten year frequency rainfall event with freeboard of not less than 0.3 of a foot.

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high risk areas, and those designed to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.

Cross Section

The diversion channel shall be parabolic or trapezoidal in shape. Parabolic Diversion design charts are provided in Figures 5B.2 through 5B.7 on pages 5B.4 to 5B.9. The diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to insure ease of maintenance of the diversion and its protective vegetative cover.

The ridge shall have a minimum width of four feet at the design water elevation; a minimum of 0.3 of a foot freeboard and a reasonable settlement factor shall be provided.

Velocity and Grade

The permissible velocity for the specified method of stabilization will determine the maximum grade. Maximum permissible velocities of flow for the stated conditions of stabilization shall be as shown in Table 5B.1 on page 5B.2 of this standard.

Diversions are not usually applicable below high sediment producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels are installed with or before the diversions.

Outlets

Each diversion must have an adequate outlet. The outlet may be a grassed waterway, vegetated or paved area, grade stabilization structure, stable watercourse, or subsurface drain outlet. In all cases the outlet must convey runoff to a point where outflow will not cause damage. Vegetated outlets shall be installed before diversion construction, if needed, to insure establishment of vegetative cover in the outlet channel.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Stabilization

Diversions shall be stabilized in accordance with the appropriate Standard and Specification for Vegetative Practices (Section 3).

Construction Specifications

See Figure 5B.1 on page 5B.3 for details.

TABLE 5B.1

DIVERSION MAXIMUM PERMISSIBLE DESIGN VELOCITIES

Soil Texture	Retardance and Cover	Permissible Velocity Feet Per Second Channel Vegetation
Sand, Silt, Sandy loam, silty loam, loamy sand (ML, SM, SP, SW)	C-Kentucky 31 tall fescue and Kentucky bluegrass	3.0
	D-Annuals[1] Small grain (rye, oats, barley, millet) Ryegrass	2.5
Silty clay loam, Sandy clay loam (ML-CL, SC)	C-Kentucky 31 tall fescue and Kentucky bluegrass	4.0
	D-Annuals[1] Small grain (rye, oats, barley, millet) Ryegrass	3.5
Clay (CL)	C-Kentucky 31 tall fescue and Kentucky bluegrass	5.0
	D-Annuals[1] Small grain (rye, oats, barley, millet) Ryegrass	4.0

[1] Annuals - Use only as temporary protection until permanent vegetation is established.

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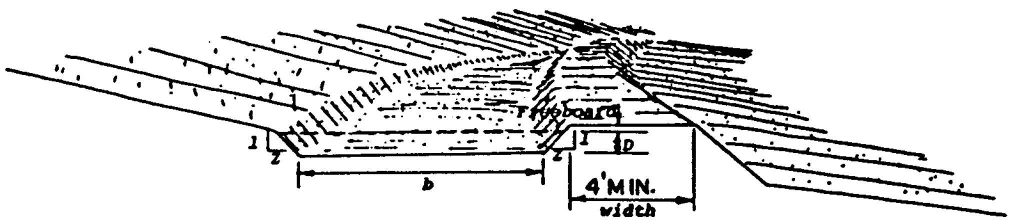
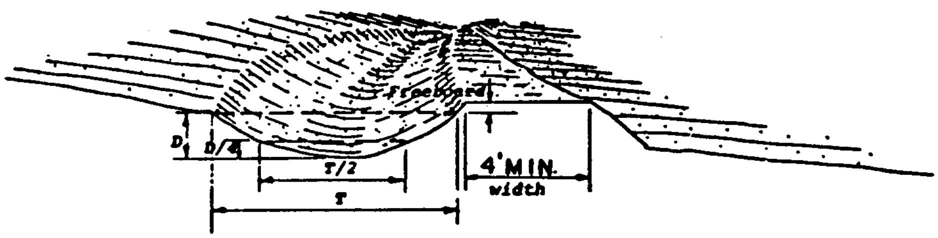
Figure 5B.1
Diversion Detail

DIVERSION



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.
2. The diversion shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the diversion.
5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.
   A. For design velocities of less than 3.5 ft. per sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means be used to prevent water from entering the diversion during the establishment of the vegetation.
   B. For design velocities of more than 3.5 ft. per sec., the diversion shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of water until the vegetation is established. See the Standard and Specifications for Protective Materials.

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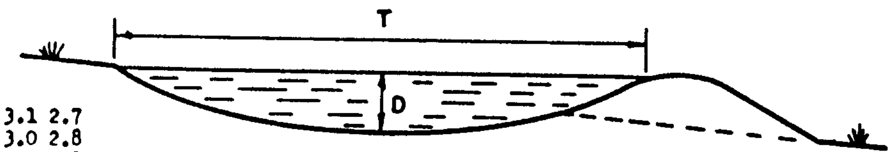
Figure 5B.2
Parabolic Diversion Design, Without Freeboard -1

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 0.25

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15																											
20																											
25	10	2.4	1.6																								
30	11	2.3	1.7																								
35	13	2.3	1.7																								
40	15	2.3	1.8	10	2.7	2.1																					
45	17	2.2	1.8	12	2.6	2.2																					
50	19	2.2	1.8	13	2.6	2.2																					
55	20	2.2	1.8	14	2.6	2.3																					
60	22	2.2	1.8	15	2.5	2.3																					
65	24	2.2	1.8	17	2.5	2.3																					
70	26	2.2	1.9	18	2.5	2.3	13	3.1	2.7																		
75	28	2.2	1.9	19	2.5	2.4	13	3.0	2.8																		
80	29	2.2	1.9	20	2.5	2.4	14	3.0	2.8																		
90	33	2.2	1.9	23	2.5	2.4	16	3.0	2.8																		
100	37	2.2	1.9	25	2.5	2.4	18	3.0	2.9																		
110	40	2.2	1.9	28	2.5	2.4	19	2.9	2.9																		
120	44	2.2	1.9	30	2.5	2.4	21	2.9	2.9	15	3.6	3.3															
130	48	2.2	1.9	33	2.5	2.4	23	2.9	2.9	16	3.6	3.3															
140	51	2.2	1.9	35	2.5	2.4	25	2.9	2.9	18	3.5	3.4															
150	55	2.2	1.9	37	2.5	2.4	26	2.9	2.9	19	3.5	3.4															
160	58	2.2	1.9	40	2.5	2.4	28	2.9	3.0	20	3.5	3.4															
170	62	2.2	1.9	42	2.5	2.4	30	2.9	3.0	21	3.5	3.4	17	4.0	3.8												
180	66	2.2	1.9	45	2.5	2.4	31	2.9	3.0	22	3.5	3.5	18	4.0	3.8												
190	69	2.2	1.9	47	2.5	2.4	33	2.9	3.0	24	3.5	3.5	19	4.0	3.9												
200	73	2.2	1.9	50	2.5	2.4	35	2.9	3.0	25	3.4	3.5	19	3.9	3.9												
220	80	2.2	1.9	55	2.5	2.4	38	2.9	3.0	27	3.4	3.5	21	3.9	3.9												
240	87	2.2	1.9	60	2.5	2.5	42	2.9	3.0	30	3.4	3.6	23	3.9	4.0												
260	95	2.2	1.9	65	2.5	2.4	45	2.9	3.0	32	3.4	3.5	25	3.9	4.0	20	4.6	4.3									
280				69	2.5	2.5	49	2.9	3.0	35	3.4	3.6	27	3.9	4.0	21	4.6	4.3									
300				74	2.5	2.5	52	2.9	3.0	37	3.4	3.6	29	3.8	4.1	22	4.5	4.4									



T = Top width, Retardance "C"
D = Flow depth, Retardance "C"
V_1 = Permissible velocity, Retardance "D"
V_2 = Velocity, Retardance "C"

T and D are the dimensions required to carry the design flow. Add freeboard and allowance for settlement as necessary.

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Figure 5B.3
Parabolic Diversion Design, Without Freeboard - 2

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 0.50

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	9	1.6	1.6																								
20	11	1.6	1.7																								
25	14	1.6	1.7	9	1.9	2.1																					
30	17	1.6	1.7	11	1.9	2.2	8	2.2	2.5																		
35	20	1.6	1.7	12	1.9	2.3	9	2.1	2.6																		
40	22	1.6	1.7	14	1.8	2.3	11	2.1	2.7																		
45	25	1.5	1.7	16	1.8	2.3	12	2.0	2.8																		
50	28	1.5	1.7	18	1.8	2.4	13	2.0	2.8	10	2.4	3.2															
55	31	1.5	1.7	19	1.8	2.4	15	2.0	2.8	11	2.4	3.3															
60	33	1.5	1.7	21	1.8	2.4	16	2.0	2.8	11	2.4	3.3															
65	36	1.5	1.8	23	1.8	2.4	17	2.0	2.9	12	2.4	3.3															
70	39	1.5	1.7	24	1.8	2.4	18	2.0	2.9	13	2.3	3.4															
75	42	1.5	1.8	26	1.8	2.4	19	2.0	2.9	14	2.3	3.4	11	2.7	3.7												
80	44	1.5	1.8	28	1.8	2.4	21	2.0	2.9	15	2.3	3.4	12	2.7	3.8												
90	50	1.5	1.8	31	1.8	2.4	24	2.0	2.9	17	2.3	3.4	13	2.7	3.8												
100	55	1.5	1.8	35	1.8	2.4	26	2.0	2.9	19	2.3	3.5	15	2.6	3.9	12	3.0	4.1									
110	61	1.5	1.8	38	1.8	2.4	29	2.0	2.9	21	2.3	3.5	16	2.6	3.9	13	3.0	4.2									
120	66	1.5	1.8	42	1.8	2.4	31	2.0	2.9	22	2.3	3.5	18	2.6	3.9	14	2.9	4.3									
130	72	1.5	1.8	45	1.8	2.4	34	2.0	2.9	24	2.3	3.5	19	2.6	4.0	15	2.9	4.4									
140	77	1.5	1.8	48	1.8	2.4	36	2.0	2.9	26	2.3	3.5	20	2.6	4.0	16	2.9	4.3									
150	83	1.5	1.8	52	1.8	2.4	39	2.0	2.9	28	2.3	3.5	22	2.6	4.0	18	2.9	4.4	14	3.3	4.8						
160	88	1.5	1.8	55	1.8	2.4	41	2.0	2.9	30	2.3	3.5	23	2.6	4.0	19	2.9	4.4	15	3.3	4.8						
170	93	1.5	1.8	59	1.8	2.4	44	2.0	2.9	32	2.3	3.6	25	2.6	4.0	20	2.9	4.4	16	3.3	4.9						
180	99	1.5	1.8	62	1.8	2.4	47	2.0	2.9	33	2.3	3.6	26	2.6	4.0	21	2.9	4.5	17	3.3	4.9						
190				65	1.8	2.4	49	2.0	2.9	35	2.3	3.6	28	2.6	4.0	22	2.9	4.5	18	3.3	5.0						
200				69	1.8	2.4	52	2.0	2.9	37	2.3	3.6	29	2.6	4.0	23	2.9	4.5	18	3.3	5.0	15	3.7	5.2			
220				76	1.8	2.4	57	2.0	2.9	41	2.3	3.6	32	2.6	4.0	25	2.9	4.5	20	3.2	5.0	17	3.7	5.4			
240				82	1.8	2.5	62	2.0	2.9	44	2.3	3.6	45	2.5	4.1	28	2.9	4.5	22	3.2	5.0	18	3.7	5.4			
260				89	1.8	2.5	67	2.0	2.9	48	2.3	3.6	38	2.6	4.1	30	2.9	4.5	24	3.2	5.1	20	3.5	5.4			
280				96	1.8	2.5	72	2.0	3.0	52	2.3	3.6	40	2.5	4.1	32	2.8	4.6	26	3.2	5.1	21	3.6	5.5	18	4.1	5.8
300							77	2.0	3.0	55	2.3	3.6	43	2.5	4.1	35	2.8	4.6	27	3.2	5.2	23	3.6	5.5	19	4.1	5.8

VOL 12

6-50

Figure 5B.4
Parabolic Diversion Design, Without Freeboard - 3

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 0.75

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	12	1.3	1.5	7	1.6	2.0																					
20	16	1.3	1.5	9	1.5	2.2																					
25	19	1.3	1.5	11	1.5	2.2	8	1.7	2.6																		
30	23	1.3	1.5	13	1.5	2.2	10	1.7	2.7	8	1.9	3.0															
35	27	1.3	1.5	15	1.5	2.3	11	1.7	2.7	9	1.9	3.1															
40	31	1.3	1.5	18	1.5	2.3	13	1.7	2.8	10	1.9	3.2															
45	35	1.3	1.6	20	1.5	2.3	14	1.7	2.8	11	1.8	3.2															
50	38	1.3	1.6	22	1.5	2.3	16	1.6	2.9	13	1.8	3.3	9	2.2	3.7												
55	42	1.3	1.6	24	1.5	2.3	18	1.6	2.9	14	1.8	3.3	10	2.1	3.8												
60	46	1.3	1.6	26	1.5	2.3	19	1.6	2.8	15	1.8	3.3	11	2.1	3.8												
65	50	1.3	1.6	28	1.5	2.3	21	1.6	2.9	16	1.8	3.3	12	2.1	3.8	10	2.4	4.1									
70	53	1.3	1.6	30	1.5	2.3	22	1.6	2.9	17	1.8	3.3	13	2.1	3.8	11	2.4	4.2									
75	57	1.3	1.6	33	1.5	2.3	24	1.6	2.9	19	1.8	3.3	14	2.1	4.0	11	2.3	4.2									
80	61	1.3	1.6	35	1.5	2.3	25	1.6	2.9	20	1.8	3.4	15	2.1	4.0	12	2.3	4.3									
90	68	1.3	1.6	39	1.5	2.3	28	1.6	2.9	22	1.8	3.4	16	2.1	4.0	13	2.3	4.4	11	2.6	4.6						
100	76	1.3	1.6	43	1.5	2.3	32	1.6	2.9	25	1.8	3.4	18	2.1	4.0	15	2.3	4.4	12	2.6	4.8						
110	83	1.3	1.6	48	1.5	2.3	35	1.6	2.9	27	1.8	3.4	20	2.0	4.0	16	2.3	4.5	13	2.6	4.8						
120	91	1.3	1.6	52	1.5	2.3	38	1.6	2.9	30	1.8	3.4	22	2.1	4.0	18	2.3	4.4	15	2.5	4.8	12	2.9	5.2			
130	98	1.3	1.6	56	1.5	2.4	41	1.6	2.9	32	1.8	3.4	23	2.1	4.0	19	2.2	4.5	16	2.5	4.9	13	2.8	5.3			
140				60	1.5	2.4	44	1.6	2.9	34	1.8	3.4	25	2.0	4.1	21	2.3	4.5	17	2.5	4.9	14	2.8	5.3			
150				65	1.5	2.4	47	1.6	2.9	37	1.8	3.4	27	2.0	4.1	22	2.2	4.5	18	2.5	4.9	15	2.8	5.3			
160				69	1.5	2.4	50	1.6	2.9	39	1.8	3.4	29	2.0	4.1	24	2.2	4.5	19	2.5	4.9	16	2.8	5.4	13	3.1	5.8
170				73	1.5	2.4	53	1.6	2.9	42	1.8	3.4	30	2.0	4.1	25	2.2	4.5	20	2.5	5.0	17	2.8	5.4	14	3.1	5.8
180				77	1.5	2.4	56	1.6	2.9	44	1.8	3.4	32	2.0	4.1	27	2.2	4.5	22	2.5	5.0	18	2.8	5.5	15	3.1	5.9
190				82	1.5	2.4	60	1.6	2.9	47	1.8	3.4	34	2.0	4.1	28	2.2	4.6	23	2.5	5.0	19	2.8	5.5	16	3.1	5.9
200				86	1.5	2.4	63	1.6	3.0	49	1.8	3.4	36	2.0	4.1	29	2.2	4.5	24	2.5	5.0	20	2.7	5.5	16	3.1	5.9
220				94	1.5	2.4	69	1.6	3.0	54	1.8	3.4	39	2.0	4.1	32	2.2	4.6	26	2.5	5.1	22	2.7	5.5	18	3.1	5.9
240							75	1.6	3.0	59	1.8	3.4	43	2.0	4.1	35	2.2	4.6	29	2.5	5.0	24	2.7	5.6	19	3.1	6.0
260							81	1.6	3.0	64	1.8	3.4	46	2.0	4.1	38	2.2	4.6	31	2.5	5.1	26	2.7	5.6	21	3.1	6.1
280							87	1.6	3.0	68	1.8	3.4	50	2.0	4.1	41	2.2	4.6	33	2.5	5.1	27	2.7	5.7	23	3.0	6.1
300							93	1.6	3.0	73	1.8	3.5	53	2.0	4.1	44	2.2	4.6	36	2.5	5.1	29	2.7	5.6	24	3.0	6.1

VOL 12

6-5-1

Figure 5B.5
Parabolic Diversion Design, Without Freeboard - 4

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 1.0

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	13	1.1	1.5	8	1.3	2.0																					
20	18	1.1	1.5	11	1.3	2.1	8	1.5	2.6																		
25	22	1.1	1.5	14	1.3	2.1	9	1.5	2.6	8	1.6	3.0															
30	27	1.1	1.5	17	1.3	2.1	11	1.5	2.7	9	1.6	3.0															
35	31	1.1	1.5	19	1.3	2.2	13	1.5	2.8	11	1.6	3.1	8	1.8	3.6												
40	35	1.1	1.5	22	1.3	2.1	15	1.4	2.8	12	1.6	3.1	9	1.8	3.7												
45	40	1.1	1.5	25	1.3	2.2	17	1.5	2.8	13	1.6	3.2	10	1.8	3.7												
50	44	1.1	1.5	28	1.3	2.2	19	1.4	2.8	15	1.6	3.2	11	1.8	3.7	9	2.0	4.2									
55	46	1.1	1.5	30	1.3	2.2	20	1.4	2.8	16	1.5	3.3	12	1.8	3.8	10	2.0	4.3									
60	53	1.1	1.5	33	1.3	2.2	22	1.4	2.8	18	1.5	3.3	14	1.7	3.8	10	2.0	4.3									
65	57	1.1	1.5	36	1.3	2.2	24	1.4	2.8	19	1.5	3.3	15	1.7	3.8	11	2.0	4.3	9	2.2	4.7						
70	61	1.1	1.5	38	1.3	2.2	26	1.4	2.8	21	1.5	3.3	16	1.7	3.9	12	2.0	4.4	10	2.2	4.7						
75	66	1.1	1.5	41	1.3	2.2	28	1.4	2.9	22	1.5	3.3	17	1.7	3.9	13	2.0	4.5	11	2.2	4.7						
80	70	1.1	1.5	44	1.3	2.2	29	1.4	2.9	24	1.5	3.3	18	1.7	3.9	14	2.0	4.4	11	2.2	4.9						
90	79	1.1	1.5	49	1.3	2.2	33	1.4	2.9	27	1.5	3.3	20	1.7	3.9	15	1.9	4.5	13	2.2	4.9	11	2.4	5.2			
100	87	1.1	1.5	55	1.3	2.2	37	1.4	2.9	29	1.5	3.3	22	1.7	3.9	17	1.9	4.5	14	2.2	4.9	12	2.4	5.3			
110	96	1.1	1.5	60	1.3	2.2	40	1.4	2.9	32	1.5	3.3	24	1.7	3.9	19	1.9	4.5	15	2.1	5.0	13	2.4	5.3	11	2.6	5.7
120				65	1.3	2.2	44	1.4	2.9	35	1.5	3.3	27	1.7	4.0	20	1.9	4.6	17	2.1	5.0	14	2.4	5.4	12	2.6	5.7
130				71	1.3	2.2	47	1.4	2.9	38	1.5	3.3	29	1.7	4.0	22	1.9	4.6	18	2.1	5.0	15	2.4	5.4	13	2.6	5.8
140				76	1.3	2.2	51	1.4	2.9	41	1.5	3.3	31	1.7	4.0	24	1.9	4.6	20	2.1	5.0	16	2.3	5.5	14	2.6	5.8
150				81	1.3	2.2	55	1.4	2.9	44	1.5	3.3	33	1.7	4.0	25	1.9	4.6	21	2.1	5.1	17	2.4	5.5	15	2.6	5.8
160				87	1.3	2.2	58	1.4	2.9	47	1.5	3.3	35	1.7	4.0	27	1.9	4.6	22	2.1	5.1	19	2.3	5.5	16	2.5	6.0
170				92	1.3	2.2	62	1.4	2.9	50	1.5	3.3	38	1.7	4.0	29	1.9	4.6	24	2.1	5.1	20	2.3	5.7	17	2.5	5.9
180				97	1.3	2.2	65	1.4	2.9	53	1.5	3.4	40	1.7	4.0	30	1.9	4.6	25	2.1	5.1	21	2.3	5.6	18	2.5	5.9
190							69	1.4	2.9	55	1.5	3.4	42	1.7	4.0	32	1.9	4.6	26	2.1	5.1	22	2.3	5.6	19	2.5	6.0
200							72	1.4	2.9	58	1.5	3.4	44	1.7	4.0	34	1.9	4.7	28	2.1	5.1	23	2.3	5.6	20	2.5	6.0
220							80	1.4	2.9	64	1.5	3.4	48	1.7	4.0	37	1.9	4.6	31	2.1	5.1	25	2.3	5.6	22	2.5	6.1
240							87	1.4	2.9	70	1.5	3.4	53	1.7	4.0	40	1.9	4.7	33	2.1	5.1	28	2.3	5.7	24	2.5	6.1
260							94	1.4	2.9	76	1.5	3.4	57	1.7	4.0	44	1.9	4.7	36	2.1	5.1	30	2.3	5.4	26	2.5	6.1
280										81	1.5	3.4	61	1.7	4.0	47	1.9	4.7	39	2.1	5.1	32	2.3	5.6	28	2.5	6.2
300										87	1.5	3.4	66	1.7	4.0	50	1.9	4.7	42	2.1	5.1	34	2.3	5.7	30	2.5	6.1

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Figure 5B.6
Parabolic Diversion Design, Without Freeboard - 5

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 1.5

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	17	0.9	1.4	11	1.1	1.9	8	1.2	2.4																		
20	23	0.9	1.4	15	1.0	1.9	10	1.2	2.5	7	1.4	3.0	6	1.5	3.4												
25	28	0.9	1.4	19	1.0	1.9	12	1.2	2.6	8	1.4	3.2	7	1.5	3.6												
30	34	0.9	1.4	22	1.0	1.9	15	1.2	2.6	10	1.3	3.2	8	1.5	3.6	7	1.6	4.0									
35	40	0.9	1.4	26	1.0	2.0	17	1.1	2.6	12	1.3	3.3	10	1.4	3.7	8	1.6	4.1									
40	45	0.9	1.4	30	1.0	1.9	20	1.2	2.6	14	1.3	3.3	11	1.4	3.7	9	1.6	4.2	7	1.8	4.6						
45	51	0.9	1.4	33	1.0	2.0	22	1.1	2.6	15	1.3	3.4	12	1.4	3.8	10	1.5	4.3	8	1.8	4.6						
50	56	0.9	1.4	37	1.0	2.0	25	1.1	2.7	17	1.3	3.4	14	1.4	3.9	11	1.5	4.3	9	1.8	4.8						
55	62	0.9	1.5	41	1.0	2.0	27	1.1	2.6	19	1.3	3.4	15	1.4	3.9	12	1.5	4.3	10	1.7	4.9	8	1.9	5.1			
60	67	0.9	1.5	44	1.0	2.0	30	1.1	2.7	20	1.3	3.4	16	1.4	3.9	14	1.5	4.4	11	1.7	4.9	9	1.9	5.2			
65	73	0.9	1.5	48	1.0	2.0	32	1.1	2.7	22	1.3	3.4	18	1.4	3.9	15	1.5	4.4	11	1.7	5.0	10	1.9	5.3			
70	78	0.9	1.5	51	1.0	2.0	34	1.1	2.7	24	1.3	3.4	19	1.4	3.9	16	1.5	4.4	12	1.7	4.9	10	1.9	5.4	9	2.1	5.6
75	83	0.9	1.5	55	1.0	2.0	37	1.1	2.7	25	1.3	3.4	21	1.4	3.9	17	1.5	4.4	13	1.7	5.0	11	1.9	5.4	9	2.1	5.6
80	89	0.9	1.5	59	1.0	2.0	39	1.1	2.7	27	1.3	3.4	22	1.4	3.9	18	1.5	4.4	14	1.7	5.0	12	1.9	5.5	10	2.1	5.8
90	100	0.9	1.5	66	1.0	2.0	44	1.1	2.7	30	1.3	3.5	25	1.4	3.9	20	1.5	4.4	16	1.7	5.0	13	1.9	5.4	11	2.0	5.9
100				73	1.0	2.0	49	1.1	2.7	33	1.3	3.5	27	1.4	3.9	22	1.5	4.5	17	1.7	5.1	15	1.9	5.5	12	2.0	6.0
110				80	1.0	2.0	54	1.1	2.7	37	1.3	3.5	30	1.4	3.9	25	1.5	4.5	19	1.7	5.1	16	1.8	5.6	14	2.0	6.0
120				87	1.0	2.0	58	1.1	2.7	40	1.3	3.5	33	1.4	4.0	27	1.5	4.5	21	1.7	5.1	18	1.9	5.5	15	2.0	6.0
130				95	1.0	2.0	63	1.1	2.7	43	1.3	3.5	35	1.4	3.9	29	1.5	4.5	22	1.7	5.1	19	1.8	5.5	16	2.0	6.1
140							68	1.1	2.7	47	1.3	3.5	38	1.4	4.0	31	1.5	4.5	24	1.7	5.2	20	1.8	5.6	17	2.0	6.1
150							73	1.1	2.7	50	1.3	3.5	41	1.4	4.0	33	1.5	4.5	26	1.7	5.2	22	1.8	5.6	18	2.0	6.1
160							78	1.1	2.7	53	1.3	3.5	43	1.4	4.0	36	1.5	4.5	27	1.7	5.2	23	1.8	5.6	20	2.0	6.1
170							82	1.1	2.7	56	1.3	3.5	46	1.4	4.0	38	1.5	4.5	29	1.7	5.2	25	1.8	5.6	21	2.0	6.1
180							87	1.1	2.7	60	1.3	3.5	49	1.4	4.0	40	1.5	4.5	31	1.7	5.2	26	1.8	5.7	22	2.0	6.1
190							92	1.1	2.7	63	1.3	3.5	51	1.4	4.0	42	1.5	4.5	33	1.7	5.2	27	1.8	5.7	23	2.0	6.2
200							97	1.1	2.7	66	1.3	3.5	54	1.4	4.0	44	1.5	4.5	34	1.7	5.2	29	1.8	5.6	24	2.0	6.2
220										73	1.3	3.5	59	1.4	4.0	49	1.5	4.5	38	1.7	5.2	32	1.8	5.7	27	2.0	6.2
240										79	1.3	3.5	65	1.4	4.0	53	1.5	4.5	41	1.7	5.2	35	1.8	5.7	29	2.0	6.2
260										86	1.3	3.5	70	1.4	4.0	57	1.5	4.5	44	1.7	5.2	37	1.8	5.7	32	2.0	6.2
280										92	1.3	3.5	75	1.4	4.0	62	1.5	4.5	48	1.7	5.2	40	1.8	5.7	34	2.0	6.2
300										99	1.3	3.5	81	1.4	4.0	66	1.5	4.5	51	1.7	5.2	43	1.8	5.7	36	2.0	6.2

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Figure 5B.7
Parabolic Diversion Design, Without Freeboard - 6

PARABOLIC DIVERSION DESIGN, WITHOUT FREEBOARD

RETARDANCE - D & C
GRADE, % - 2.0

V_1 Based on Permissible Velocity of the Soil With Retardance "D"
Top Width, Depth & V_2 Based on Retardance "C"

Q	V_1 = 2.0			V_1 = 2.5			V_1 = 3.0			V_1 = 3.5			V_1 = 4.0			V_1 = 4.5			V_1 = 5.0			V_1 = 5.5			V_1 = 6.0		
cfs	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2	T	D	V_2
15	21	0.8	1.3	13	0.9	1.9	9	1.0	2.4	7	1.2	2.9															
20	28	0.8	1.3	17	0.9	1.9	12	1.0	2.4	9	1.1	3.0	7	1.3	3.5	5	1.4	3.8									
25	35	0.8	1.3	21	0.9	1.9	15	1.0	2.4	11	1.1	3.0	8	1.3	3.7	7	1.4	4.0									
30	41	0.8	1.3	26	0.9	1.9	18	1.0	2.5	13	1.1	3.0	10	1.2	3.7	8	1.3	4.2	7	1.5	4.5						
35	48	0.8	1.4	30	0.9	1.9	22	1.0	2.4	15	1.1	3.1	11	1.2	3.8	9	1.3	4.2	8	1.5	4.7						
40	55	0.8	1.3	34	0.9	1.9	25	1.0	2.5	18	1.1	3.1	13	1.2	3.8	11	1.3	4.3	9	1.5	4.7	7	1.7	5.0			
45	62	0.8	1.4	38	0.9	1.9	28	1.0	2.5	20	1.1	3.1	14	1.2	3.8	12	1.3	4.3	10	1.4	4.8	8	1.6	5.2			
50	68	0.8	1.4	42	0.9	1.9	31	1.0	2.5	22	1.1	3.1	16	1.2	3.9	13	1.3	4.3	11	1.4	4.8	9	1.6	5.3	8	1.7	5.6
55	75	0.8	1.4	46	0.9	1.9	34	1.0	2.5	24	1.1	3.1	17	1.2	3.8	14	1.3	4.3	12	1.4	4.9	10	1.6	5.3	8	1.7	5.8
60	82	0.8	1.4	51	0.9	1.9	37	1.0	2.5	26	1.1	3.1	19	1.2	3.9	16	1.3	4.4	13	1.4	4.8	11	1.6	5.3	9	1.7	5.7
65	88	0.8	1.4	55	0.9	1.9	40	1.0	2.5	28	1.1	3.1	21	1.2	3.9	17	1.3	4.4	14	1.4	4.9	11	1.6	5.4	10	1.7	5.7
70	95	0.8	1.4	59	0.9	1.9	43	1.0	2.5	30	1.1	3.1	22	1.2	3.9	18	1.3	4.4	15	1.4	4.9	12	1.6	5.4	10	1.7	5.8
75				63	0.9	1.9	46	1.0	2.5	32	1.1	3.2	24	1.2	3.9	20	1.3	4.4	16	1.4	5.0	13	1.6	5.5	11	1.7	5.9
80				67	0.9	2.0	48	1.0	2.5	35	1.1	3.1	25	1.2	3.9	21	1.3	4.4	17	1.4	4.9	14	1.6	5.4	12	1.7	6.0
90				75	0.9	2.0	54	1.0	2.5	39	1.1	3.2	28	1.2	3.9	23	1.3	4.4	19	1.4	4.9	16	1.6	5.5	13	1.7	5.9
100				83	0.9	2.0	60	1.0	2.5	43	1.1	3.2	31	1.2	3.9	26	1.3	4.4	21	1.4	5.0	17	1.6	5.5	15	1.7	6.0
110				92	0.9	2.0	66	1.0	2.5	47	1.1	3.2	34	1.2	3.9	28	1.3	4.4	23	1.4	5.0	19	1.5	5.6	16	1.7	6.0
120				100	0.9	2.0	72	1.0	2.5	52	1.1	3.2	38	1.2	3.9	31	1.3	4.4	26	1.4	5.0	21	1.5	5.6	18	1.7	6.1
130							78	1.0	2.5	56	1.1	3.2	41	1.2	3.9	34	1.3	4.5	29	1.4	5.0	23	1.5	5.6	19	1.7	6.0
140							84	1.0	2.5	60	1.1	3.2	44	1.2	4.0	36	1.3	4.5	30	1.4	5.0	24	1.5	5.6	21	1.7	6.1
150							90	1.0	2.5	64	1.1	3.2	47	1.2	4.0	39	1.3	4.5	32	1.4	5.0	26	1.5	5.6	22	1.7	6.1
160							96	1.0	2.5	69	1.1	3.2	50	1.2	4.0	41	1.3	4.5	34	1.4	5.1	28	1.5	5.6	23	1.7	6.1
170										73	1.1	3.2	53	1.2	4.0	44	1.3	4.5	36	1.4	5.1	29	1.5	5.7	25	1.7	6.1
180										77	1.1	3.2	56	1.2	4.0	46	1.3	4.5	38	1.4	5.0	31	1.5	5.7	26	1.7	6.1
190										81	1.1	3.2	59	1.2	4.0	49	1.3	4.5	40	1.4	5.0	33	1.5	5.7	28	1.7	6.1
200										85	1.1	3.2	62	1.2	4.0	51	1.3	4.5	42	1.4	5.0	34	1.5	5.7	29	1.7	6.2
220										94	1.1	3.2	68	1.2	4.0	56	1.3	4.5	46	1.4	5.1	38	1.5	5.7	32	1.7	6.2
240													74	1.2	4.0	61	1.3	4.5	51	1.4	5.1	41	1.5	5.7	35	1.7	6.2
260													80	1.2	4.0	66	1.3	4.5	55	1.4	5.1	45	1.5	5.7	38	1.7	6.2
280													86	1.2	4.0	71	1.3	4.5	59	1.4	5.1	48	1.5	5.7	41	1.7	6.2
300													92	1.2	4.0	76	1.3	4.5	63	1.4	5.1	51	1.5	5.7	44	1.7	6.2

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STANDARD AND SPECIFICATIONS FOR GRASSED WATERWAY

Definition

A natural or man-made channel of parabolic or trapezoidal cross-section that is below adjacent ground level and is stabilized by suitable vegetation. The flow channel is normally wide and shallow and conveys the runoff down the slope.

Purpose

The purpose of a grassed waterway is to convey runoff without causing damage by erosion.

Conditions Where Practice Applies

Grass waterways are used where added vegetative protection is needed to control erosion resulting from concentrated runoff.

Design Criteria

Capacity

The minimum capacity shall be that required to confine the peak rate of runoff expected from a 10 year frequency rainfall event or a higher frequency corresponding to the hazard involved. This requirement for confinement may be waived on slopes of less than one (1) percent where out-of-bank flow will not cause erosion or property damage.

Peak rates of runoff values used in determining the capacity requirements shall be as outlined in Chapter 2, Estimating Runoff, Engineering Field Manual for Conservation Practices, Section 10 of this manual or by TR-55, Urban Hydrology for Small Watersheds.

Where there is base flow, it shall be handled by a stone center, subsurface drain, or other suitable means since sustained wetness usually prevents adequate vegetative cover. The cross-sectional area of the stone center or subsurface drain size to be provided shall be determined by using a flow rate of 0.1 cfs/acre or by actual measurement of the maximum base flow.

Velocity

Maximum permissible velocities (1) of flow shall not exceed the values shown:

Slope	Channel Lining	Permissible Velocity[1] (ft/sec.)
0-5%	Reed canarygrass	5
	Tall fescue	
	Kentucky bluegrass	
0-5% (cont'd)	Grass-legume mixture	4
	Red fescue	2.5
	Redtop	
	Sericea lespedeza	
	Annual lespedeza	
	Small grains	
5-10%	Reed canarygrass	4
	Tall fescue	
	Kentucky bluegrass	
	Grass-legume mixture	3

[1] For highly erodible soils, permissible velocities should be decreased 25%. An erodibility factor (K) greater than 0.35 would indicate a highly erodible soil. Erodibility factors (K factors) for New York soils are listed on the Soils 5 forms available in each SCS office.

Cross Section

The design water surface elevation of a grassed waterway receiving water from diversions or other tributary channels shall be equal to or less than the design water surface elevation in the diversion or other tributary channels.

The top width of parabolic waterways shall not exceed 30 feet and the bottom width of trapezoidal waterways shall not exceed 15 feet unless multiple or divided waterways, stone center, or other means are provided to control meandering of low flows.

Structural Measures

In cases where grade or erosion problems exist, special control measures may be needed such as stone centers, drop structures, or grade stabilization measures. Where needed, these measures will be supported by adequate design computations. For typical cross sections of waterways with riprap sections or stone centers, refer to Figure 5B.8 on page 5B.13.

The design procedures for parabolic and trapezoidal channels are available in the SCS Engineering Field Manual for Conservation Practices; Figure 5B.9 on page 5B.14 also provides a design chart for parabolic waterway.

Outlets

Each waterway shall have a stable outlet. The outlet may be another waterway, a stabilized open channel, grade stabilization structure, etc. In all cases, the outlet must discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized prior to the operation of the waterway.

Stabilization

Waterways shall be stabilized in accordance with the appropriate vegetative stabilization standard and specifications.

Construction Specifications

See Figure 5B.10 on page 5B.15 for details

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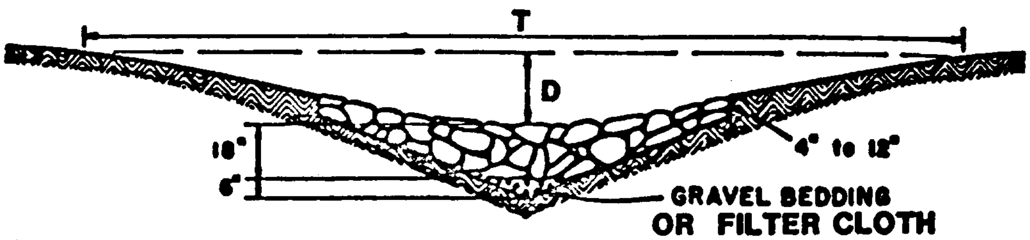
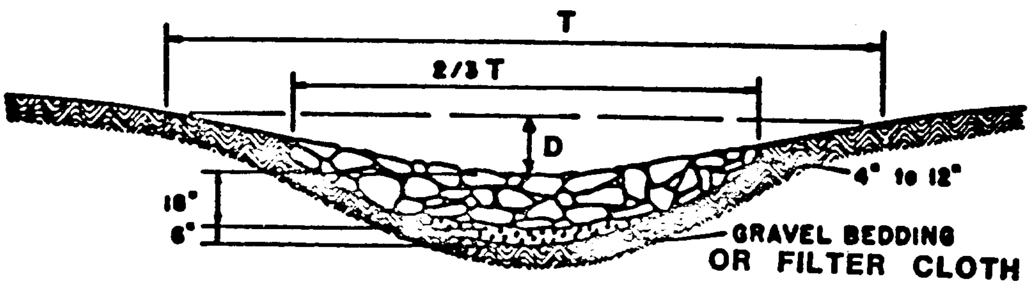
Figure 5B.8
Typical Waterway Cross Sections



Waterway with stone center drain. "V" section shaped by motor grader.



Waterway with stone center drain. Rounded section shaped by bulldozer.

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Figure 5B.9
Waterway-Parabolic Design Chart

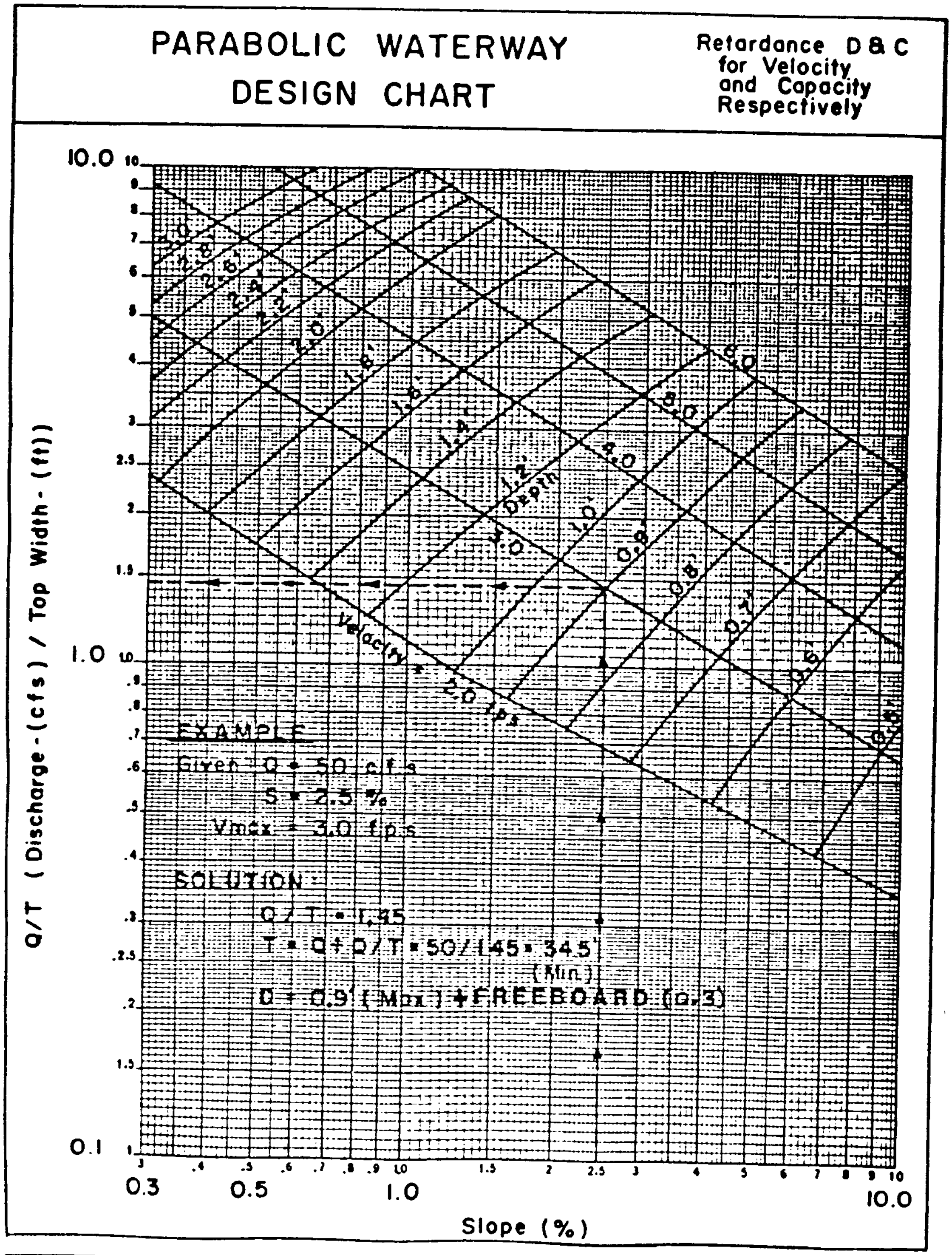

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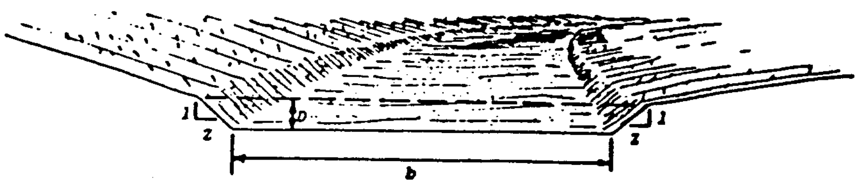
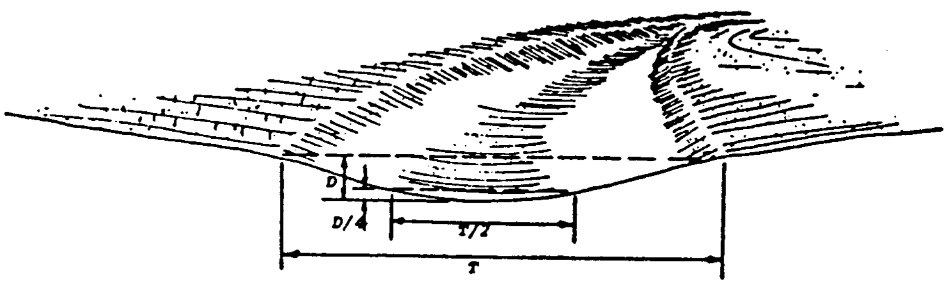
Figure 5B.10
Grassed Waterway Construction Details

GRASSED WATERWAY



TRAPEZOIDAL CROSS-SECTION



PARABOLIC CROSS-SECTION

Construction Specifications

1. All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway.
2. The waterway shall be excavated or shaped to line, grade, and cross section as required to meet the criteria specified herein, and be free of bank projections or other irregularities which will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete waterway.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway.
5. Stabilization shall be done according to the appropriate Standard and Specifications for Vegetative Practices.
   A. For design velocities of less than 3.5 ft. per sec., seeding and mulching may be used for the establishment of the vegetation. It is recommended that, when conditions permit, temporary diversions or other means should be used to prevent water from entering the waterway during the establishment of the vegetation.
   B. For design velocities of more than 3.5 ft. per sec., the waterway shall be stabilized with sod, with seeding protected by jute or excelsior matting or with seeding and mulching including temporary diversion of the water until the vegetation is established.
   C. Structural - Vegetative Protection
      (1) Subsurface drain for base flow shall be constructed as shown on the Standard Drawing and as specified in the Standard and Specifications for Subsurface Drain.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	GRASSED WATERWAY	STANDARD SYMBOL GL

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STANDARD AND SPECIFICATIONS FOR LINED WATERWAY OR OUTLET

Definition

A waterway or outlet with a lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to the designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

Purpose

To provide for the disposal of concentrated runoff without damage from erosion or flooding where grassed waterways would be inadequate due to high velocities.

Scope

This standard applies to waterways or outlets with linings of cast-in-place concrete, flagstone mortared in place, rock riprap, gabions or similar permanent linings. It does not apply to irrigation ditch and canal linings, grassed waterways with stone centers or small lined sections to carry prolonged low flows, or to reinforced concrete channels. The maximum capacity of the waterway flowing at design depth shall not exceed 100 cubic feet per second.

Conditions Where Practice Applies

This practice applies where the following or similar conditions exist:

1. Concentrated runoff is such that a lining is required to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.
3. The location is such that damage from use by people or animals precludes use of vegetated waterways or outlets.
4. Soils are highly erosive or other soil and climate conditions preclude using vegetation.
5. High value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.

Design Criteria

Capacity

1. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10 year, 24-hour storm. Velocity shall be computed using Manning's equation with a coefficient of roughness "n" as follows:

Lined Material	"n"
Concrete (Type):	
Trowel Finish	0.015
Float Finis	0.019
Gunite	0.019
Flagstone	0.022
Riprap	Determine from Fig. 5B.11 on page 5B.19
Gabion	0.030

2. Riprap and filter (bedding) shall be designed in accordance with criteria set forth in the National Cooperative Highway Research Program Report 108, available from the University Microfilm International, 300 N. Ree Road, Ann Arbor, Michigan 48016, Publication No. PB-00839; or the Hydraulic Engineering Circular No. 11, prepared by the U.S. Bureau of Public Roads, available from Federal Highway Administration, 400 7th Street, S.W., Washington, D.C. 20590, HNG-31, or the procedure in the Soil Conservation Service's Engineering Field Manual, Chapter 16.

Velocity

1. Maximum design velocity shall be as shown below. Except for short transition sections, flow with a channel gradient within the range of 0.7 to 1.3 of this flow's critical slope must be avoided unless the channel is straight. Velocities exceeding critical will be restricted to straight reaches.

Design Flow Depth (ft.)	Maximum Velocity (ft./sec.)
0.0 - 0.5	25
0.5 - 1.0	15
Greater than 1.0	10

2. Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical, or to a velocity the downstream soil and vegetative conditions will allow.

Cross Section

The cross section shall be triangular, parabolic, or trapezoidal. Monolithic concrete or gabions may be rectangular.

Freeboard

The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required where good vegetation can be grown and is maintained.

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Side Slope

Steepest permissible side slopes, horizontal to vertical will be as follows:

1. Non-Reinforced Concrete
   Hand-placed, formed concrete
   Height of lining, 1.5 ft. or less.................... Vertical
   Hand placed screened concrete or mortared in-place flagstone
   Height of lining, less than 2 ft........................1 to 1
   Height of lining, more than 2 ft...................... 2 to 1
2. Slip form concrete:
   Height of lining, less than 3 ft.........................1 to 1
3. Rock Riprap...2 to 1
4. Gabions .... Vertical
5. Pre-cast Concrete Sections.......................... Vertical

Lining Thickness

Minimum lining thickness shall be as follows:

1. Concrete.................4 in. (In most problem areas, shall be 5 in. with welded wire fabric reinforcing.)

2. Rock Riprap......1.5 x maximum stone size plus thickness of filter or bedding.

3. Flagstone.............4 in. including mortar bed.

Related Structures

Side inlets, drop structures, and energy dissipators shall meet the hydraulic and structural requirement of the site.

Filters or Bedding

Filters or bedding to prevent piping, reduce uplift pressure, and collect water will be used as required and will be designed in accordance with sound engineering principles. Weep holes and drains will be provided as needed.

Concrete

Concrete used for lining shall be so proportioned that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense product will be required. A mix that can be certified as suitable to produce a minimum strength of at least 3,000 pounds per square inch will be required. Cement used shall be Portland Cement, Type I, II, IV, or V. Aggregate used shall have a maximum diameter of 1 1/2 inches.

Weep holes should be provided in concrete footings and retaining walls to allow free drainage of water. Pipe used for weep holes shall be non-corrosive.

Mortar

Mortar used for mortared in-place flagstone shall consist of a mix of cement, sand, and water with a water/cement ratio of not more than 6 gallons of water per bag of cement.

Contraction Joints

Contraction joints in concrete linings, where required, shall be formed transversely to a depth of about one third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

Rock Riprap or Flagstone

Stone used for riprap or gabions shall be dense and hard enough to withstand exposure to air, water, freezing and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

Cutoff

Cutoff walls shall be used at the beginning and ending of concrete lining, and for rock riprap lining shall be keyed into the channel bottom and at both ends of the lining.

Construction Specifications

1. The foundation area shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.
2. The cross-section shall be excavated to the neat lines and grades as shown on the plans. Over-excavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.
3. No abrupt deviations from design grade or horizontal alignment shall be permitted.
4. Concrete linings shall be placed to the thickness shown on the plans and finished in a workmanlike manner. Adequate precautions shall be taken to protect freshly placed concrete from freezing or extremely high temperatures, to insure proper curing.
5. Filter bedding, and rock riprap shall be placed to line and grade in the manner specified.
6. Construction operation shall be done in such a manner that erosion, air and water pollution will be minimized and held within legal limits. The completed job shall present a workmanlike appearance. All disturbed areas shall be vegetated or otherwise protected against soil erosion.

Maintenance

Pavement or lining should be maintained as built to prevent undermining and deterioration. Trees should be removed next to pavements, as roots can cause uplift damage.

Vegetation next to pavement should be maintained in good condition to prevent scouring if the pavement is overtopped. See Standard and Specifications for Critical Area Seeding on page 3.3.

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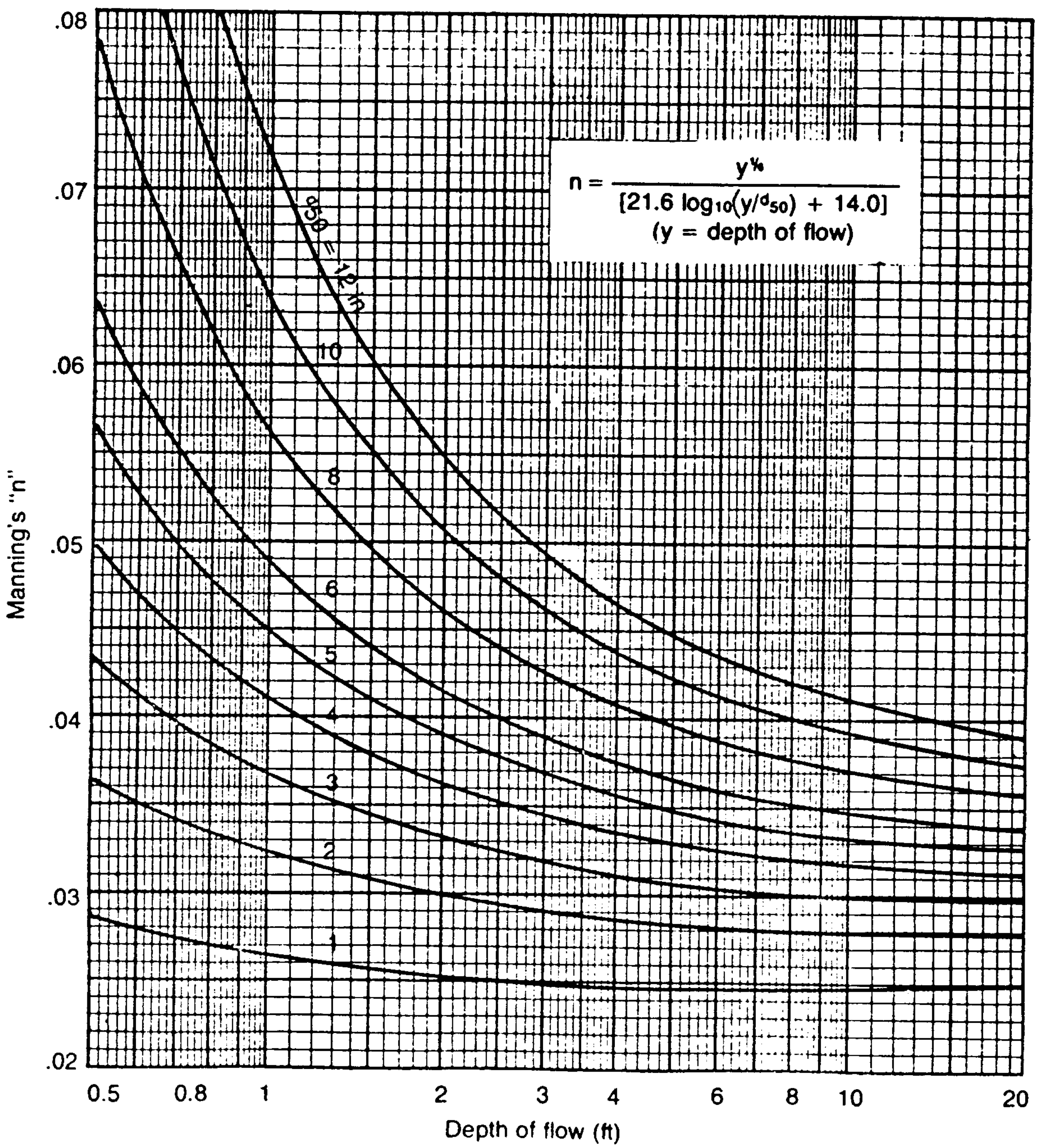
Figure 5B.11
Determining "n" for Riprap Lined Channel using Depth of Flow



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STANDARD AND SPECIFICATIONS FOR ROCK OUTLET PROTECTION

Definition

A section of rock protection placed at the outlet end of the culverts, conduits or channels.

Purpose

The purpose of the rock outlet protection is to reduce the depth, velocity, and energy of water, such that the flow will not erode the receiving downstream reach.

Scope

This standard applies to the planning, design, and construction of rock riprap and gabions for protection of downstream areas. It does not apply to rock lining of channels or streams.

Conditions Where Practice Applies

This practice applies where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the next downstream reach. This applies to:

1. Culvert outlets of all types.
2. Pipe conduits from all sediment basins, dry storm water ponds, and permanent type ponds.
3. New channels constructed as outlets for culverts and conduits.

Design Criteria

The design of rock outlet protection depends entirely on the location. Pipe outlets at the top of cuts or on slopes steeper than 10 percent, cannot be protected by rock aprons or riprap sections due to reconcentration of flows and high velocities encountered after the flow leaves the apron.

Many counties and state agencies have regulations and design procedures already established for dimensions, type and size of materials, and locations where outlet protection is required. Where these requirements exist, they shall be followed.

Tailwater depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a Minimum Tailwater Condition; see Figure 5B.14 on page 5B.26 as an example. If the tailwater depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a Maximum Tailwater Condition; see Figures 5B.15 and 5B.16 on pages 5B.27 and 5B.28 as an example. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition; see Figure 5B.14 on page 5B.26 as an example.

Apron Size

The apron length and width shall be determined from the curves according to the tailwater conditions:

Minimum Tailwater - Use Figure 5B.12 on page 5B.24
Maximum Tailwater - Use Figure 5B.13 on page 5B.25

If the pipe discharges directly into a well defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less.

The upstream end of the apron, adjacent to the pipe shall have a width two (2) times the diameter of the outlet pipe, or conform to pipe end section if used.

Bottom Grade

The outlet protection apron shall be constructed with no slope along its length. There shall be no overfall at the end of the apron. The elevation of the downstream end of the apron shall be equal to the elevation of the receiving channel or adjacent ground.

Alignment

The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

Materials

The outlet protection may be done using rock riprap, grouted riprap or gabions.

Riprap shall be composed of a well graded mixture of stone size so that 50 percent of the pieces, by weight, shall be larger than the d_{50} size determined by using the charts. A well graded mixture as used herein is defined as a mixture composed primarily of larger stone sizes but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the d_{50} size.

Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter for d_{50} of 15 inches or less; and 1.2 times the maximum stone size for d_{50} greater than 15 inches. The following chart lists some examples:

D_{50} (inches)	d_{max} (inches)	Mimimum Blanket Thickness (inches)
4	6	9
6	9	14
9	14	20
12	18	27
15	22	32
18	27	32
21	32	38
24	36	43

Stone Quality

Stone for riprap shall consist of field stone or rough unhewn quarry stone. The stone shall be hard and angular and of a quality that will not disintegrate on exposure to water or weathering. The specific gravity of the individual stones shall be at least 2.5.

Recycled concrete equivalent may be used provided it has a density of at least 150 pounds per cubic foot, and does not have any exposed steel or reinforcing bars.

Filter

A filter is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into and through the riprap. Riprap shall have a filter placed under it in all cases.

A filter can be of two general forms: A gravel layer or a plastic filter cloth. The plastic filter cloth can be woven or non-woven monofilament yarns, and shall meet these base requirements: thickness 20-60 mils, grab strength 90-120 lbs; and shall conform to ASTM D-1777 and ASTM D-1682.

Gravel filter blanket when used shall be designed by comparing particle sizes of the overlying material and the base material. Design criteria are available in Standard and Specification for Riprap Slope Protection, page 5B.55.

Gabions

Gabions shall be made of hexagonal triple twist mesh with heavily galvanized steel wire. The maximum linear dimension of the mesh opening shall not exceed 4 1/2 inches and the area of the mesh opening shall not exceed 10 square inches.

Gabions shall be fabricated in such a manner that the sides, ends, and lid can be assembled at the construction site into a rectangular basket of the specified sizes. Gabions shall be of single unit construction and shall be installed according to manufacturers recommendations.

The area on which the gabion is to be installed shall be graded as shown on the drawings. Foundation conditions shall be the same as for placing rock riprap and filter cloth shall be placed under all gabions. Where required, a key may be needed to prevent undermining of the main gabion structure.

Maintenance

Once a riprap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows to see if scour beneath the riprap has occurred, or any stones have been dislodged. Repairs should be made immediately.

Design Procedure

1. Investigate the downstream channel to assure that non-erosive velocities can be maintained.
2. Determine the tailwater condition at the outlet to establish which curve to use.
3. Enter the appropriate chart with the depth of flow and discharge velocity to determine the riprap size and apron length required. It is noted that references to pipe diameters in the charts are based on full flow. For other than full pipe flow, the parameters of depth of flow and velocity must be used.
4. Calculate apron width at the downstream end if a flared section is to be employed.

Examples

Example 1: Pipe Flow (full) with discharge to unconfined section.

Given: A circular conduit flowing full.

Q = 280 cfs, diam. = 66 in., tailwater (surface) is 2 ft. above pipe invert (minimum tailwater condition).

Find: Read d_{50} = 1.2 and apron length (L_a) = 38 ft.

Apron width = diam. + L_a = 5B.5 + 38 = 43.5 ft.

Use: d_{50} = 15", d_{max} = 22", blanket thickness = 32"

Example 2: Box Flow (partial) with high tailwater

Given: A box conduit discharging under partial flow conditions. A concrete box 5.5 ft. x 10 ft. flowing 5.0 ft. deep,

Q = 600 cfs and tailwater surface is 5 ft. above invert (max. tailwater condition).

Since this is not full pipe flow and does not directly fit the nomograph assumptions, it is necessary to compute the

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velocity in the conduit and then substitute the depth of flow as a diameter to find a discharge equal to full flow for that diameter, in this case 60 inches.

Compute velocity:

$$V = (Q/A) = (600/(5)(10)) = 12 \text{ fps}$$

Then substituting:

$$Q = \frac{\pi D^2}{4} \times V = \frac{3.14\,(5\text{ ft})^2}{4} \times 12 \text{ fps} = 236 \text{ cfs}$$

At the intersection of the curve d = 60 in. and Q = 236 cfs, read d_{50} = 0.4 ft.

Then reading the d = 60 in. curve, read apron length (L_a) = 40 ft.

Apron width, W = conduit width + (0.04)(L_a) = 10 + (0.4)(40) = 26 ft.

Example 3: Open Channel Flow with Discharge to Unconfined Section

Given: A trapezoidal concrete channel 5 ft. wide with 2:1 side slopes is flowing 2 ft. deep, Q = 180 cfs (velocity = 10 fps) and the tailwater surface downstream is 0.8 ft. (minimum tailwater condition).

Find: Using similar principles as Example 1, compute equivalent discharge for a 2-foot circular pipe flowing full at 10 feet per second.

Velocity:

$$Q = \frac{\pi\,(2\text{ft})^2}{4} \times 10 \text{ fps} = 31.4 \text{ cfs}$$

At intersection of the curve, d = 24 in. and Q = 32 cfs, read d_{50} = 0.6 ft.

Then reading the d = 24 in. curve, read apron length (L_a) = 20 ft.

Apron width, W = bottom width of channel + L_a = 5 + 20 = 25 ft.

Example 4: Pipe flow (partial) with discharge to a confined section

Given: A 48 in. pipe is discharging with a depth of 3 ft., Q = 100 cfs, and discharge velocity of 10 fps (established from partial flow analysis) to a confined trapezoidal channel with a 2 ft. bottom, 2:1 side slopes, n = .04, and grade of 0.6%.

Calculation of the downstream channel (by Manning's Equation) indicates a normal depth of 3.1 ft. and normal velocity of 3.9 fps.

Since the receiving channel is confined, the maximum tailwater condition controls.

Find: discharge using above principles:

$$Q = \frac{\pi\,(3\text{ft})^2}{4} \times 10 \text{ fps} = 71 \text{ cfs}$$

At the intersection of d = 36 in. and Q = 71 cfs, read d_{50} = 0.3 ft.

Reading the d = 36" curve, read apron length (L_a) = 30 ft.

Since the maximum flow depth in this reach is 3.1 ft., that is the minimum depth of riprap to be maintained for the entire length.

Construction Specifications

1. The subgrade for the filter, riprap or gabion shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density of approximately that of the surrounding undisturbed material.
2. The rock or gravel shall conform to the specified grading limits when installed respectively in the riprap or filter.
3. Filter cloth shall be protected from punching, cutting or tearing. Any damage other than an occasional small hole shall be repaired by placing another piece of cloth over the damaged part or by completely replacing the cloth. All overlaps whether for repairs or for joining two pieces of cloth shall be a minimum of one foot.
4. Stone for the riprap or gabion outlets may be placed by equipment. Both shall each be constructed to the full course thickness in one operation and in such a manner as to avoid displacement of underlying materials. The stone for riprap or gabion outlets shall be delivered and placed in a manner that will insure that it is reasonably homogenous with the smaller stones and spalls filling the voids between the larger stones. Riprap shall be placed in a manner to prevent damage to the filter blanket or filter cloth. Hand placement will be required to the extent necessary to prevent damage to the permanent works.

Figure 5B.12
Outlet Protection Design - Minimum Tailwater Condition
(Design of Outlet Protection from a Round Pipe Flowing Full,
Minimum Tailwater Condition: $T_W < 0.5D_O$)

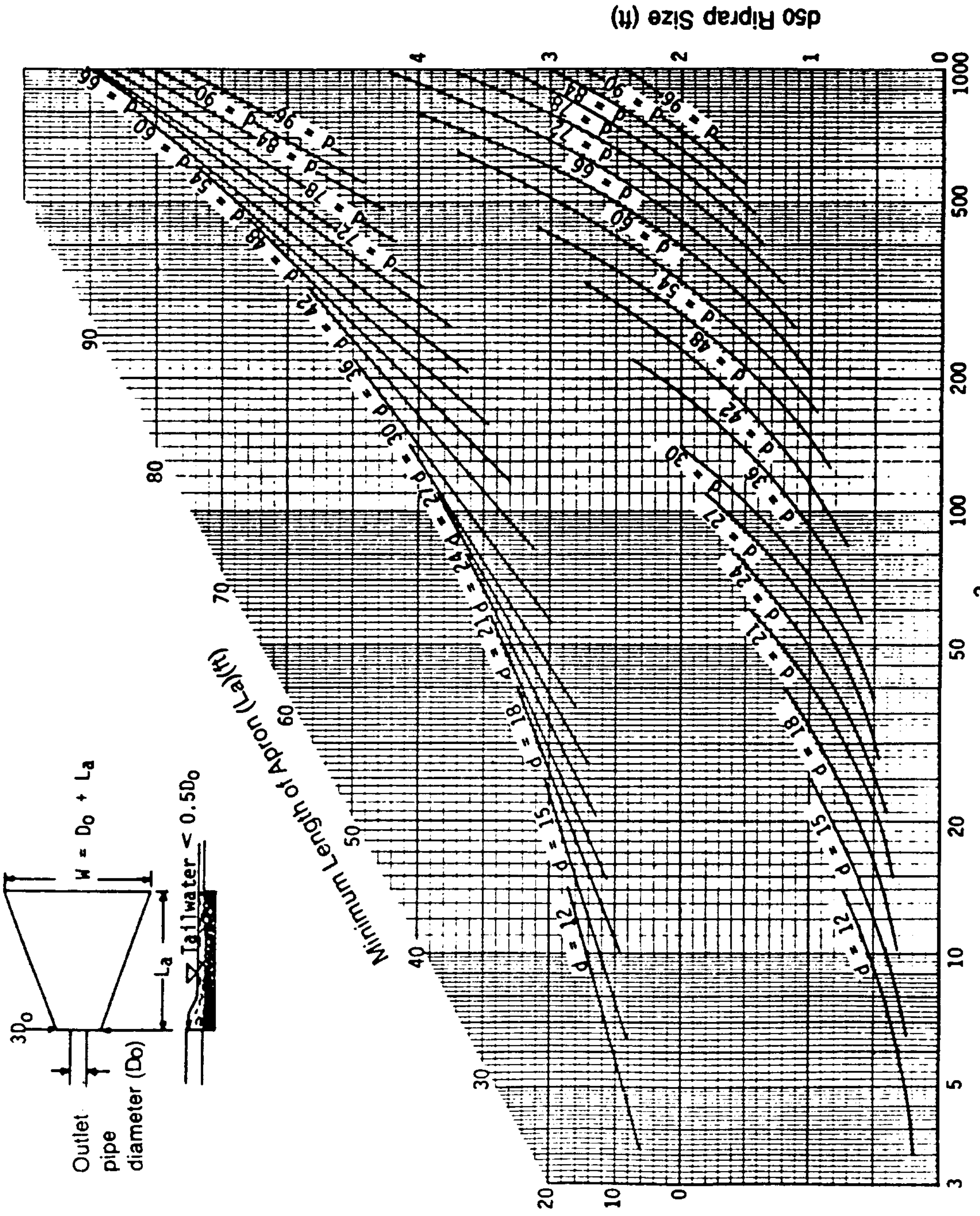

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Figure 5B.13
Outlet Protection Design - Maximum Tailwater Condition
(Design of Outlet Protection from a Round Pipe Flowing Full, Maximum Tailwater Condition: $T_W \geq 0.5D_o$)

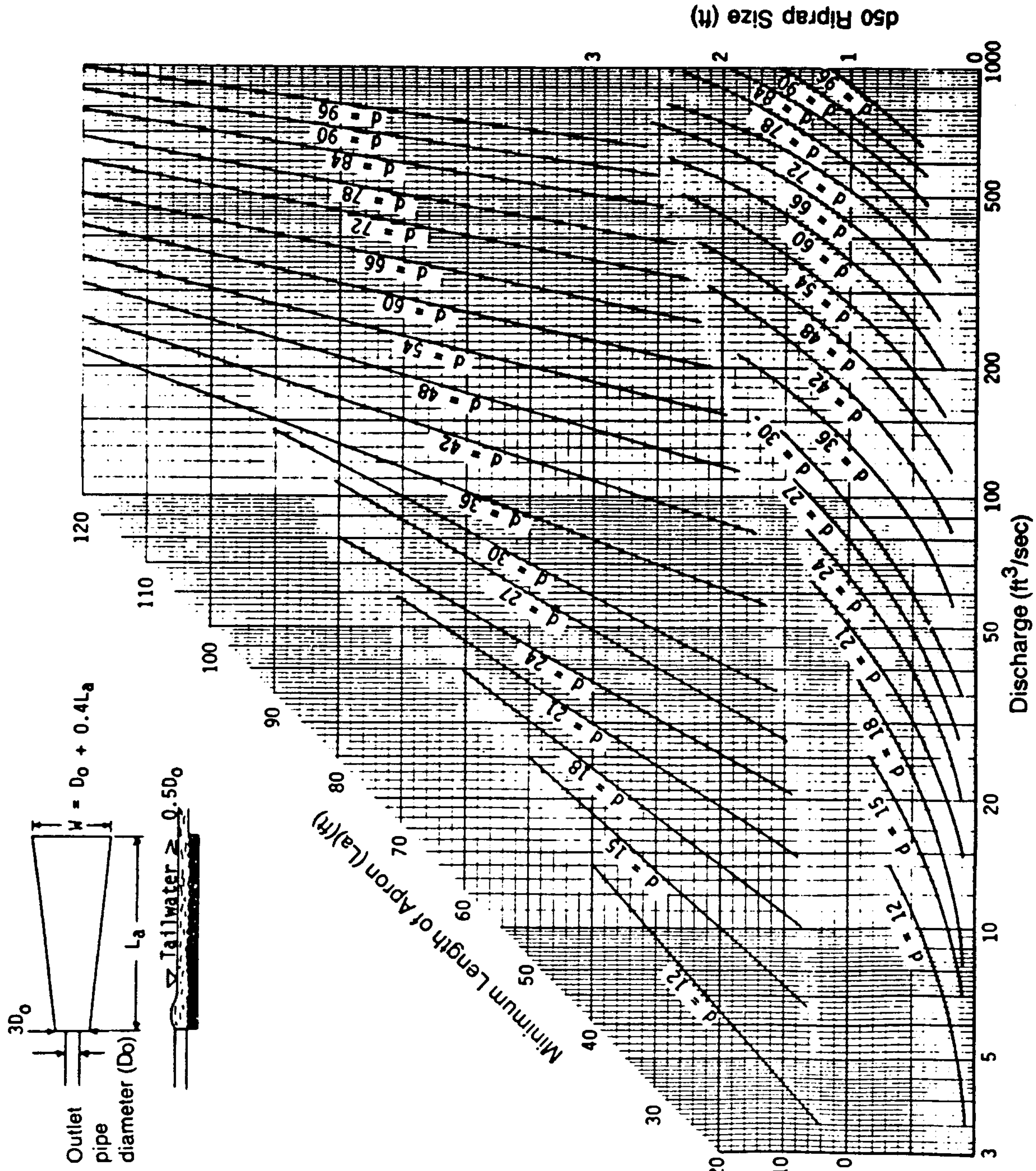

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Figure 5B.14
Riprap Outlet Protection Example

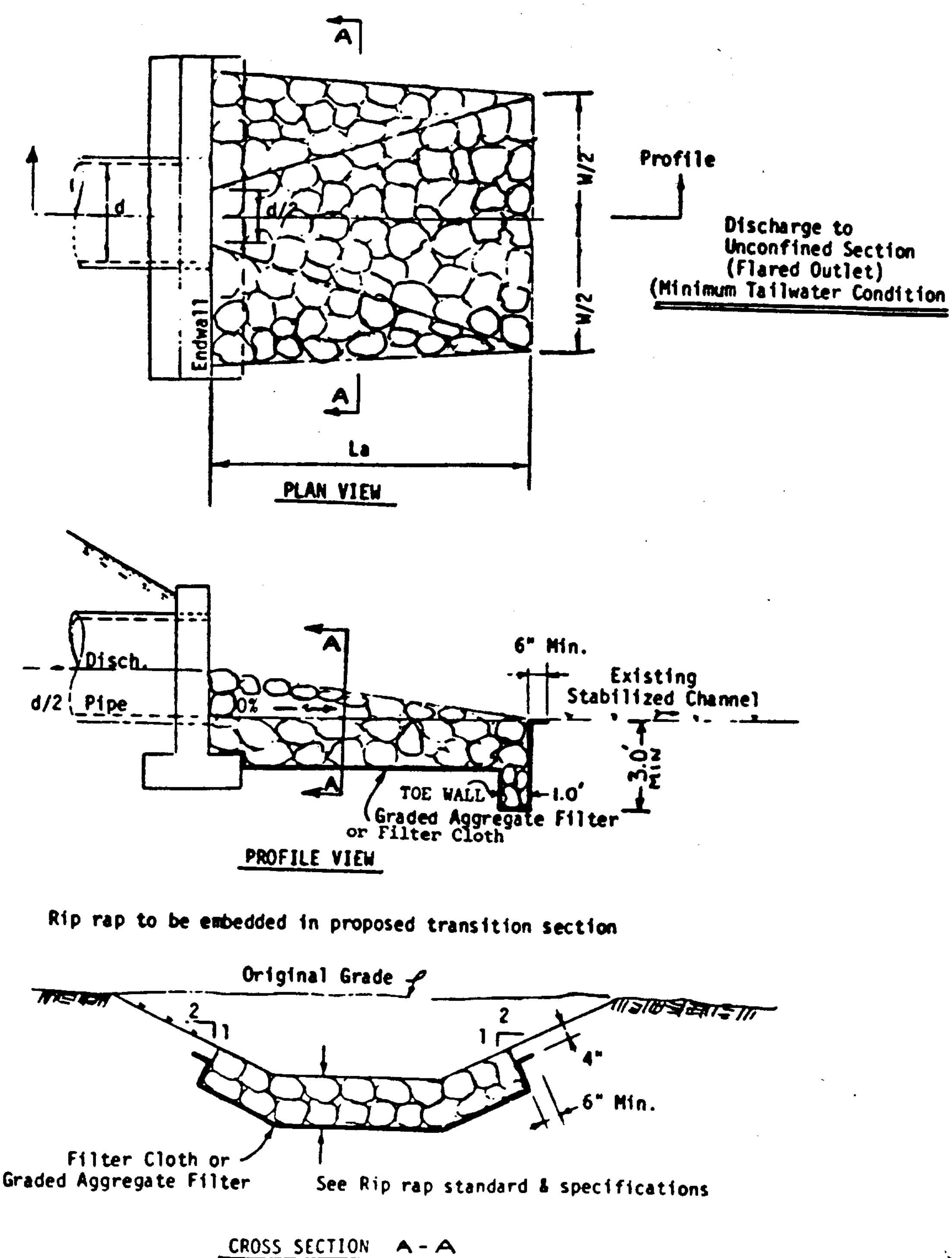

Figure 5B.15
Riprap Outlet Protection Example

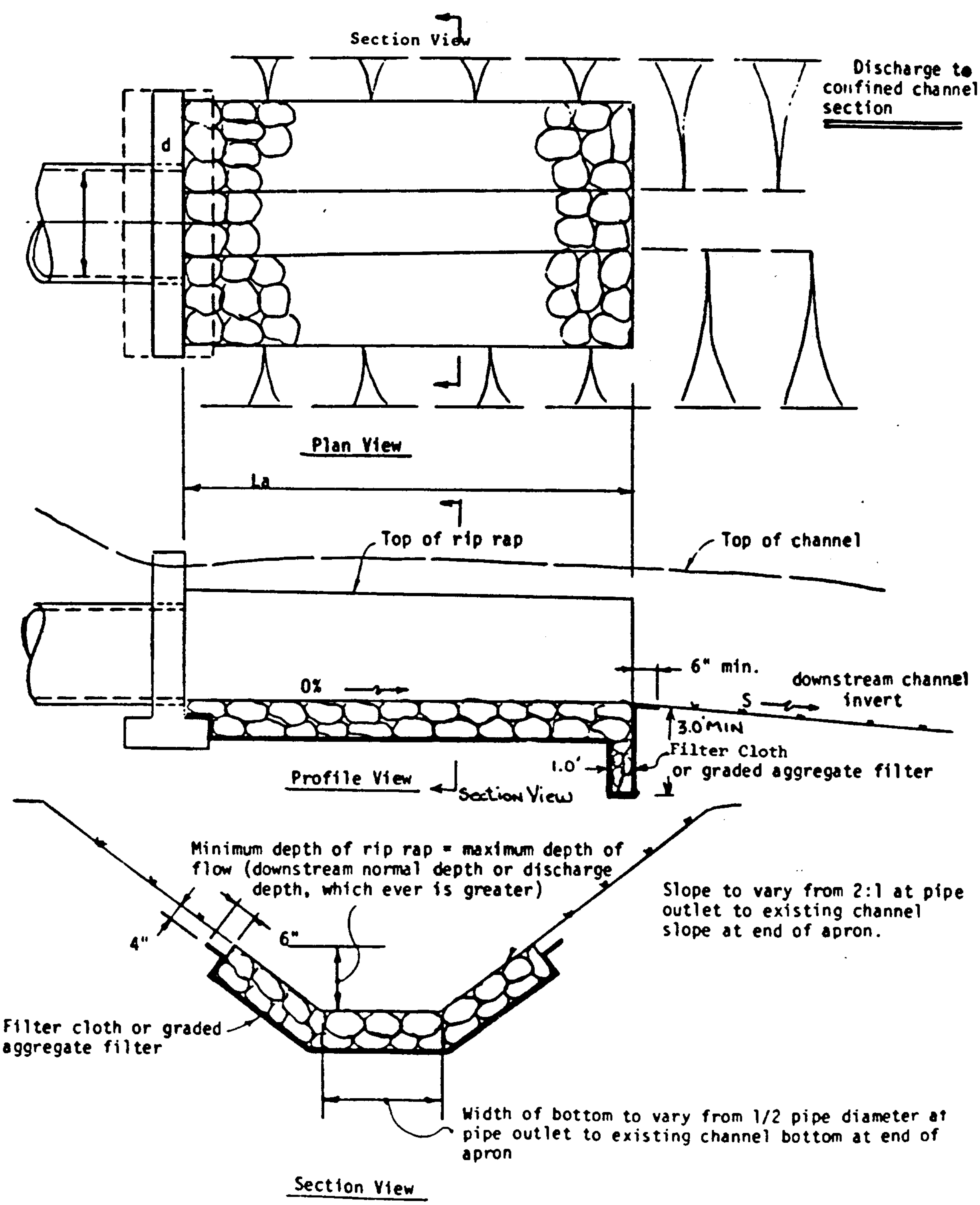

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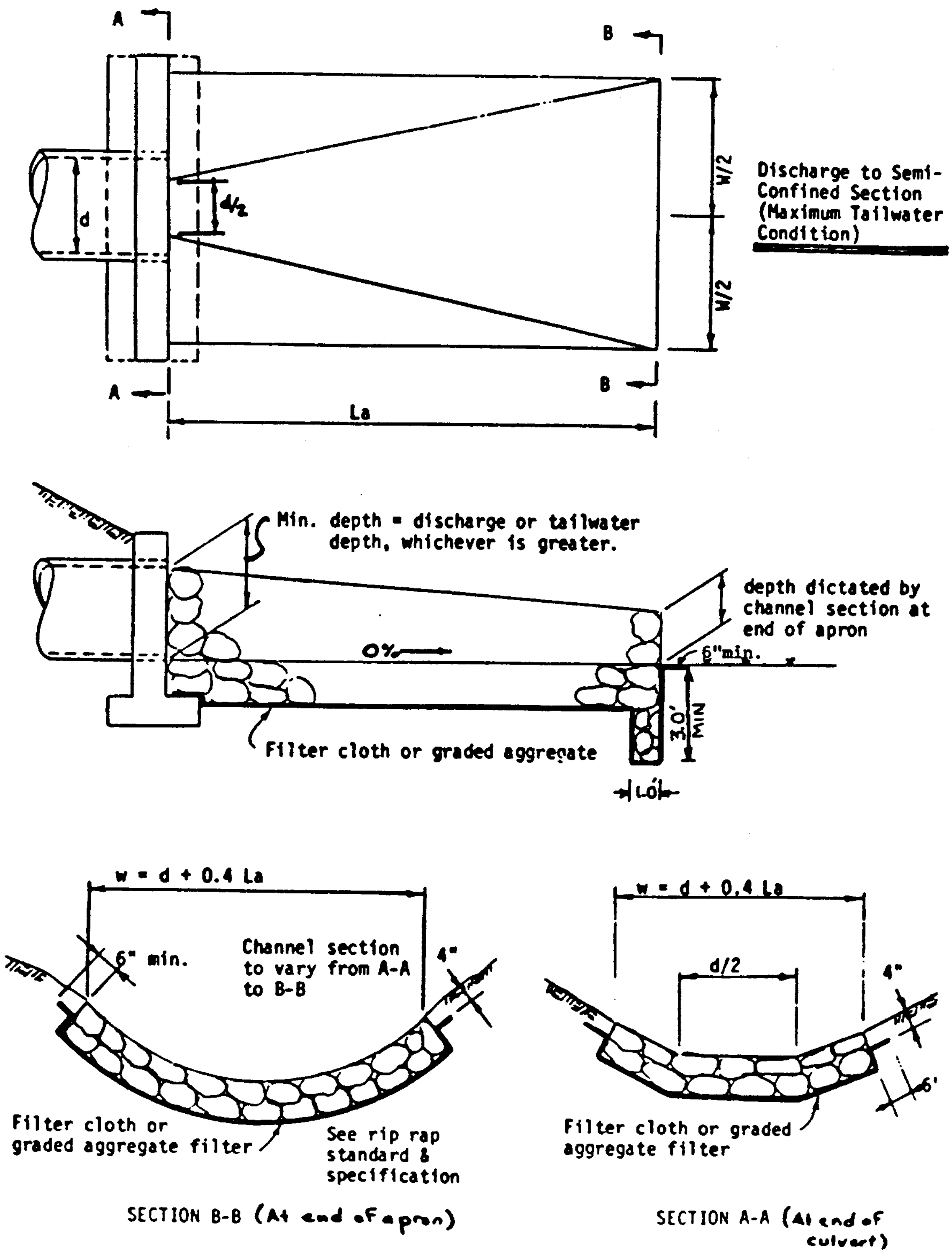
Figure 5B.16
Riprap Outlet Protection Example



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STANDARD AND SPECIFICATIONS FOR GRADE STABILIZATION STRUCTURE

Definition

A structure to stabilize the grade or to control head cutting in natural or artificial channels.

Scope

This standard applies to all types of grade stabilization structures. It does not apply to storm sewers or their component parts.

Purpose

Grade stabilization structures are used to reduce or prevent excessive erosion by reduction of velocities and grade in the watercourse or by providing channel linings or structures that can withstand the higher velocities.

Conditions Where Practice Applies

This practice applies to sites where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overfall conditions are encountered or where water is to be lowered structurally from one elevation to another. These structures should generally be planned and installed along with or as a part of other conservation practices in an overall surface water disposal system.

Design Criteria

Compliance with Laws and Regulations

Design and construction shall be in compliance with state and local laws and regulations. Such compliance is the responsibility of the landowner or developer.

General

Designs and specifications shall be prepared for each structure on an individual job basis depending on its purpose, site conditions and the basic criteria of the conservation practice with which the structure is planned. Typical structures are as follows:

1. Channel linings of concrete, asphalt, half round metal pipe or other suitable lining materials. These linings should generally be used where channel velocities exceed safe velocities for vegetated channels due to increased grade or a change in channel cross section or where durability of vegetative lining is adversely affected by seasonal changes. Adequate protection will be provided to prevent erosion or scour of both ends of the channel lining.
2. Overfall structures of concrete, metal, rock riprap or other suitable material is used to lower water from one elevation to another. These structures are applicable where it is desirable to drop the watercourse elevation over a very short horizontal distance. Adequate protection will be provided to prevent erosion or scour upstream, downstream and along sides of overfall structures. Structures should be located on straight sections of channel with a minimum of 100 feet of straight channel each way.
3. Pipe drops of metal pipe with suitable inlet and outlet structures. The inlet structure may consist of a vertical section of pipe or similar material, an embankment or a combination of both. The outlet structure will provide adequate protection against erosion or scour at the pipe outlet.

Capacity

Structures which are designed to operate in conjunction with other erosion control practices shall have as a minimum capacity equal to the bankfull capacity of the channel delivering water to the structures. The minimum design capacity for structures that are not designed to perform in conjunction with other practices shall be that required to handle the peak rate of flow from a 10 year, 24 hour frequency storm or bankfull, whichever is greater. Peak rates of runoff used in determining the capacity requirements shall be determined as outlined in Chapter 2, Estimating Runoff, Engineering Field Manual for Conservation Practices, Section 10 in this manual or by TR-55, Urban Hydrology for Small Watersheds.

Set the rest of the structure at an elevation that will stabilize the grade of the upstream channel. The outlet should be set at an elevation to assure stability. Outlet velocities should be kept within the allowable limits for the receiving stream. Structural drop spillways need to include a foundation drainage system to reduce hydrostatic loads.

Structures which involve the retarding of floodwater or the impoundment of water shall be designed using the criteria set forth in the guidelines for Ponds or Floodwater Retarding Structures, whichever is applicable.

Construction Specifications

Structures shall be installed according to lines and grades shown on the plan. The foundation for structures shall be cleared of all undesirable materials prior to the installation of the structure. Materials used in construction shall be of a permanency commensurate with the design frequency and life expectancy of the practice. Earthfill, when used as a part of the structure, shall be placed in 4 inch lifts and hand compacted within 2 feet of the structure.

Seeding, fertilizing and mulching shall conform to the recommendation specification in Section 3.

Construction operations shall be carried out in such a manner that erosion and air and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

Locate emergency bypass areas so floods in excess of structural capacity enters the channel far enough downstream so as not to cause damage to the structure.

Maintenance

Once properly installed, the maintenance for the grade stabilization structure should be minimal. Inspect the structure periodically and after major storm events. Check fill for piping or extreme settlement. Ensure a good vegetative cover. Check the channel for scour or debris and loss of rock from aprons. Repair or replace failing structures immediately.

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STANDARD AND SPECIFICATIONS
FOR
PAVED FLUME

Definition

A small concrete-lined channel to convey water on a relatively steep slope.

Purpose

To convey concentrated runoff safely down the face of a cut or fill slope without causing erosion.

Condition Where Practice Applies

Where concentrated storm runoff must be conveyed down a cut or fill slope as part of a permanent erosion control system. Paved flumes serve as stable outlets for diversions, drainage channels, or natural drainageways that are located above relatively steep slopes. Paved flumes should be used on slopes of 1:5 to 1 or flatter.

Design Criteria

Capacity - Minimum capacity should be the 10 year frequency storm. Freeboard or enough bypass capacity should be provided to safeguard the structure from peak flows expected for the life of the structure.

Slope - The slope should not be steeper than 1.5:1 (67%).

Cutoff Walls - Install cutoff walls at the beginning and end of paved flumes. The cutoff should extend a minimum of 18 inches into the soil and across the full width of the flume and be 6 inches thick. Cutoff walls should be reinforced with #3 reinforcing bars (3/8") placed on a 6 inch grid in the center of the wall.

Anchor Lugs - Space anchor lugs a minimum of 10 feet on centers for the length of the flume. They will extend the width of the flume, extend 1 foot into subsoil, be a minimum of 6 inches thick and reinforced with #3 reinforcing bars placed on a 6 inch grid.

Concrete - Minimum strength of design mix shall 3000 psi. Concrete thickness shall be a minimum of 6 inches reinforced with #3 reinforcing bars. Mix shall be dense, durable, and stiff enough to stay in place on steep slopes and sufficiently plastic for consolidation. Concrete mix should include an air-entraining admixture to resist freeze-thaw cycles.

Cross Section - Flumes shall have minimum depth of 1 foot with 1.5:1 side slopes. Bottom widths shall be based on maximum flow capacity. Chutes will be maintained in a straight alignment because of supercritical flow velocities.

Drainage filters - Use a drainage filter with all paved flumes to prevent piping and reduce uplift pressures. Size of the filter material will be dependent on the soil material the flume is located in.

Inlet section - Design the inlet to the following minimum dimensions: side walls 2 feet high, length 6 feet, width equal to the flume channel bottom, and side slopes the same as the flume channel side slopes.

Outlet section - Outlets must be protected from erosion. Usually an energy dissipator is used to reduce the high chute velocities to lower non erosive velocities. Rock riprap should be placed at the end of the dissipator to spread flow evenly to the receiving channel.

See figure 5B.17 on page 5B.33 for examples of outlet structures.

Invert - Precast concrete sections may be used in lieu of cast in place concrete. These sections should be designed at the joint to be overlapped to prevent displacement between sections. Joint sealing compound should be used to prevent migration of soil through a joint. Cutoff walls and anchor lugs should be cast in the appropriate sections to accomodate the design criteria.

Small Flumes - Where the drainage area is 10 acres or less the design dimensions for concrete flumes may be selected from those shown in the following table:

	Drainage Area (Acres)	
	5	10
Min Bottom Width	4	8
Min Inlet Depth (ft)	2	2
Min Channel Depth (ft)	1.3	1.3
Max Channel Slope	1.5:1	1.5:1
Max Side Slope	1.5:1	1.5:1

See figure 5B.18 on page 5B.34 for details.

Construction Specifications

1. The subgrade shall be constructed to the lines and grades shown on the plans. Remove all unsuitable material and replace them if necessary with compacted stable fill materials. Shape subgrade to uniform surface. Where concrete is poured directly on subsoil maintain it in a moist condition.

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2. On fill slopes the soil adjacent to the chute for a minimum of 5 feet must be well compacted.

3. Where drainage filters are placed under the structure the concrete will not be poured on the filter. A plastic liner, a minimum of 4 mils thick, will be placed to prevent contamination of filter layer.

4. Place concrete for the flume to the thickness shown on the plans and finish according to details. Protect freshly poured concrete from extreme temperatures (hot or cold) and ensure proper curing.

5. Form, reinforce, and pour together cutoff walls, anchor lugs and channel linings. Provide traverse joints to control cracking at 20 foot intervals. Joints can be formed by using a 1/8 inch thick removable template or by sawing to a minimum depth of 1 inch. Flumes longer than 50 feet shall have preformed expansion joints installed.

6. Immediately after construction, all disturbed areas will be final graded and seeded.

Maintenance

Inspect flumes after each rainfall until all areas adjoining the flume are permanently stabilized. Repair all damage immediately. Inspect outlet and rock riprap to assure presence and stability. Any missing components should be immediately replaced.

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Figure 5B.17
EXAMPLES OF OUTLET STRUCTURES

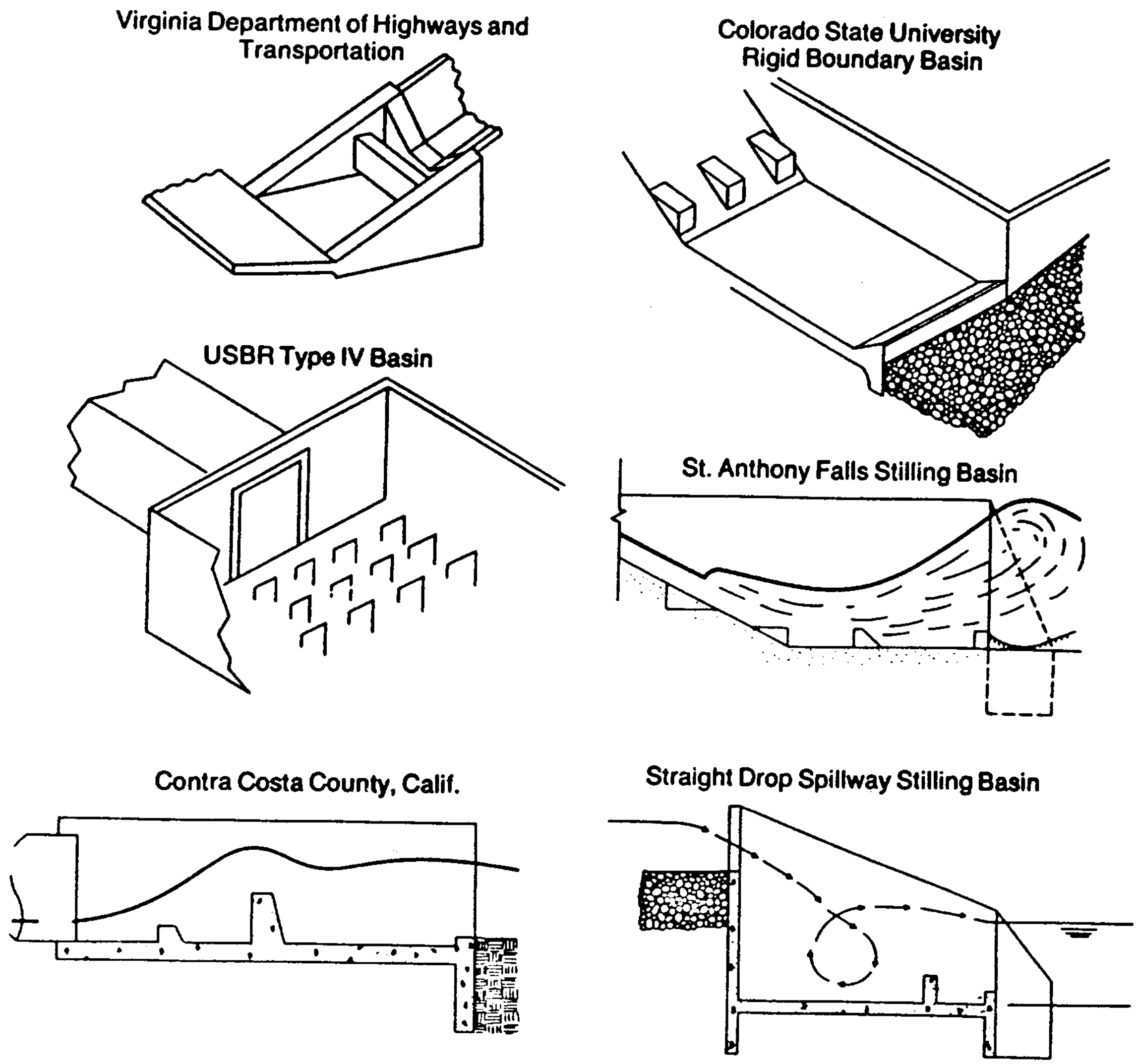

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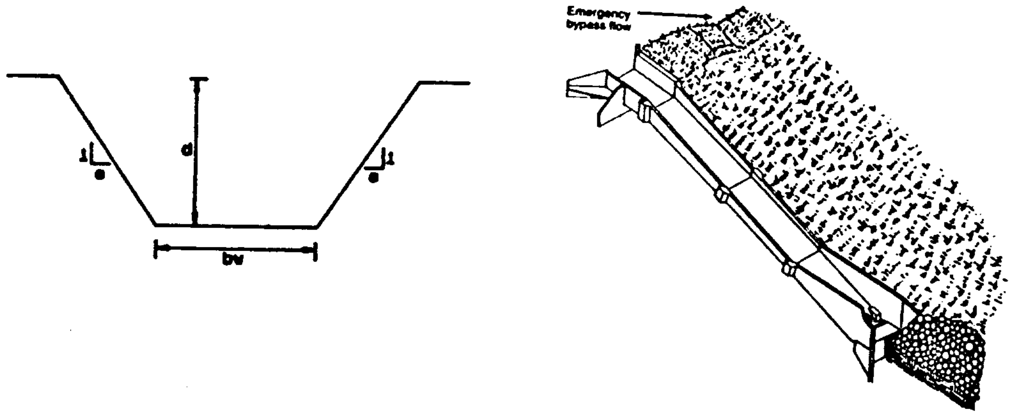
Figure 5B.18
PAVED FLUME DETAILS



DRAINAGE AREA (AC)	MIN BOTTOM WIDTH (FT)	MIN CHANNEL DEPTH (FT)	MAX SIDE SLOPE (FT/FT)	MIN INLET DEPTH (FT)	MAX CHANNEL SLOPE (FT/FT)
5	4	1.3	1.5:1	2	1.5:1
10	8	1.3	1.5:1	2	1.5:1

CONSTRUCTION SPECIFICATIONS

1. SUBGRADE SHALL BE CONSTRUCTED TO THE LINES AND GRADES SHOWN ON THE PLANS. REMOVE ALL UNSUITABLE MATERIAL AND REPLACE THEM IF NECESSARY WITH COMPACTED STABLE FILL MATERIALS. SHAPE SUBGRADE TO UNIFORM SURFACE. WHERE CONCRETE IS POURED DIRECTLY ON SUBSOIL MAINTAIN IT IN A MOIST CONDITION.
2. ON FILL SLOPES THE SOIL ADJACENT TO THE CHUTE FOR A MINIMUM OF 5 FEET MUST BE WELL COMPACTED.
3. WHERE DRAINAGE FILTERS ARE PLACED UNDER THE STRUCTURE THE CONCRETE WILL NOT BE POURED ON THE FILTER. A PLASTIC LINER, MINIMUM 4 MILS THICK, WILL BE PLACED TO PREVENT CONTAMINATION OF THE FILTER LAYER.
4. PLACE CONCRETE FOR THE FLUME TO THE THICKNESS SHOWN ON THE PLANS AND FINISH ACCORDING TO DETAILS. PROTECT FRESHLY POURED CONCRETE FROM EXTREME TEMPERATURES (HOT OR COLD) AND ENSURE PROPER CURING.
5. FORM, REINFORCE, AND POUR TOGETHER CUTOFF WALLS, ANCHOR LUGS AND CHANNEL LININGS. PROVIDE TRAVERSE JOINTS TO CONTROL CRACKING AT 20 FOOT INTERVALS. JOINTS CAN BE FORMED BY USING A 1/8 INCH THICK REMOVABLE TEMPLATE OR BY SAWING TO A MINIMUM DEPTH OF 1 INCH. FLUMES LONGER THAN 50 FEET SHALL HAVE PERFORMED EXPANSION JOINTS INSTALLED.
6. IMMEDIATELY AFTER CONSTRUCTION, ALL DISTURBED AREAS WILL BE FINAL GRADED AND SEEDED.
7. MAINTENANCE - INSPECT FLUMES AFTER EACH RAINFALL UNTIL ALL AREAS ADJOINING THE FLUME ARE PERMANENTLY STABILIZED. REPAIR ALL DAMAGE IMMEDIATELY. INSPECT OUTLET AND ROCK RIPRAP TO ASSURE PRESENCE AND STABILITY. ANY MISSING COMPONENTS SHOULD BE IMMEDIATELY REPLACED.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	PAVED FLUME	STANDARD SYMBOL

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R0039487

STANDARD AND SPECIFICATIONS FOR STRUCTURAL STREAMBANK PROTECTION

Definition

Stabilization of eroding streambanks by the use of designed structural measures.

Purpose

To protect exposed or eroded streambanks from the erosive forces of flowing water.

Condition Where Practice Applies

Generally applicable where flow velocities exceed 6 feet per second or where vegetative streambank protection is inappropriate. Necessary where excessive runoff or construction activities creates an erosive condition on a streambank.

Design Criteria

Since each channel is unique, measures for structural streambank should be installed according to a design based on specific site conditions.

Develop designs according to the following principles:

Make protective measures compatible with other channel modifications planned or being carried out in the channel reaches.

Use the design velocity of the peak discharge of the 10-year storm or bankfull discharge, whichever is less. Structural measures should be capable of withstanding greater flows without serious damage.

Ensure that the channel bottom is stable or stabilized by structural means before installing any permanent bank protection.

Streambank protection should begin at a stable location and end at a stable point along the bank.

Changes in alignment should not be done without a complete analysis of effects on the rest of the stream system for both environmental and stability effects.

Provisions should be made to maintain and improve fish and wildlife habitat.

Ensure that all requirements of state law and all permit requirements of local, state and federal agencies are met.

Construction Specifications

Riprap - Riprap is the most commonly used material to structurally stabilize a streambank.

1. Bank slope - slopes shall be graded to 2:1 or flatter prior to placing bedding, filter fabric or riprap.
2. Filter - filters should be placed between the base bank material and the riprap and meet the requirements of criteria listed in the Standards and Specifications for Riprap Slope Protection, page 5B.55.
3. Gradation - The gradation of the riprap is dependent on the velocity expected against the bank for the design conditions. Once the velocity is known gradation can be selected from the gradations below. The riprap should extend 2 feet below the channel bottom and be keyed into the bank both at the upstream end and downstream end of the proposed work or reach.

See Figure 5B.19 on page 5B.37 for details.

Gabions - Design and install gabions according to manufacturers recommendations. Since these are rectangular, rock-filled wire baskets they are somewhat flexible in armoring channel bottoms and banks. They can withstand significantly higher velocities for the size stone they contain due to the basket structure. They also stack vertically to act as a retaining wall for constrained areas (figure 5B.20).

Gabions should not be used in streams that carry a bedload that can abrade the wire causing separation and failure.

Reinforced Concrete - May be used to armor eroding sections of streambank by constructing walls, bulk heads, or bank linings. Provide positive drainage behind these structures to relieve uplift pressures.

Grid pavers - Modular concrete units with or without void areas can be used to stabilize streambanks. Units with void areas can allow the establishment of vegetation. These structures may be obtained in a variety of shapes (figure 5B.20) or they may be formed and poured in place. Maintain design and installation in accordance with manufacturers instructions.

Revetment - Structural support or armoring to protect an embankment from erosion. Riprap and gabions are commonly used. Also used is a hollow fabric mattress with cells that receive a concrete mixture, (ie. Fabriform). Any revetment should be installed to a depth below the anticipated

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channel degradation and into the channel bed as necessary to provide stability.

Modular Pre-Cast Units - Interlocking modular precast units of different sizes, shapes, heights and depths have been developed for a wide variety of applications. These serve in the same manner as gabions. They provide verticality in tight areas as well as durability. Many types are available with textured surfaces. They also act as gravity retaining walls. They should be designed and installed in accordance with the manufacturers recommendations (figure 5B.20).

All areas disturbed by construction should be stabilized as soon as the structural measures are complete.

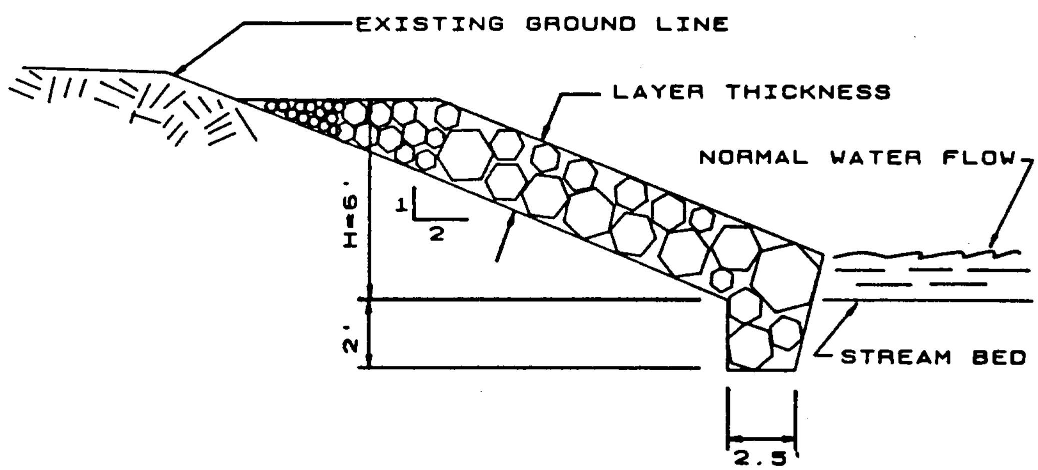
Maintenance

Check stabilized streambank sections after every high-water event, and make any needed repairs immediately to prevent any further damage or unraveling of the existing work.

Table 5B.2
Riprap Gradations

Class	Layer Thickness In.	Max. Velocity ft/sec	Wave Height Feet		PERCENT FINER BY WEIGHT											
					D10			D50			D85			D100		
					Wt. Lbs.	de In.	da In.	Wt. Lbs.	de In.	da In.	Wt. Lbs.	de In.	da In.	Wt. Lbs.	de In.	da In.
I	1	8.5	-		5	5	4	50	10	8	100	13	10	150	15	12
II		10	-		17	7	6	170	15	12	340	19	15	500	22	18
III	24	12	2		46	10	8	460	21	17	920	26	21	1400	30	24
IV	36	14	3		150	15	12	1500	30	25	3000	39	32	4500	47	36
V	48	17	4.8		370	20	16	3700	42	34	7400	53	43	11,000	60	49

Figure 5B.19
RIPRAP STREAMBANK PROTECTION DETAILS



RIPRAP DESIGN TABLE

REACH	CLASS	THICKNESS	LAYER	HEIGHT	D10	D50	D85	D100	FILTER

CONSTRUCTION SPECIFICATIONS

1. SLOPE SHALL BE GRADED TO 2:1 OR FLATTER PRIOR TO PLACING FILTER, FILTER FABRIC, OR RIPRAP.
2. RIPRAP WILL BE PLACED TO MAINTAIN A UNIFORM GRADATION. LARGER STONE SHOULD BE PLACED IN THE TOE.
3. ENDS OF THE RIPRAP WILL BE KEYED INTO A STABLE BANK. WHEN TYING INTO OTHER STRUCTURES LARGER RIPRAP CAN BE LAID IN STEPS OR STACKED AS NEEDED TO FIT. LARGER STONES THAN FLOW DESIGN WILL BE USED FOR THIS PURPOSE.
4. REMAINING DISTURBED AREAS SHALL BE GRADED AND PERMANENTLY SEEDED AND MULCHED.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	RIPRAP STREAMBANK PROTECTION	STANDARD SYMBOL S

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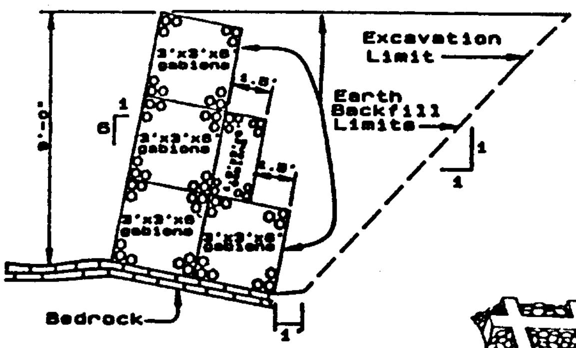
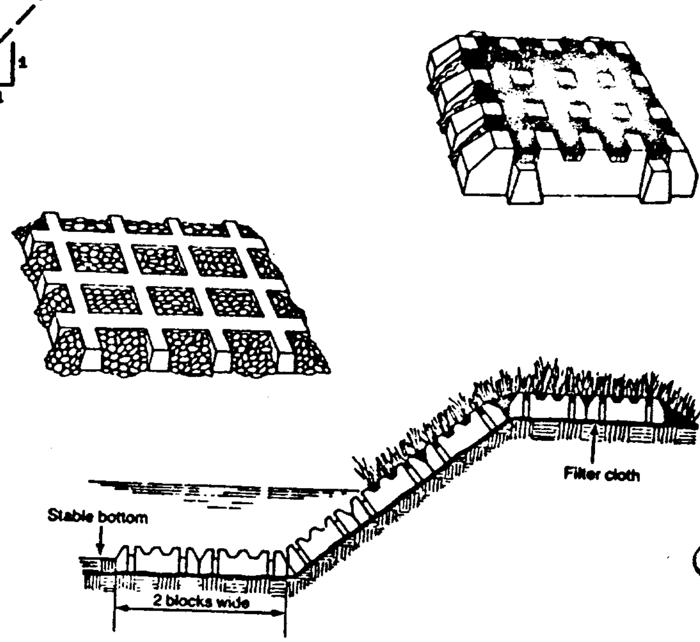
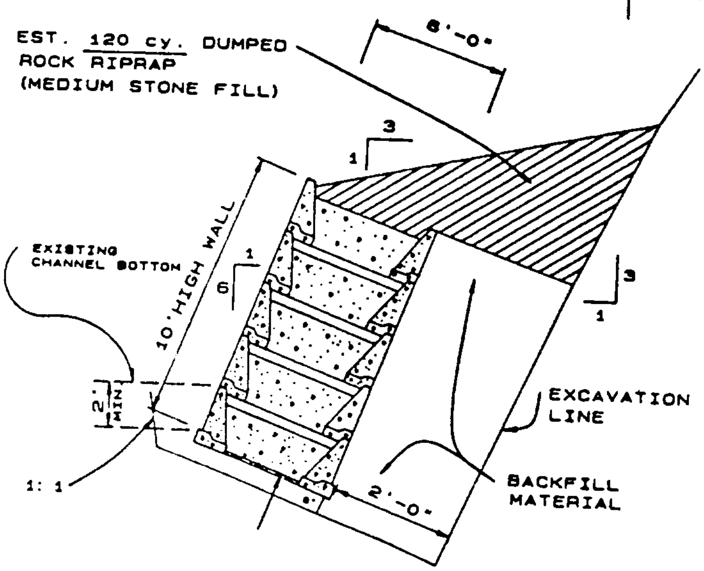
Figure 5B.20
STRUCTURAL STREAMBANK PROTECTION EXAMPLES



Gablons



Grid Pavers



Pre-Cast Modular Units

STANDARD AND SPECIFICATIONS FOR DEBRIS BASIN

Definition

A barrier or dam constructed across a waterway or at other suitable locations to form a basin for catching and storing sediment and other waterborne debris.

Scope

This standard covers the installation of debris basins on sites where: (1) failure of the structure would not result in loss of life or interruption of use or service of public utilities; (2) the drainage area does not exceed 200 acres; and (3) the water surface area at the crest of the emergency spillway does not exceed 5 acres. For the purpose of this standard, debris basins are classified according to the following table:

Class	Maximum Drainage Area(Ac)	Maximum Height[1] of Dam(ft)	Emergency Spillway Required	Design Storm Frequency
1[2]	20	5	No	--
2	20	10	Yes	10 yrs.
3	200	20	Yes	25 yrs.

[1] Height is measured from the low point of original ground along the centerline of dam to the top of dam for Class 1 and to crest of emergency spillway for Classes 2 and 3.

[2] Class 1 basins are to be used only where site conditions are such that it is impractical to construct an emergency spillway in undisturbed ground.

Purpose

To provide a permanent or temporary means of trapping and storing sediment from eroding areas in order to protect properties or stream channels below the installation from damage by excessive sedimentation and debris.

Conditions Where Practice Applies

Where physical conditions or land ownership preclude the treatment of the sediment source by the installation of erosion control measures to reduce runoff and erosion. It may also be used as a permanent or temporary measure during grading and development of areas above. If it is a temporary structure, it may be removed once the development is complete and the area is permanently protected against erosion by vegetative or mechanical means.

Design Criteria

The capacity of the debris basin to the elevation of the crest of the principal spillway is to equal the volume of the expected sediment yield from the unprotected portions of the drainage area during the planned useful life of the structure. The minimum volume of sediment in acre feet per year can be determined for various drainage areas under construction from curves on Figure 5B.21 on page 5B.42. Values of iso-erodents for a specific area or state can be obtained from Figure 8.1, "Average Annual Iso-Erodent Values" on page 8.3. Also, an example of sediment capacity determined by computing an equation is given in Section 6, Guidelines for Estimating Sediment Yields for Urban Construction Areas.

<u>Spillway Design</u>

Runoff will be computed by the method outlined in Chapter 2, Estimating Runoff "Engineering Field Manual for Conservation Practices" or Section 10. Runoff computations should be based upon the soil cover conditions expected to prevail during the construction period of the development.

For Class 2 basins, the combined capacities of the principal and emergency spillways will be sufficient to pass the peak rate of runoff from a 10 year frequency storm after adjusting for flood routing (method shown in SCS Engineering Field Manual may be used).

For Class 3 basins, the combined capacities of the pipe and emergency spillways will be sufficient to pass the peak rate of runoff from a 25 year frequency storm.

<u>Pipe Spillway</u>

The pipe spillway will consist of a vertical pipe box type riser jointed to a conduit which will extend through the embankment and outlet beyond the downstream toe of the fill. The minimum diameter of the conduit will be 8 inches. The riser will be perforated to provide for a gradual drawdown after each storm event. The minimum average capacity of the principal spillway will be sufficient to discharge 5 inches of runoff from the drainage area in 24 hours (0.21 cfs per acre of drainage area). The riser of the principal spillway shall be a cross-sectional area at least 1.3 times that of the barrel.

1. Crest Elevation: The crest elevation of the riser shall be at least 3 feet below the crest elevation of the embankment.

2. Perforated: Metal pipe risers shall be perforated with 1-1/2 inch diameter holes spaced 8 inches vertically and 10-12 inches horizontally around the pipe. Box type risers shall be ported or have some means for complete drainage of the sediment pool within a 5 day period following storm inflows.

3. Anti-vortex device: An anti-vortex device shall be installed on the top of the riser.

4. Base: The riser shall have a base attached with a watertight connection. The base shall have sufficient weight to prevent flotation of the riser.

5. Trash rack: An approved trash rack shall be firmly attached to the top of the riser if the pipe spillway conveys 25 percent or more of the peak rate or runoff from the design storm.

6. Anti-seep collars: Anti-seep collars shall be installed around the pipe conduit within the normal saturation zone when any of the following conditions exist:

   A. The settled height of dam exceeds 15 ft.

   B. The conduit is of smooth pipe larger than 8 inches in diameter.

   C. The conduit is of corrugated metal pipe larger than 12 inches in diameter.

   The anti-seep collars and their connections to the pipe shall be watertight. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe.

7. Outlet protection: Protection against scour at the discharge end of the pipe spillway shall be provided. Protective measures may include structures of the impact basin type, rock riprap, paving, revetment, excavation of plunge pool or use of other approved methods.

Emergency spillway

Class 2 and 3 basins: An emergency spillway shall be excavated in undisturbed ground wherever site conditions permit. The emergency spillway cross section shall be trapezoidal with a minimum bottom width of 8 feet.

Class 1 basins: The embankment may be used as an emergency spillway. In these cases, the downstream slope of the embankment shall be 5:1 or flatter and the embankment must be immediately protected against erosion by means such as sodding, rock riprap, asphalt coating or other approved methods.

1. Capacity: The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the design storm, less any reduction due to flow in the pipe spillway. Emergency spillway dimensions can be determined by using the method outlined in Chapter 11 of "Engineering Field Manual for Conservation Practices."

2. Velocities: The maximum allowable velocity of flow in the exit channel shall be 6 feet per second for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be in the safe range for the type of protection used.

3. Erosion protection: Provide for erosion protection by vegetation or by other suitable means such as rock riprap, asphalt, concrete, etc.

4. Freeboard: Freeboard is the difference between the design flow elevation in the emergency spillway and the top of the settled embankment. The minimum freeboard for Class 2 and Class 3 basins shall be 1 foot.

Embankment (Earth Fill)

Class 1 basins: The minimum top width shall be 10 feet. The upstream slope shall be no steeper than 3:1. The downstream slope shall be no steeper than 5:1.

Class 2 basins: The minimum top width shall be 8 feet. The combined upstream and downstream side slopes shall not be less than 5:1 with neither slope steeper than 2-1/2:1.

Class 3 basins: The minimum top width shall be 10 feet. Side slopes shall be no steeper than 2-1/2:1.

Embankment (other than Earth Fill)

Class 1 basins only: The embankment may be constructed of the following materials:

1. Pressure treated timber crib - rock filled.
2. Precast reinforced concrete crib - rock filled.
3. Gabions.

When the above material is used for the embankment, a principal spillway is not required; however, the dam shall be pervious to allow for drainage during time of low inflow. Basins constructed of the above materials should be used only when the sediment to be trapped is coarse grained material such as GW or GP material (Unified Soil Classification System).

Construction Specifications

Site Preparation

Areas under the embankment and any structural works shall be cleared, grubbed and the topsoil stripped to remove trees, vegetation, roots, and other objectionable material. In order to facilitate cleanout and restoration, the pool area will be cleared of all brush and excess trees.

Cutoff Trench

A cutoff trench shall be excavated along the centerline of dam on earth fill embankments to a depth of at least 1.0 foot into a layer of slowly permeable material. The minimum depth shall be 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum bottom width shall be 4 feet, but wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for embankment. The trench shall be kept free from standing water during the backfilling operations.

Embankment

The fill material shall be taken from approved designated borrow areas. It shall be free of roots, woody vegetation, oversized stones, rocks or other objectionable material. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain sufficient moisture so that it can be formed into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction.

Fill material will be placed in 6 to 9 inch layers and shall be continuous over the entire length of the fill. Compaction will be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one track width of the equipment or compaction shall be achieved by the use of a compactor. The embankment shall be constructed to an elevation 10 percent higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to 5 percent.

Pipe Spillway

The riser shall be solidly attached to the barrel and all connections shall be watertight. The barrel and riser shall be placed on a firm foundation. The fill material around the pipe spillway will be placed in 4 inch layers and compacted to at least the same density as the adjacent embankment.

Emergency Spillway (Class 2 and 3 basins)

The emergency spillway shall be installed in undisturbed earth unless specified otherwise in the plan. The lines and grades must conform to those shown on the plans as nearly as skillful operation of the excavating equipment will permit.

Embankment (other than Earth Fill)

The rock used to fill cribbing or gabions will be hard and durable and of an approved size and gradation.

Erosion and Pollution Control

Construction operations will be carried out in such a manner that erosion and water pollution will be minimized. State and local laws concerning pollution abatement shall be complied with.

Safety

State requirements shall be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

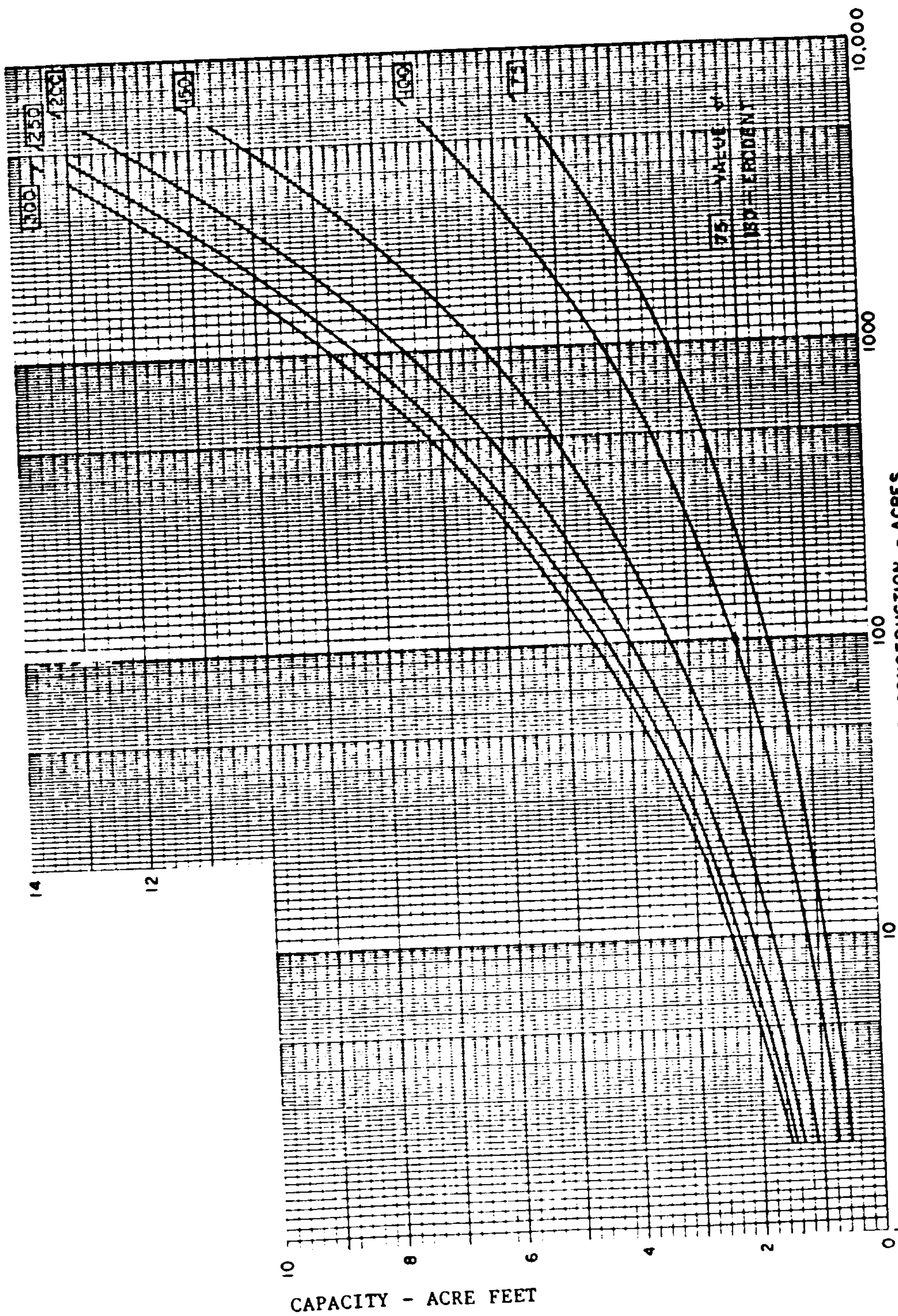
Seeding

Seeding, fertilizing and mulching shall conform to the recommendations in Section 3, Vegetative Measures for Erosion and Sediment Control in Urban Areas, of this manual.

Final Disposal

In the case of temporary structures, when the intended purpose has been accomplished and the drainage area properly stabilized, the embankment and resulting silt deposits are to be leveled or otherwise disposed of in accordance with the plan.

Figure 5B.21
One-Year Debris Basin Sediment Capacity



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STANDARD AND SPECIFICATIONS FOR SUBSURFACE DRAIN

Definition

A conduit, such as tile, pipe or tubing, installed beneath the ground surface which intercepts, collects, and/or conveys drainage water.

Purpose

A subsurface drain may serve one or more of the following purposes:

1. Improve the environment for vegetative growth by regulating the water table and groundwater flow.
2. Intercept and prevent water movement into a wet area.
3. Relieve artesian pressures.
4. Remove surface runoff.
5. Provide internal drainage of slopes to improve their stability and reduce erosion.
6. Provide internal drainage behind bulkheads, retaining walls, etc.
7. Replace existing subsurface drains that are interrupted or destroyed by construction operations.
8. Provide subsurface drainage for dry storm water management structures.
9. Improve dewatering of sediment in sediment basins. (See Standard and Specification for Sediment Basins on page 5A.47).

Conditions Where Practice Applies

Subsurface drains are used in areas having a high water table or where subsurface drainage is required. The soil shall have enough depth and permeability to permit installation of an effective system. This standard does not apply to storm drainage systems or foundation drains.

An outlet for the drainage system shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity of water to be discharged without causing damage above or below the point of discharge and shall comply with all state and local laws.

Design Criteria

The design and installation shall be based on adequate surveys and on-site soils investigations.

Required Capacity of Drains

The required capacity shall be determined by one or more of the following:

1. Where sub-surface drainage is to be uniform over an area through a systematic pattern of drains, a drainage coefficient of 1 inch to be removed in 24 hours shall be used; see Drain Charts, Figures 5B.22 through 5B.24 on pages 5B.46 to 5B.48.
2. Where sub-subsurface drainage is to be by a random interceptor system, a minimum inflow rate of 0.5 cfs per 1,000 feet of line shall be used to determine the required capacity. If actual field tests and measurements of flow amounts are available, they may be used for determining capacity.

   For interceptor subsurface drains on sloping land, increase the inflow rate as follows:

Land Slope	Increase Inflow Rate By
2-5 percent	10 percent
5-12 percent	20 percent
Over 12 percent	30 percent

3. Additional design capacity must be provided if surface water is allowed to enter the system.

Size of Subsurface Drain

The size of subsurface drains shall be determined from drain charts found on Figures 5B.22 through 5B.24 on pages 5B.46 to 5B.48. All subsurface drains shall have a nominal diameter which equals or exceeds four (4) inches.

Depth and Spacing

The minimum depth of cover of subsurface drains shall be 24 inches where possible. The minimum depth of cover may be reduced to 15 inches where it is not possible to attain the 24 inch depth and where the drain is not subject to equipment loading or frost action. Roots from some types of vegetation can plug drains as the drains get closer to the surface.

The spacing of drain laterals will be dependent on the permeability of the soil, the depth of installation of the drains and degree of drainage required. Generally, drains installed 36 inches deep and spaced 50 feet center-to-center will be adequate. For more specific information see the New York Drainage Guide.

Minimum Velocity and Grade

The minimum grade for subsurface drains shall be 0.10 percent. Where surface water enters the system a velocity of not less than 2 feet per second shall be used to establish the minimum grades. Provisions shall be made for preventing debris or sediment from entering the system by means of filters or collection and periodic removal of sediment from installed traps.

Materials for Subsurface Drains

Acceptable subsurface drain materials include perforated, continuous closed joint conduits of polyethylene plastic, concrete, corrugated metal, asbestos cement, bituminized fiber, polyvinyl chloride and clay tile.

The conduit shall meet strength and durability requirements of the site.

Loading

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A factor of safety of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Envelopes and Envelope Materials

Envelopes shall be used around subsurface drains for proper bedding and to provide better flow into the conduit. Not less than three inches of envelope material shall be used for sand/gravel envelopes. Where necessary to improve the characteristics of flow of groundwater into the conduit, more envelope material may be required.

Where county regulations do not allow sand/gravel envelopes, but require a special type and size of envelope material, they shall be followed.

Envelope material shall be placed to the height of the uppermost seepage strata. Behind bulkheads and retaining walls, it shall go to within twelve inches of the top of the structure. This standard does not cover the design of filter materials where needed.

Materials used for envelopes shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelope materials shall consist of either filter cloth or sand/gravel material, which shall pass a 1 1/2 inch sieve, 90 to 100 percent shall pass a 3/4 inch sieve, and not more than 10 percent shall pass a No. 60 sieve.

Filter cloth envelope can be either woven or nonwoven monofilament yarns and shall have a sieve opening ranging from 40 to 80. The envelope shall be placed in such manner that once the conduit is installed, it shall completely encase the conduit.

The conduit shall be placed and bedded in a sand/gravel envelope. A minimum of three inches depth of envelope materials shall be placed on the bottom of a conventional trench. The conduit shall be placed on this and the trench completely filled with envelope material to minimum depth of 3 inches above the conduit.

Soft or yielding soils under the drain shall be stabilized where required and lines protected from settlement by adding gravel or other suitable material to the trench, by placing the conduit on plank or other rigid support, or by using long sections of perforated or watertight pipe with adequate strength to insure satisfactory subsurface drain performance.

Use of Heavy Duty Corrugated Plastic Drainage Tubing

Heavy duty corrugated drainage tubing shall be specified where rocky or gravelly soils are expected to be encountered during installation operations. The quality of tubing will also be specified when cover over this tubing is expected to exceed 24 inches for 4, 5, 6, or 8 inch tubing. Larger size tubing designs will be handled on an individual job basis.

Auxiliary Structure and Subsurface Drain Protection

The outlet shall be protected against erosion and undermining of the conduit, against damaging periods of submergence and against entry of rodents or other animals into the subsurface drain. An animal guard shall be installed on the outlet end of the pipe. A swinging animal guard shall be used if surface water enters the pipe.

A continuous 10 foot section of corrugated metal, cast iron, polyvinyl chloride or steel pipe without perforations shall be used at the outlet end of the line and shall outlet 1.0 foot above the normal elevation of low flow in the outlet ditch or above mean high tide in tidal areas. No envelope material shall be used around the 10 foot section of pipe. Two-thirds of the pipe shall be buried in the ditch bank and the cantilevered section shall extend to a point above the toe of the ditch side slope. If not possible, the side slope shall be protected from erosion.

Conduits under roadways and embankments shall be watertight and designed to withstand the expected loads.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Surface waterways shall be used where feasible.

The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material unless connected to a structure.

Construction Specifications

1. Deformed, warped, or otherwise damaged pipe or tubing shall not be used.
2. All subsurface drains shall be laid to a uniform line and covered with envelope material. The pipe or tubing

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shall be laid with the perforations down and oriented symmetrically about the vertical center line. Connections will be made with manufactured functions comparable in strength with the specified pipe or tubing unless otherwise specified. The method of placement and bedding shall be as specified on the drawing.

3. Envelope material shall consist of filter cloth or a sand/gravel (which shall pass the 1 1/2 inch sieve, 90 to 100 percent shall pass 3/4 inch sieve, and not more than 10 percent shall pass the No. 60 sieve).
4. The upper end of each subsurface drain line shall be capped with a tight fittings cap of the same material as the conduit or other durable material unless connected to a structure.
5. A continuous 10 foot section of corrugated metal, cast iron, polyvinyl chloride or steel pipe without perforations shall be used at the outlet end of the line. No envelope material shall be used around the 10 foot section of pipe. An animal guard shall be installed on the outlet end of the pipe.
6. Earth backfill material shall be placed in the trench in such a manner that displacement of the drain will not occur.
7. Where surface water is entering the system, the pipe outlet section of the system shall contain a swing type trash and animal guard.

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DRAIN CHART - CLAY, CONCRETE TILE AND BITUMINIZED FIBER PIPE

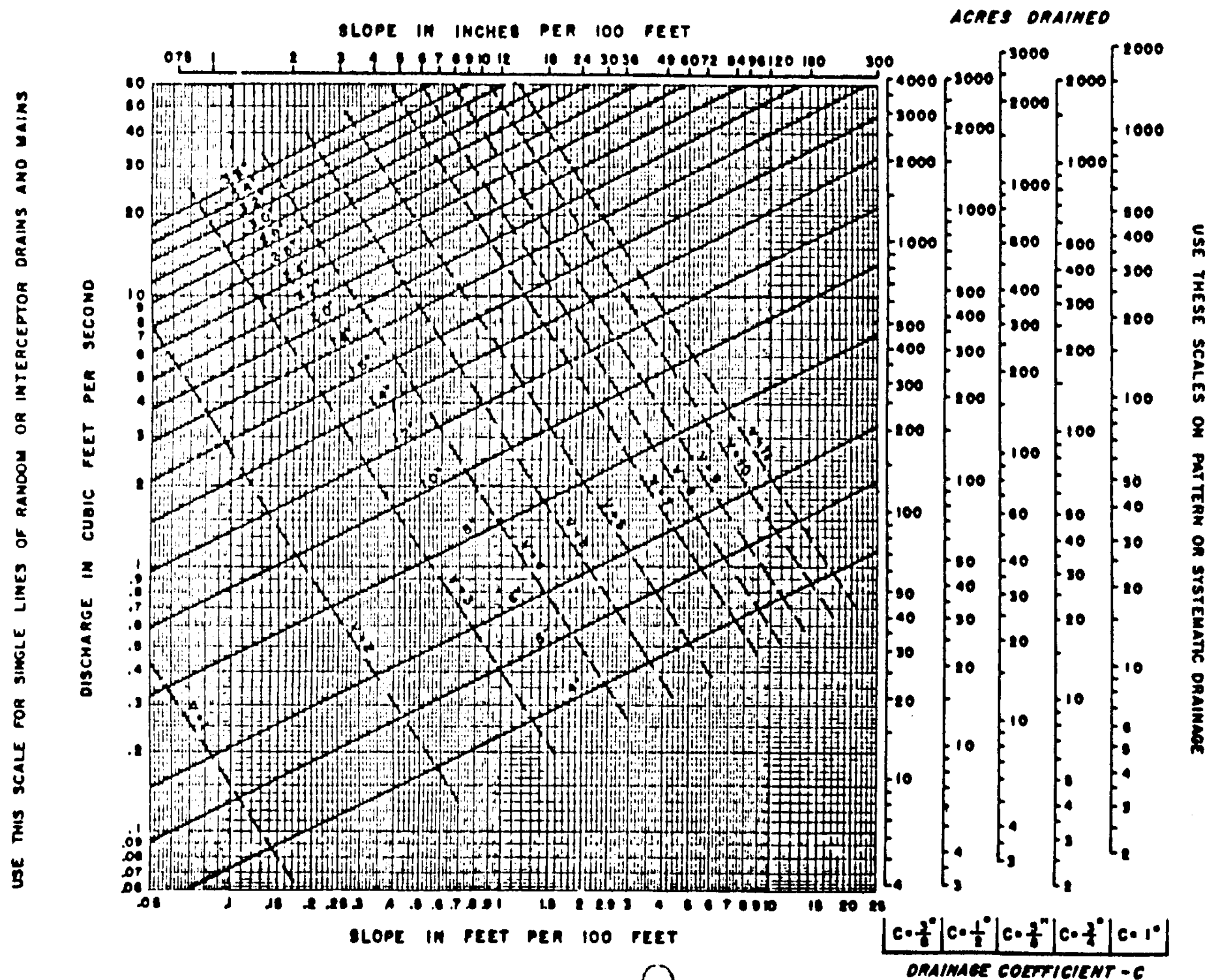

Figure 5B.22
Drain Chart - Clay

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Figure 5B.23
Drain Chart - CPT

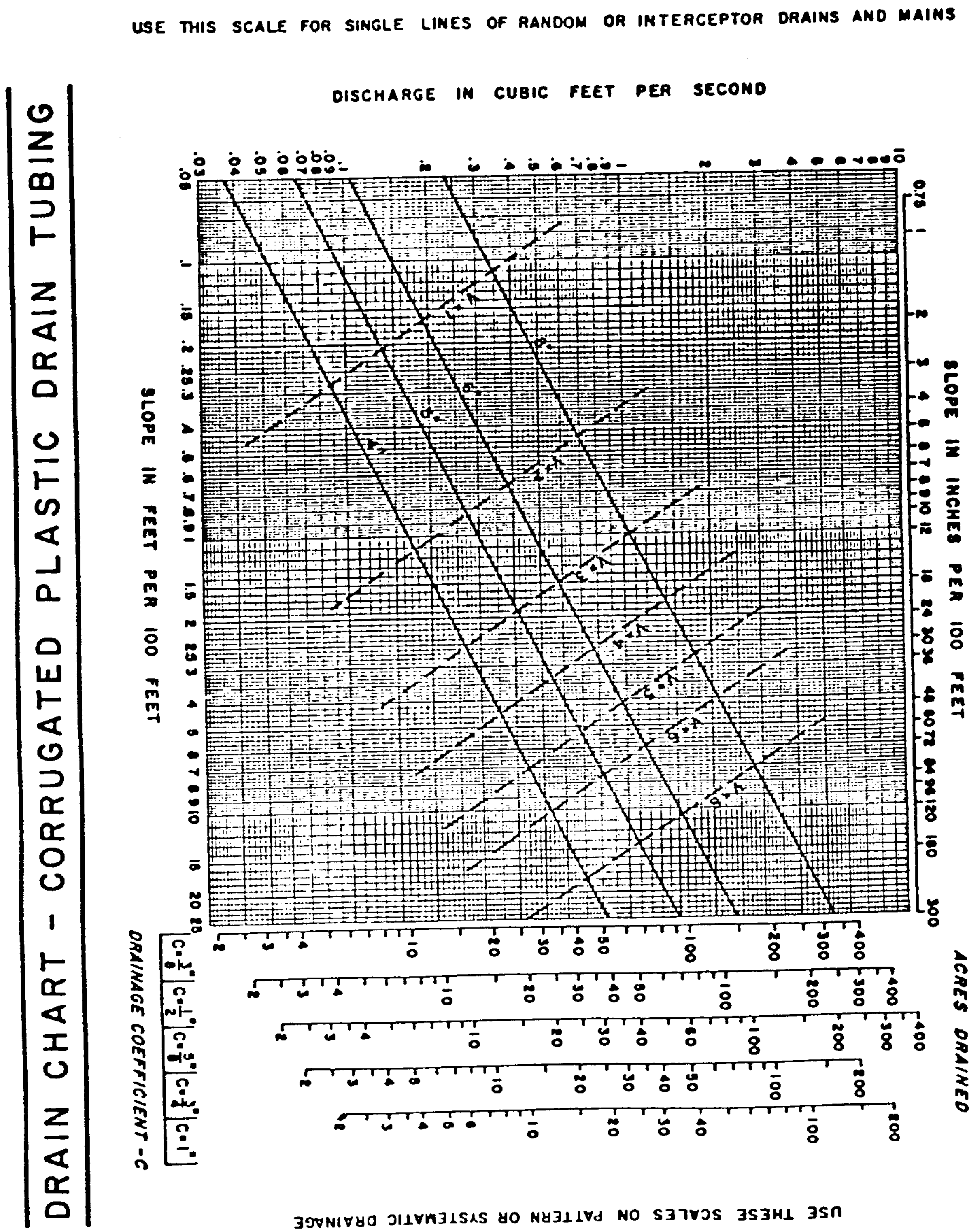

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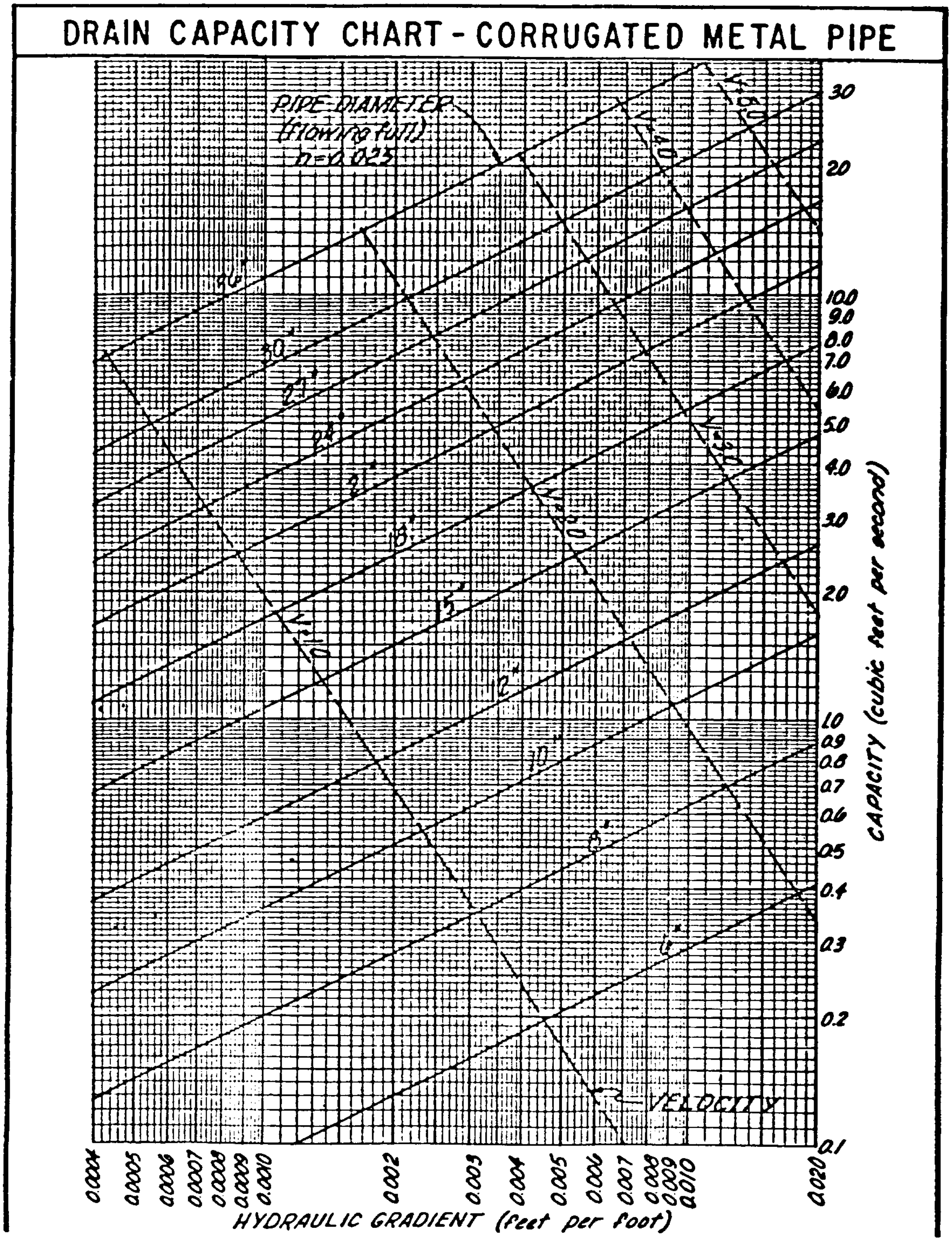
Figure 5B.24
Drain Capacity Chart



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STANDARD AND SPECIFICATIONS FOR LAND GRADING

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Definition

Reshaping of the existing land surface in accordance with a plan as determined by engineering survey and layout.

Purpose

The purpose of a land grading specification is to provide for erosion control and vegetative establishment on those areas where the existing land surface is to be reshaped by grading according to plan.

Design Criteria

The grading plan should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surrounding to avoid extreme grade modifications. Information submitted must provide sufficient topographic surveys and soil investigations to determine limitations that must be imposed on the grading operation related to slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal and vegetative treatment, etc.

Many counties have regulations and design procedures already established for land grading and cut and fill slopes. Where these requirement exist, they shall be followed.

The plan must show existing and proposed contours of the area(s) to be graded. The plan shall also include practices for erosion control, slope stabilization, safe disposal of runoff water and drainage, such as waterways, lined ditches, reverse slope benches (include grade and cross section), grade stabilization structures, retaining walls, and surface and subsurface drains. The plan shall also include phasing of these practices. The following shall be incorporated into the plan:

1. Provisions shall be made to safely conduct surface runoff to storm drains, protected outlets or to stable water courses to insure that surface runoff will not damage slopes or other graded areas; see standards and specifications for Grassed Waterway, Diversion, Grade Stabilization Structure.
2. Cut and fill slopes that are to be stabilized with grasses shall not be steeper than 2:1. when slopes exceed 2:1 special design and stabilization consideration are required and shall be adequately shown on the plans. (Note: Where the slope is to be mowed the slope should be no steeper than 3:1 although 4:1 is preferred because of safety factors related to mowing steep slopes.)
3. Reverse slope benches or diversion shall be provided whenever the vertical interval (height) of any 2:1 slope exceeds 20 feet; for 3:1 slope it shall be increased to 30 feet and for 4:1 to 40 feet. Benches shall be located to divide the slope face as equally as possible and shall convey the water to a stable outlet. Soils, seeps, rock outcrops, etc., shall also be taken into consideration when designing benches.
   A. Benches shall be a minimum of six feet wide to provide for ease of maintenance.
   B. Benches shall be designed with a reverse slope of 6:1 or flatter to the toe of the upper slope and with a minimum of one foot in depth. Bench gradient to the outlet shall be between 2 percent and 3 percent, unless accompanied by appropriate design and computations.
   C. The flow length within a bench shall not exceed 800 feet unless accompanied by appropriate design and computations; see Standard and Specifications for Diversion on page 5B.1.
4. Surface water shall be diverted from the face of all cut and/or fill slopes by the use of diversions, ditches and swales or conveyed downslope by the use of a designed structure, except where:
   A. The face of the slope is or shall be stabilized and the face of all graded slopes shall be protected from surface runoff until they are stabilized.
   B. The face of the slope shall not be subject to any concentrated flows of surface water such as from natural drainage ways, graded swales, downspouts, etc.
   C. The face of the slope will be protected by special erosion control materials, sod, gravel, riprap or other stabilization method.
5. Cut slopes occurring in ripable rock shall be serrated as shown in Figure 5B.25 on page 5B.51. The serrations shall be made with conventional equipment as the excavation is made. Each step or serration shall be constructed on the contour and will have steps cut at nominal two foot intervals with nominal three foot horizontal shelves. These steps will vary depending on the slope ratio or the cut slope. The nominal slope line is 1-1/2:1. These steps will weather and act to hold moisture, lime, fertilizer and seed thus producing a much quicker and longer lived vegetative cover and better slope stabilization. Overland flow shall be diverted from the top of all serrated cut slopes and carried to a suitable outlet.

6. Subsurface drainage shall be provided where necessary to intercept seepage that would otherwise adversely affect slope stability or create excessively wet site conditions.

7. Slopes shall not be created so close to property lines as to endanger adjoining properties without adequately protecting such properties against sedimentation, erosion, slippage, settlement, subsidence or other related damages.

8. Fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris, and other objectionable material. It should be free of stones over two (2) inches in diameter where compacted by hand or mechanical tampers or over eight (8) inches in diameter where compacted by rollers or other equipment. Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

9. Stockpiles, borrow areas and spoil shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

10. All disturbed areas shall be stabilized structurally or vegetatively in compliance with the Standard and Specifications for Critical Area Treatment in Section 3.

Construction Specifications

See Figure 5B.26 on page 5B.52 for details.

1. All graded or disturbed areas including slopes shall be protected during clearing and construction in accordance with the erosion and sediment control plan until they are adequately stabilized.

2. All erosion and sediment control practices and measures shall be constructed, applied and maintained in accordance with the sediment control plan and the "New York Guidelines for Urban Erosion and Sediment Control."

3. Topsoil required for the establishment of vegetation shall be stockpiled in amount necessary to complete finished grading of all exposed areas.

4. Areas to be filled shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots or other objectionable material.

5. Areas which are to be topsoiled shall be scarified to a minimum depth of three inches prior to placement of topsoil.

6. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

7. All fill shall be placed and compacted in layers not to exceed 8 inches in thickness.

8. Except for approved landfills or nonstructural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.

9. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills.

10. Fill shall not be placed on frozen foundation.

11. All benches shall be kept free of sediment during all phases of development.

12. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specification for Subsurface Drain on page 5B.43 or other approved methods.

13. All graded areas shall be permanently stabilized immediately following finished grading.

14. Stockpiles, borrow areas, and spoil areas shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

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Figure 5B.25
Typical Section of Serrated Cut Slope

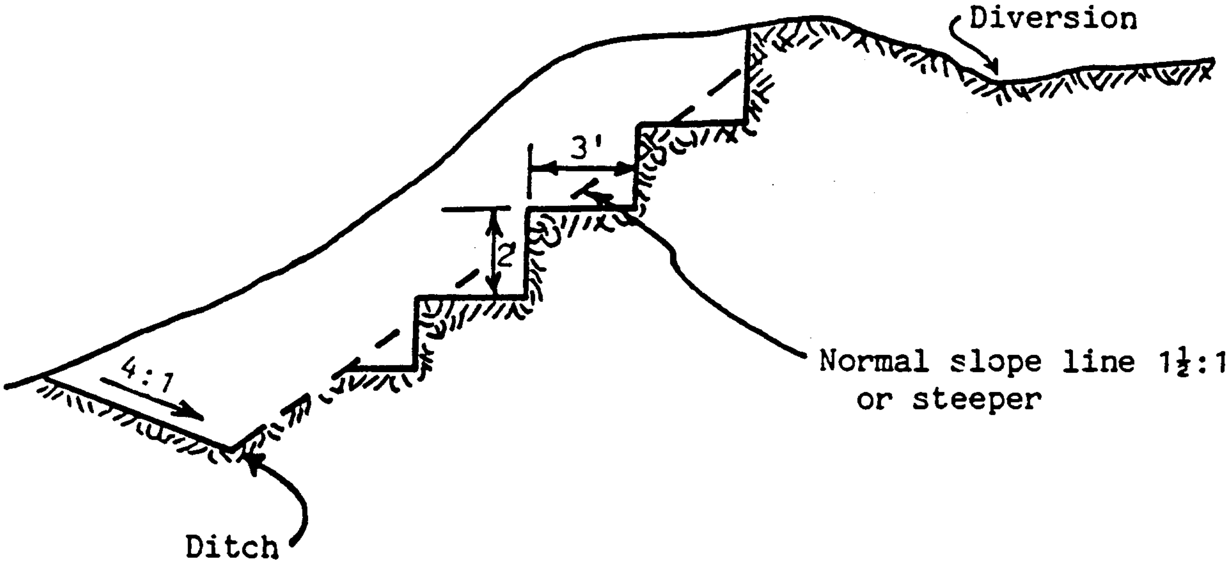

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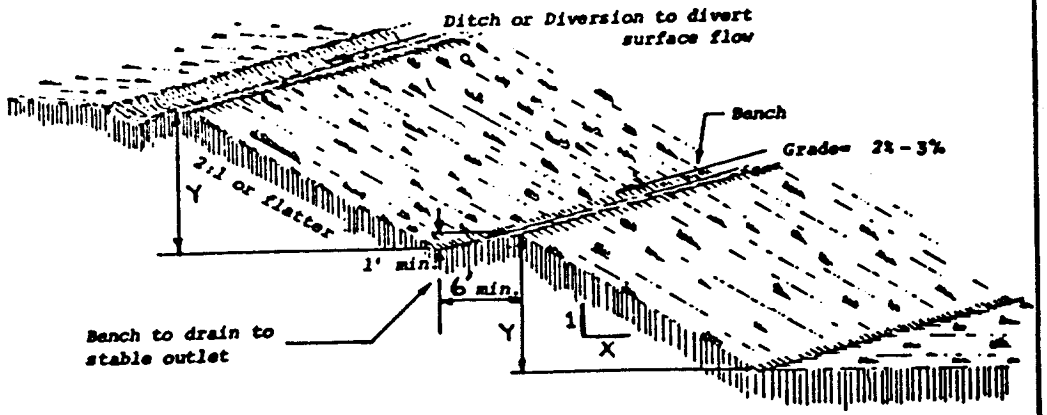
Figure 5B.26
Landgrading Details

LANDGRADING



X	Y(MAX)
2	20'
3	30'
4	40'

SLOPE DETAIL (WITH BENCH)

Construction Specifications

1. All graded or disturbed areas including slopes shall be protected during clearing and construction in accordance with the approved sediment control plan until they are permanently stabilized.
2. All sediment control practices and measures shall be constructed, applied and maintained in accordance with the approved sediment control plan and the "Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas".
3. Topsoil required for the establishment of vegetation shall be stockpiled in amount necessary to complete finished grading of all exposed areas.
4. Areas to be filled shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots or other objectionable material.
5. Areas which are to be topsoiled shall be scarified to a minimum depth of three inches prior to placement of topsoil.
6. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.
7. All fill to be placed and compacted in layers not to exceed 8 inches in thickness.
8. Except for approved landfills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills.
9. Frozen materials or soft, mucky or highly compressible materials shall not be incorporated into fills.
10. Fill shall not be placed on a frozen foundation.
11. All benches shall be kept free of sediment during all phases of development.
12. Seeps or springs encountered during construction shall be handled in accordance with the Standard and Specifications for Subsurface Drain or other approved method.
13. All graded areas shall be permanently stabilized immediately following finished grading.
14. Stockpiles, borrow areas and spoil areas shall be shown on the plans and shall be subject to the provisions of this Standard and Specifications.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE SYRACUSE, NEW YORK	LANDGRADING DETAILS	STANDARD SYMBOL

STANDARD AND SPECIFICATIONS FOR SURFACE ROUGHENING

Definition

Roughening a bare soil surface with horizontal grooves running across the slope, stair-stepping, or tracking with construction equipment.

Purpose

To aid the establishment of vegetative cover from seed, to reduce runoff velocity and increase infiltration, and to reduce erosion and provide for trapping of sediment.

Conditions Where Practice Applies

All construction slopes require surface roughening to facilitate stabilization with vegetation, particularly slopes steeper than 3:1.

Design Criteria

There are many different methods to achieve a roughened soil surface on a slope. No specific design criteria is required. However, the selection of the appropriate method depends on the type of slope. Methods include tracking, grooving and stair-stepping. Steepness, mowing requirements, a cut or fill slope operation are all factors considered in choosing a roughening method.

Construction Specifications

A. <u>Cut slope, No mowing</u>

1. Stair-step grade or groove cut slopes with a gradient steeper than 3:1. (figure 5B.27).
2. Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes of soft rock with some soil are particularly suited to stair-step grading.
3. Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" to the vertical wall.
4. Do not make vertical cuts more than 2 feet in soft materials or 3 feet in rocky materials.

Grooving uses machinery to create a series of ridges and depressions that run across the slope on the contour. Groove using any appropriate implement that can be safely operated on the slope, such as disks, tillers, spring harrows, or the teeth of a front end loader bucket. Do not make the grooves less than 3 inches deep or more than 15 inches apart.

B. <u>Fill slope, No Mowing</u>

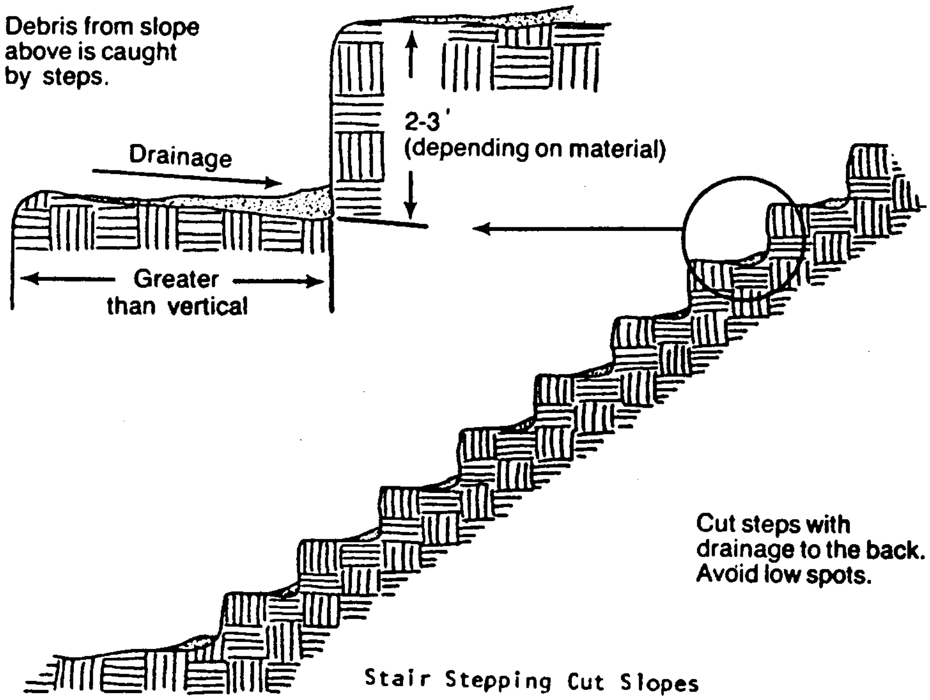
1. Place fill to create slopes with a gradient steeper than 3:1 in lifts 9 inches or less and properly compacted. Ensure the face of the slope consists of loose, uncompacted fill 4 to 6 inches deep. Use grooving as described above to roughen the slope, if necessary.
2. Do not blade or scrape the final slope face.

C. <u>Cuts/Fills, Mowed Maintenance</u>

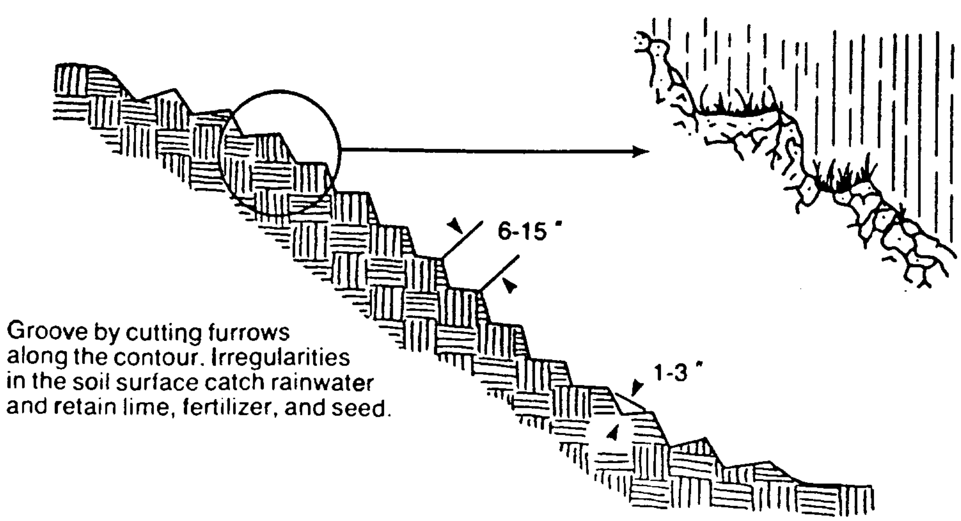
1. Make mowed slopes no steeper than 3:1.
2. Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use of cultipacker-seeder. Make the final pass of such tillage equipment on the contour.
3. Make grooves at least 1 inch deep and a maximum of 10 inches apart.
4. Excessive roughness is undesirable where mowing is planned.

Tracking should be used primarily in sandy soils to avoid undue compaction of the soil surface. Tracking is generally not as effective as the other roughening methods described. (It has been used as a method to track down mulch). Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.

Figure 5B.27
SURFACE ROUGHENING DETAILS



Stair Stepping Cut Slopes



Grooving Slopes

STANDARD AND SPECIFICATIONS FOR RIPRAP SLOPE PROTECTION

Definition

A layer of stone designed to protect and stabilize areas subject to erosion.

Purpose

To protect the soil surface from erosive forces and/or improve the stability of soil slopes that are subject to seepage or have poor soil structure.

Conditions Where Practice Applies

Riprap is used for cut and fill slopes subject to seepage, erosion, or weathering, particularly where conditions prohibit the establishment of vegetation. Riprap is also used for channel side slopes and bottoms, streambanks and grade sills, on shorelines subject to erosion, and at inlets and outlets to culverts, bridges, slope drains, grade stabilization structures and storm drains.

Design Criteria

Gradation - Riprap should be a well-graded mixture with 50% by weight larger than the specified design size. The diameter of the largest stone size in such a mixture should be 1.5 times the d50 size with smaller sizes grading down to 1 inch. The designer should determine the riprap size that will be stable for design conditions. Having determined the stone size, the designer should select the size or sizes that equal or exceed that minimum size based on riprap gradations commercially available in the area.

Thickness - The minimum layer thickness should be 1.5 times the maximum stone diameter, but in no case less than 6 inches.

Quality - Stone for riprap should be hard, durable field or quarry materials. They should be angular and not subject to breaking down when exposed to water or weathering. The specific gravity should be at least 2.5.

Size - The sizes of stones used for riprap protection are determined by purpose and specific site conditions:

1. Slope Stabilization - Riprap stone for slope stabilization not subject to flowing water or wave action should be sized for the proposed grade. The gradient of the slope to be stabilized should be less than the natural angle of repose of the stone selected. Angles of repose of riprap stones may be estimated from figure 5B.28.

   Riprap used for surface stabilization of slopes does not add significant resistance to sliding or slope failure and should not be considered a retaining wall. Slopes approaching 1.5:1 may require special stability analysis. The inherent stability of the soil must be satisfactory before riprap is used for surface stabilization.

2. Outlet Protection - Design criteria for sizing stone and determining dimensions of riprap aprons are presented in Standards and Specifications for Rock Outlet Protection.

3. Streambank Protection - Design criteria for sizing stone for stability of channel bank are presented in Standard and Specifications for Structural Streambank Protection.

Filter Blanket - A filter blanket is a layer of material placed between the riprap and the underlying soil to prevent soil movement into or through the riprap. A suitable filter may consist of a well-graded gravel or sand-gravel layer or a synthetic filter fabric manufactured for this purpose. The design of a gravel filter blanket is based on the ratio of particle size in the overlying filter material to that of the base material in accordance with the criteria below. Multiple layers may be designed to effect a proper filter if necessary.

A gravel filter blanket should have the following relationship for a stable design:

$$\frac{d_{15}\text{ filter}}{d_{85}\text{ base}} \leq 5$$

$$5 < \frac{d_{15}\text{ filter}}{d_{50}\text{ base}} \leq 40$$

and

$$\frac{d_{50}\text{ filter}}{d_{50}\text{ base}} \leq 40$$

Filter refers to the overlying material while base refers to the underlying material. These relationship must hold between the base and filter and the filter and riprap to prevent migration of material. In some cases more than one filter may be needed. Each filter layer should be a minimum of 6 inches thick.

A synthetic filter fabric may be used with or in place of gravel filters. The following particle size relationships should exist:

1. Filter fabric covering a base containing 50% or less by weight of fine particles (#200 sieve size):

a. $$\frac{d_{85}\text{ base (mm)}}{\text{EOS}^{*}\text{filter fabric (mm)}} > 1$$

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b. total open area of filter fabric should not exceed 36%

2. Filter fabric covering other soils:

a. EOS is no larger than 0.21 mm (#70 sieve size)

b. total open area of filter fabric should not exceed 10%.

*EOS - Equivalent opening size compared to a U.S. standard sieve size.

No filter fabric should have less than 4% open area or an EOS less than U.S. Standard Sieve #100 (0.15 mm). The permeability of the fabric must be greater than that of the soil. The fabric may be made of woven or nonwoven monofilament yarns and should meet the following minimum requirements:

thickness 20-60 mils

grab strength 90-120 lbs.

conform to ASTM D-1682 or ASTM D-177

Filter blankets should always be provided where seepage is significant or where flow velocity and duration of flow or turbulence may cause underlying soil particles to move through the riprap.

Construction Specifications

Subgrade Preparation - Prepare the subgrade for riprap and filter to the required lines and grades shown on the plans. Compact any fill required in the subgrade to a density approximating that of the undisturbed material or overfill depressions with riprap. Remove brush, trees, stumps, and other objectionable material. Cut the subgrade sufficiently deep so that the finished grade of the riprap will be at the elevation of the surrounding area. Channels should be excavated sufficiently to allow placement of the riprap in a manner such that the finished inside dimensions and grade of the riprap meet design specifications.

Sand and gravel filter blanket - Place the filter blanket immediately after the ground foundation is prepared. For gravel, spread filter stone in a uniform layer to the specified depth. Where more than one layer of filter material is used, spread the layers with minimal mixing.

Synthetic filter fabric - Place the cloth directly on the prepared foundation. Overlap the edges by at least 2 feet, and space the anchor pins every 3 feet along the overlap. Bury the upper and lower ends of the cloth a minimum of 12 inches below ground. Take precautions not to damage the cloth by dropping the riprap. If damage occurs remove the riprap and repair the sheet by adding another layer of filter fabric with a minimum overlap of 12 inches around the damaged area. Where large stones are to be place, a 4 inch layer of fine sand or gravel is recommended to protect the filter cloth.

Stone placement - Placement of the riprap should follow immediately after placement of the filter. Place riprap so that it forms a dense, well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement. Place riprap to its full thickness in one operation. Do not place riprap by dumping through chutes or other methods that cause segregation of stone sizes. Be careful not to dislodge the underlying base or filter when placing the stones.

The toe of the riprap should be keyed into a stable foundation at its base as shown in figure 5B.29. The toe should be excavated to a depth of 2.0 feet. The design thickness of the riprap should extend a minimum of 3 feet horizontally from the slope. The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the riprap should blend with the surrounding area.

Maintenance

Riprap should be inspected periodically for scour or dislodged stones. Control weed and brush growth as needed.

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FIGURE 5B.28
ANGLES OF REPOSE OF RIPRAP STONES

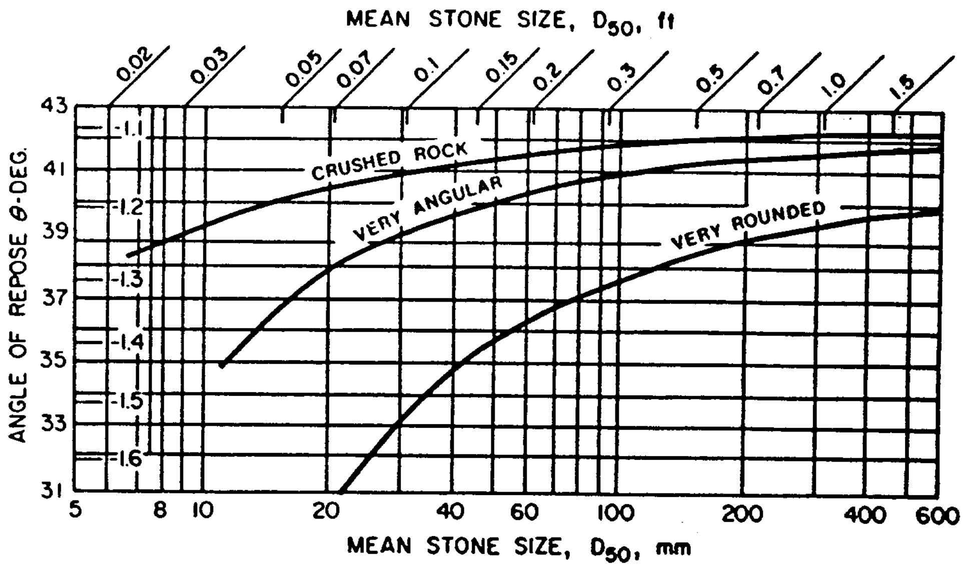
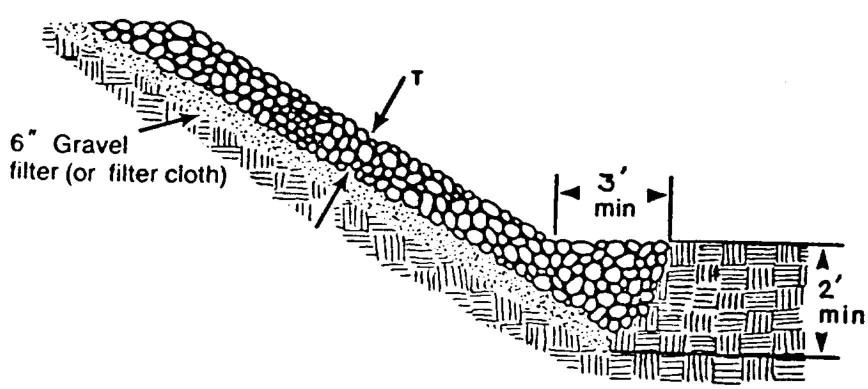


FIGURE 5B.29
TYPICAL RIPRAP SLOPE PROTECTION DETAIL



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STANDARD AND SPECIFICATIONS FOR RETAINING WALLS

Definition

A structural wall constructed and located to prevent soil movement.

Purpose

To retain soil in place and prevent slope failures and movement of material down steep slopes.

Conditions Where Practice Applies

A retaining wall may be used where site constraints won't allow slope shaping and seeding to stabilize an area. Slope areas that demonstrate seepage problems or experience erosive conditions at the toe can utilize retaining walls to help stabilize these areas. Retaining walls can be built from mortared block or stone, cast-in-place concrete, railroad ties, gabions, and more recently, precast concrete modular units that form a gravity retaining wall (see figure 5B.30). These precast units allow for ease and quickness of installation while their granular backfill provides drainage. Selection of materials and type of wall should be based on hazard potential, load conditions, soil parameters, groundwater conditions, site constraints and aesthetics.

Design Criteria

The design of any retaining wall structure must address the aspects of foundation bearing capacity, sliding, overturning, drainage and loading systems. These are complex systems and all but the smallest retaining walls should be designed by a licensed engineer.

Bearing Capacity - A minimum factor of safety of 1.5 should be maintained as the ratio of the ultimate bearing capacity to the designed unit loading. Spread footers and other methods may be used to meet factor requirements.

Sliding - A minimum factor of 2.0 should be maintained against sliding. This factor is usually reduced to 1.5 when passive pressures on the front of the wall are ignored.

Overturning - A minimum factor of safety of 1.5 should be used as the ratio of the resisting moment (that which tends to keep the wall in place) to the overturning moment.

Drainage - Unless adequate provisions are made to control both surface and groundwater behind the retaining wall, a substantial increase in active pressures tending to slide or overturn the wall will result. When backfill is sloped down to a retaining wall surface drainage should be provided. Drainage systems with adequate outlets should be provided behind retaining walls that are placed in cohesive soils. Drains should be graded or protected by filters so soil material will not move through the drainfill.

Load systems - Several different loads or combination of loads need to be considered when designing a retaining wall. The minimum load is the level backfill that the wall is being constructed to retain. Its unit weight will vary depending on its composition.

Additional loads such as line loads, surcharge loads or slope fills will add to make the composite design load system for the wall.

Construction Specifications

Concrete Walls

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings and removing all objectionable material.
2. Subgrade will be compacted and kept moist at least 2 hours prior to placement of concrete.
3. Steel reinforcing will be in accordance with the schedule on the drawings and kept free of rust, scale or dirt.
4. Exposed edges will be chamfered 3/4 inches.
5. Drainfill will meet the gradations shown on the drawings.
6. Weep holes will be provided as drain outlets as shown on the drawings.
7. Concrete will be poured and cured in accordance with ACI specifications.

Precast Units

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings.
2. Subgrade will be compacted and trimmed to receive the leveling beam.
3. Precast units will be placed in accordance with the manufacturers recommendation.
4. Granular fill placed in the precast bins shall be placed in 3 foot lifts, leveled off and compacted with a plate vibrator.

Gabions

1. Foundation will be prepared by excavating to the lines and grades shown on the drawings.

2. Subgrade will be compacted and leveled to receive first layer of gabions. The first row will be keyed into the existing grade at the toe, a minimum of 1.5 feet.
3. Gabions will be placed according to the manufacturers recommendations.
4. They will be filled with stone or crushed rock from 4 to 8 inches in diameter.
5. In corrosive environments, gabion wire should be coated with PVC.

Maintenance

Once in place a retaining wall should require little maintenance. They should be inspected annually for signs of tipping, clogged drains or soil subsidence. If such conditions exist they should be corrected immediately.

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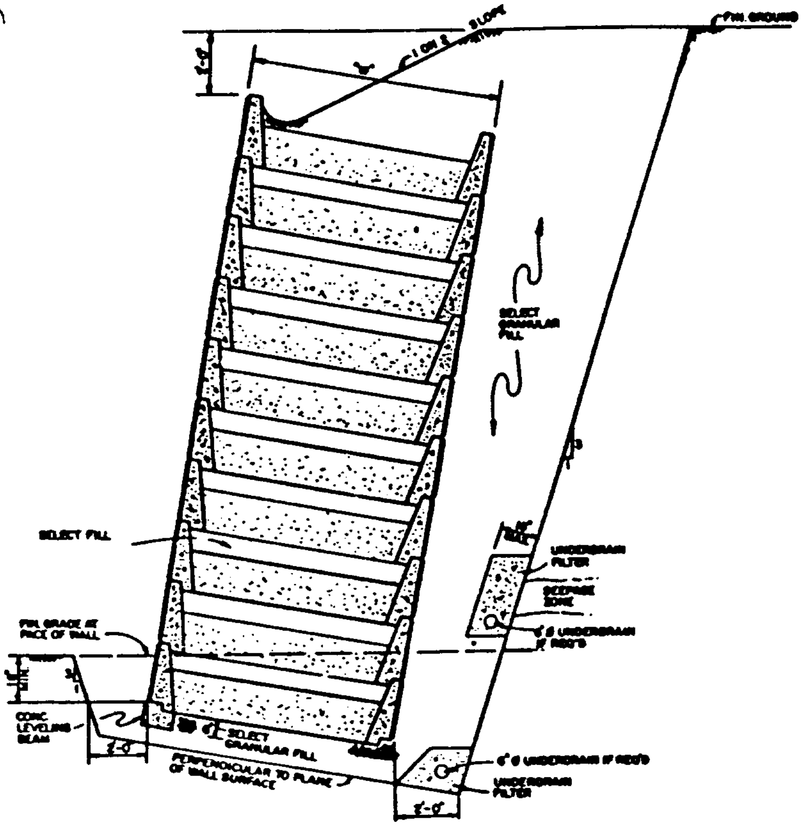
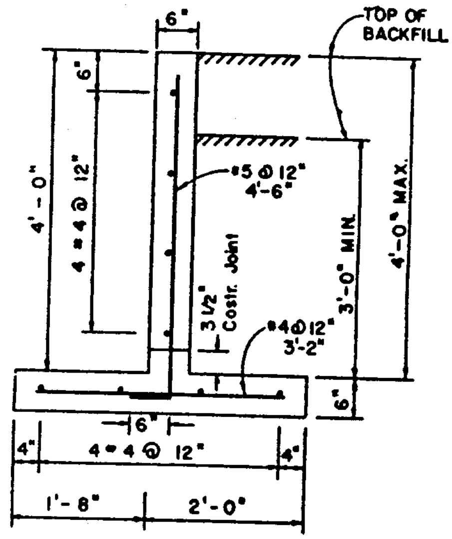
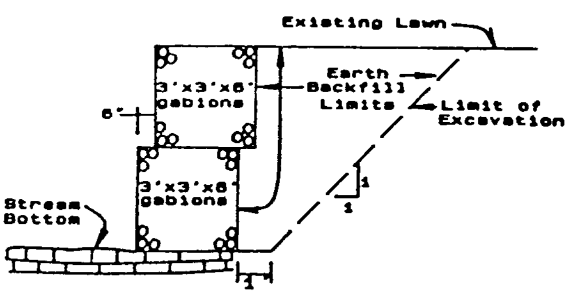
FIGURE 5B.30
RETAINING WALL EXAMPLES



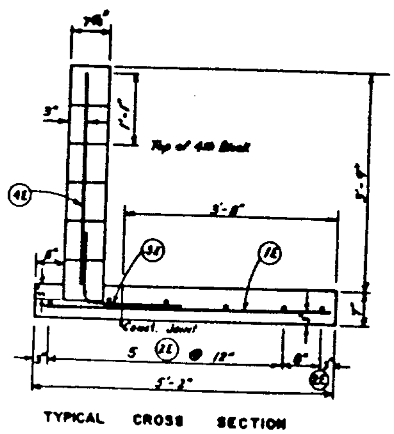
Precast Units



Cast In Place Concrete



Gabions



Mortared Block

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Section 6
Example Erosion and Sediment Control Plan

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This section adapted from North Carolina Erosion and Sediment Control Planning and Design Manual, North Carolina Sedimentation Control Commission by Donald W. Lake, Jr., P.E. State Conservation Engineer, USDA-Soil Conservation Service, Syracuse, New York

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Example Erosion and Sediment Control Plan

Introduction

What follows is an example erosion and sedimentation control plan based on one from the files of the State of North Carolina. The site is located in the Piedmont region. The plan was modified to demonstrate the application of a variety of erosion and sedimentation control practices.

This example plan was developed in detail for instructive purposes. The specific number of maps, practices, drawings, specifications, and calculations required depends on the size and complexity of the development. The designer should select the most practical and effective practices to control erosion and prevent sediment from leaving the site. The plan should be organized and presented in a clear, concise manner. Sufficient design and background information should be included to facilitate review by erosion control personnel. Construction details should be precise and clear for use by an experienced general contractor.

An acceptable erosion and sedimentation control plan must contain:

1. brief narrative
2. construction schedule
3. maintenance plan
4. vicinity map
5. site topo map
6. site development plan
7. erosion and sedimentation control plan drawing
8. detail drawings and specifications
9. vegetative plan

Although this example is from North Carolina, its organization, analysis and detail are appropriate in all locations. The original content of the example was retained for continuity. Regarding practices selected, refer to the flow charts in Section 2 to correlate with the control groups. In the example, the temporary diversion equate to New York's earth dike. Supporting calculations for these practices are not included to maintain the size of this publication. However, the criteria in each of the practice standards in the appropriate sections, will guide the user in their design.

Narrative

Project Description

The purpose of the project is to construct two large commercial buildings with associated paved roads and parking area. Another building will be added in the future. Approximately 6 acres will be disturbed during this construction period. The site is 11.1 acres located in Granville County, 2 miles north of Deal, NC, off Terri Road (see Vicinity Map).

Site Description

The site has rolling topography with slopes generally 4 to 6%. Slopes steepen to 10 to 20% in the northwest portion of the property where a small, healed-over gully serves as the principal drainageway for the site. The site is now covered with volunteer heavy, woody vegetation, predominately pines, 15 to 20 ft high. There is no evidence of significant erosion under present site conditions. The old drainage gully indicates severe erosion potential and receives flow from 5 acres of woods off-site. There is one large oak tree, located in the western central portion of the property, and a buffer area, fronting Terri Road, that will be protected during construction.

Adjacent Property

Land use in the vicinity is commercial/industrial. The land immediately to the west and south has been developed for industrial use. Areas to the north and east are undeveloped and heavily wooded, primarily in volunteer pine. Hocutt Creek, the off-site outlet for runoff discharge, is presently a well-stabilized, gently flowing perennial stream. Sediment control measures will be taken to prevent damage to Hocutt Creek. Approximately 5 acres of wooded area to the east contribute runoff into the construction area.

Soils

The soil in the project area is mapped as Creedmoor sandy loam in B and C slope classes. Creedmoor soils are considered moderately well to somewhat poorly drained with permeability rates greater than 6 inches/hour at the surface but less than 0.1 inches/hour in the subsoil. The subsurface is pale brownstone loam, 6 inches thick. The subsoil consists of a pale brown and brownish yellow sandy clay loam ranging from light gray clay, 36 inches thick. Below 36 inches is a layer of fine sandy loam to 77 inches. The soil erodibility factor (K value) ranges from 0.20 at the surface to 0.37 in the subsoil.

Due to the soil permeability of the subsoil that will be exposed during grading, a surface wetness problem with high runoff is anticipated following significant rainfall events. No groundwater problem is expected. The tight clay in the subsoil will make vegetation difficult to establish. A small amount of topsoil exists on-site and will be stockpiled for use in landscaping.

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Planned Erosion and Sedimentation Control Practices

1. **Sediment Basin:** A sediment basin will be constructed in the northwest corner of the property. All water from disturbed areas, about 6 acres, will be directed to the basin before leaving the site. (Note: The undisturbed areas to the east and north could have been diverted, but this was not proposed because it would have required clearing to the property line to build the diversion and the required outlet structure.) See pages 6.11-6.13 for details.

2. **Temporary Gravel Construction Entrance/Exit:** A temporary gravel construction entrance will be installed near the northwest corner of the property. During wet weather it may be necessary to wash vehicle tires at this location. The entrance will be graded so that runoff water will be directed to an inlet protection structure and away from the steep fill area to the north. See page 6.13 for specifications.

3. **Temporary Block and Gravel Drop Inlet Protection:** A temporary block and gravel drop inlet protection will be installed at the drop inlet located on the south side of the construction entrance. Runoff from the device will be directed into the sediment basin. (Note: The presence of this device reduces the sediment load on the sediment basin and provides sediment protection for the pipe. In addition, sediment removal at this point is more convenient than from the basin.) See page 6.14 for specifications.

4. **Temporary Diversion:** Temporary diversions will be constructed above the 3:1 cut slopes south of Buildings A and B to prevent surface runoff from eroding these banks. (Note: Sediment-free water may be diverted away from the project sediment basin.) A temporary diversion will be constructed near the middle of the disturbed area to break up this long, potentially erosive slope should the grading operation be temporarily discontinued. A temporary diversion dike will be constructed along the top edge of the fill slope at the end of each day during the filling operation to protect the fill slope. This temporary diversion will outlet to the existing undisturbed channel near the north edge of the construction site and/or to the temporary inlet protection device at the construction entrance as the fill elevation increases. See page 6.15 for specifications.

5. **Level Spreader:** A level spreader will serve as the outlet for the diversion east of Building A and south of Building B. The area below the spreader is relatively smooth and heavily vegetated with a slope of approximately 4%. See page 6.16 for specifications.

6. **Tree Preservation and Protection:** A minimum 2.0 ft. high protective fence will be erected around a large oak tree at the dripline to prevent damage during construction. Sediment fence materials may be used for this purpose. See page 6.17 for specifications.

7. **Land Grading:** Heavy grading will be required on approximately 6 acres. The flatter slope after grading will reduce the overall erosion potential of the site. The buildings will be located on the higher cut areas, and the access road and open landscaped areas will be located on fill areas. See pages 6.17-6.18 for specifications.

All cut slopes will be 3:1 or flatter to avoid instability due to wetness, provide fill material, give an open area around the buildings, and allow vegetated slopes to be mowed. Cut slopes will be fine graded immediately after rough grading; the surface will be disked and vegetated according to the Vegetation Plan (pages 6.30-6.32).

Fill slopes will be 2:1 with fill depths as much as 12 to 15 ft. Fill will be placed in layers not to exceed 9 inches in depth and compacted. (Note: Fills of this depth should have detailed compaction specifications in the general construction contract. These specifications are not part of the erosion and sedimentation control plan.)

The fill slope in the north portion of the property is the most vulnerable area to erosion on the site. Fill slopes will be 2:1 with fill depths as much as 12 to 15 ft. Fill will be placed in layers not to exceed 9 inches in depth and compacted.

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(Note: Fills of this depth should have detailed compaction specifications in the general construction contract. These specifications are not part of the erosion and sedimentation control plan.)

The fill slope in the north portion of the property is the most vulnerable area to erosion on the site. Temporary diversions will be maintained at the top of this fill slope at all times, and the filling operation will be graded to prevent overflow to the north. Filling will be done as a continuous operation until final grade is reached. The paved road located on the fill will be sloped to the south and will function as a permanent diversion. The area adjacent to the roads and parking area will be graded to conduct runoff to the road culverts. Runoff water from the buildings will be guttered to the vegetated channels. The finished slope face to the north will not be back-bladed. The top 2 to 6 inches will be left in a loose and roughened condition. Plantings will be protected with mulch, as specified in the Vegetation Plan.

A minimum 15-ft undisturbed buffer zone will be maintained around the perimeter of the disturbed area. (NOTE: This will reduce water and wind erosion, help contain sediment, reduce dust, and reduce final landscaping costs.)

8. **Temporary Sediment Trap:** A small sediment trap will be constructed at the intersection of the existing road ditch and channel number 3 to protect the road ditch. Approximately 2 acres of disturbed area will drain into this trap. See pages 6.19-6.20 for specifications.

9. **Sediment Fence:** A sediment fence will be constructed around the topsoil stockpile and along the channel berm adjacent to the deep cut area as necessary to prevent sediment from entering the channels. See pages 6.20-6.21 for specifications.

10. **Sod Drop Inlet Protection:** Permanent sod drop inlet protection will replace the temporary block and gravel structure when the contributing drainage area has been permanently seeded and mulched. See pages 6.21-6.22 for specifications.

11. **Grass-Lined Channel:** Grass-lined channels with temporary straw-net liners will be constructed around Buildings A and B to collect and convey site water to the project's sediment basin. See pages 6.22-6.24 for specifications.

Should the disturbed areas adjoining the channels not be stabilized at the time the channels are vegetated, a sediment fence will be installed adjacent to the channel to prevent channel siltation.

12. **Riprap-Lined and Paved Channels:** A riprap channel will be constructed in the old gully along the north side of the property starting in the northwest corner after all other construction is complete. This channel will replace the old gully as the principal outlet from the site. See pages 6.25-6.26 for specifications.

13. **Construction Road Stabilization:** As soon as final grade is reached on the entrance road, the subgrade will be sloped to drain to the south and stabilized with a 6-inch course of NC DOT standard ABC stone. The parking area and its entrance road will also be stabilized with ABC stone to prevent erosion and dust during the construction of the buildings prior to paving. See pages 6.26-6.27 for specifications.

14. **Outlet Stabilization Structure:** A riprap apron will be located at the outlet of the three culverts to prevent scour. See pages 6.27-6.28 for specifications.

15. **Surface Roughening:** The 3:1 cut slopes will be lightly roughened by disking just prior to vegetating, and the surface 4 to 6 inches of the 2:1 fill slopes will be left in a loose condition and grooved on the contour. See page 6.29 for specifications.

16. **Surface stabilization**: will be accomplished with vegetation and mulch as specified in the vegetation plan. One large oak tree southwest of Building A and a buffer area between the parking lot and Terri Road will be preserved. Roadway and parking lot base courses will be installed as soon as finished grade is reached.

17. **Dust control**: is not expected to be a problem due to the small area of exposure, the undisturbed perimeter of trees around the site, and the relatively short time of exposure (not to exceed 9 months). Should excessive dust be generated, it will be controlled by sprinkling.

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Construction Schedule

1. Obtain plan approval and other applicable permits.
2. Flag the work limits and mark the oak tree and buffer area for protection.
3. Hold preconstruction conference at least one week prior to starting construction.
4. Install sediment basin as the first construction activity.
5. Install storm drain with block and gravel inlet protection at construction entrance/exit.
6. Install temporary gravel construction entrance/exit.
7. Construct temporary diversions above proposed building sites. Install level spreader and sediment trap and vegetate disturbed areas.
8. Complete site clearing except for the old gully channel in the northwest portion of the site. This area will be cleared during last construction phase for the installation of the riprap liner.
9. Clear waste disposal area in the northeast corner of property, only as needed.
10. Rough grade site, stockpile topsoil, construct channels, install culverts and outlet protection, and install sediment fence as needed. Maintain diversions along top of fill slope daily. NOTE: A temporary diversion will be constructed across the middle of the graded area to reduce slope length and the bare areas mulched should grading be discontinued fort more than 3 weeks.
11. Finish the slopes around buildings as soon as rough grading is complete. Leave the surface slightly roughened and vegetate and mulch immediately.
12. Complete final grading for roads and parking and stabilize with gravel.
13. Complete final grading for buildings.
14. Complete final grading of grounds, topsoil critical areas, and permanently vegetate, landscape, and mulch.
15. Install riprap outlet channel and extend riprap to the pipe outlet under entrance road.
16. All erosion and sediment control practices will be inspected weekly and after rainfall events. Needed repairs will be made immediately.
17. After the site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas.
18. Estimated time before final stabilization--9 months.

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Maintenance Plan

1. All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every week. Any needed repairs will be made immediately to maintain all practices as designed.

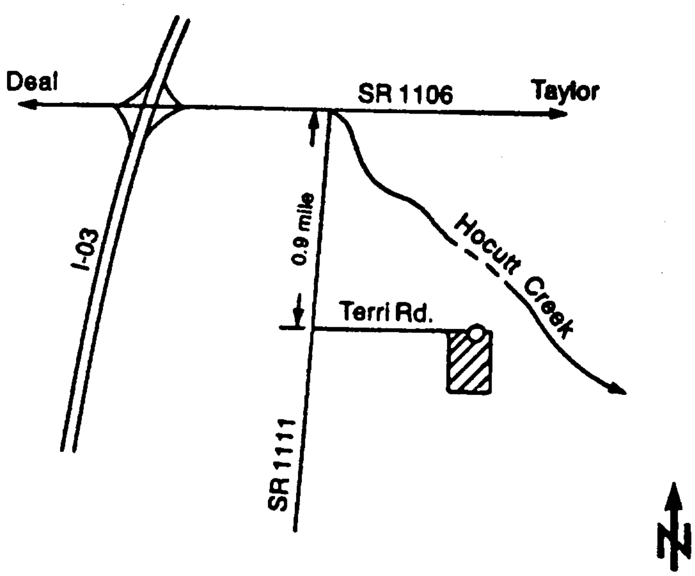
2. The sediment basin will be cleaned out when the level of sediment reaches 2.0 ft below the top of the riser. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.

3. Sediment will be removed from the sediment trap and block and gravel inlet protection device when storage capacity has been approximately 50% filled. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.

4. Sediment will be removed from behind the sediment fence when it becomes about 0.5 ft deep at the fence. The sediment fence will be repaired as necessary to maintain a barrier.

5. All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

Vicinity Map



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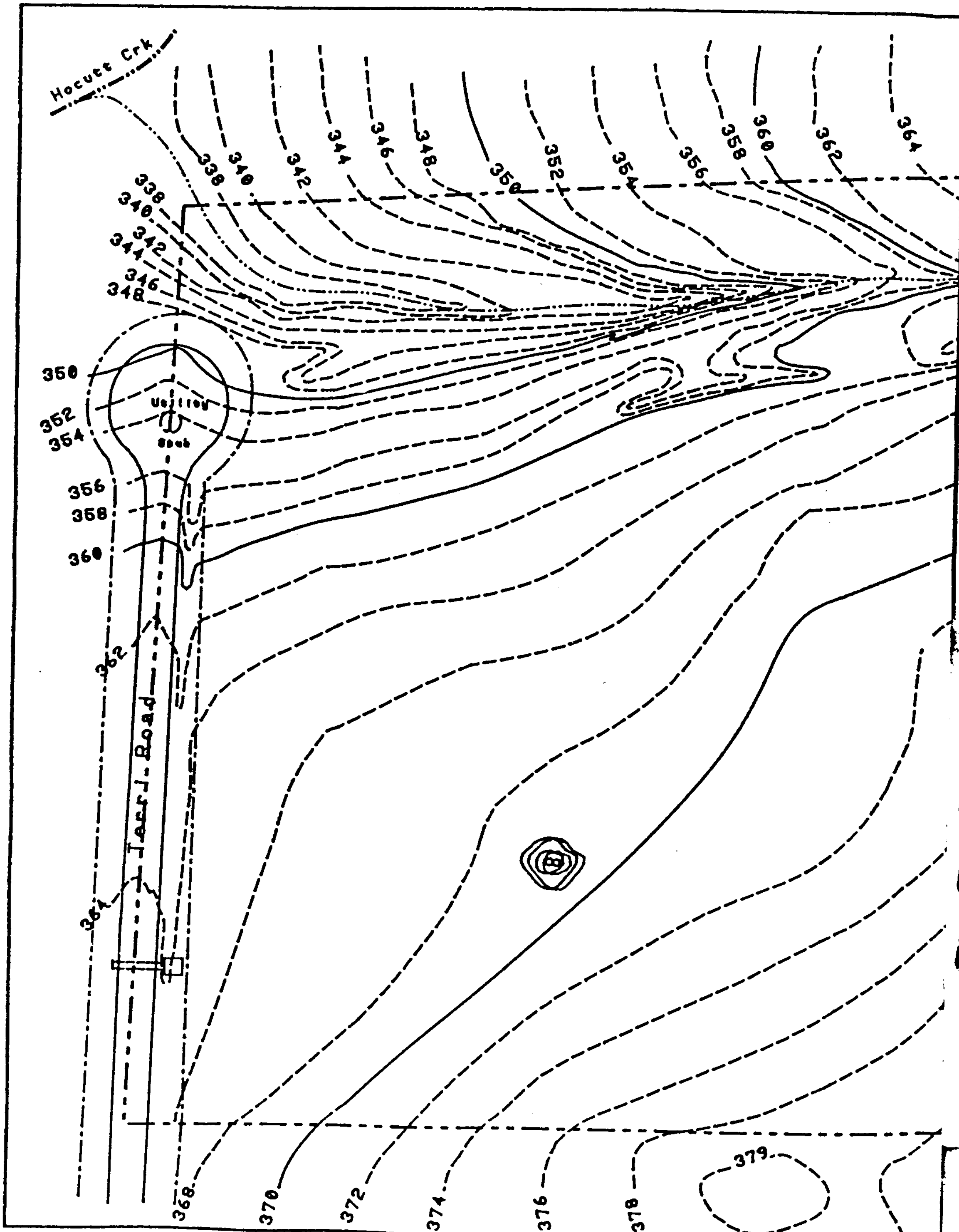

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New York Guidelines for Urban
Erosion and Sediment Control

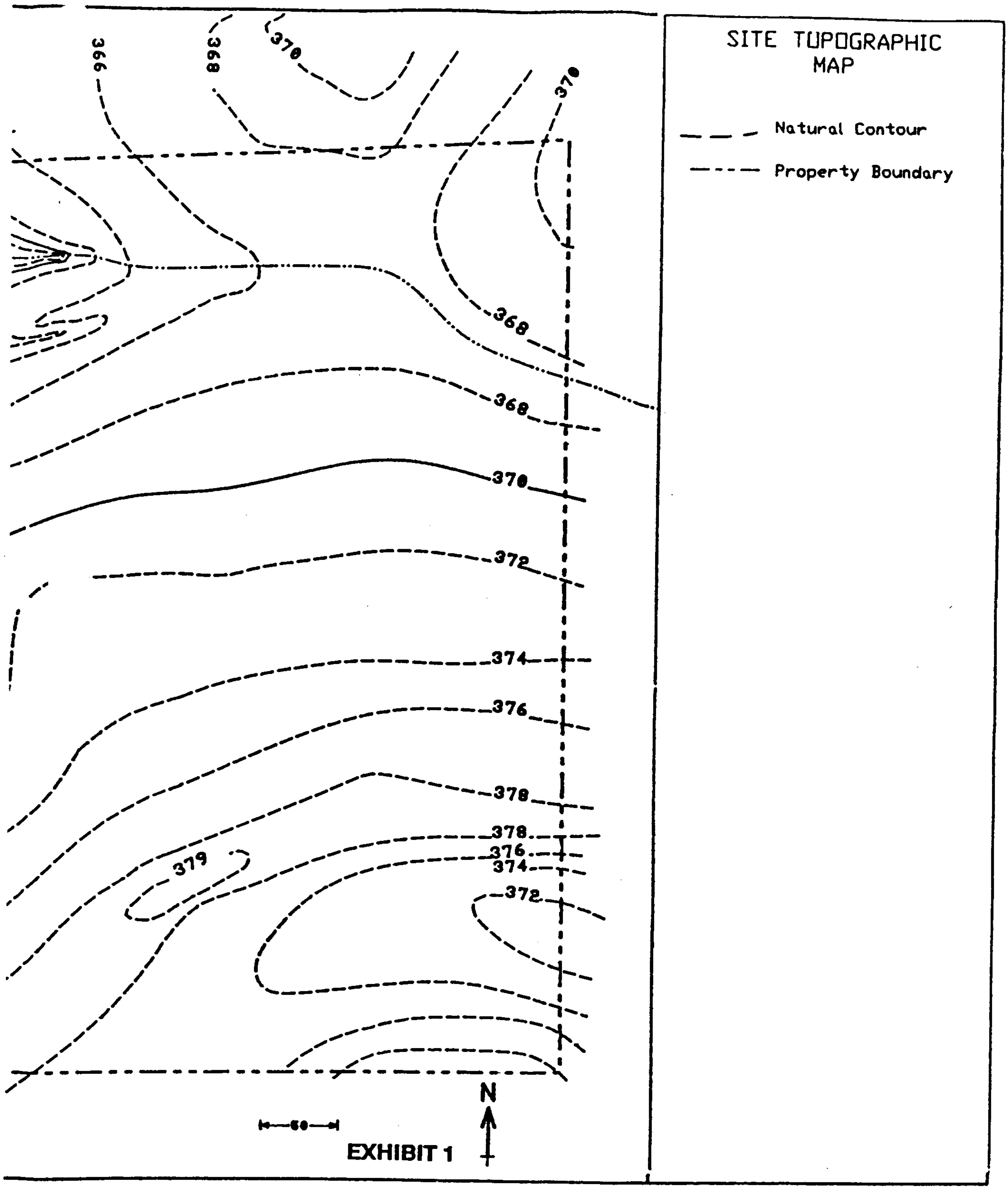

EXHIBIT 1

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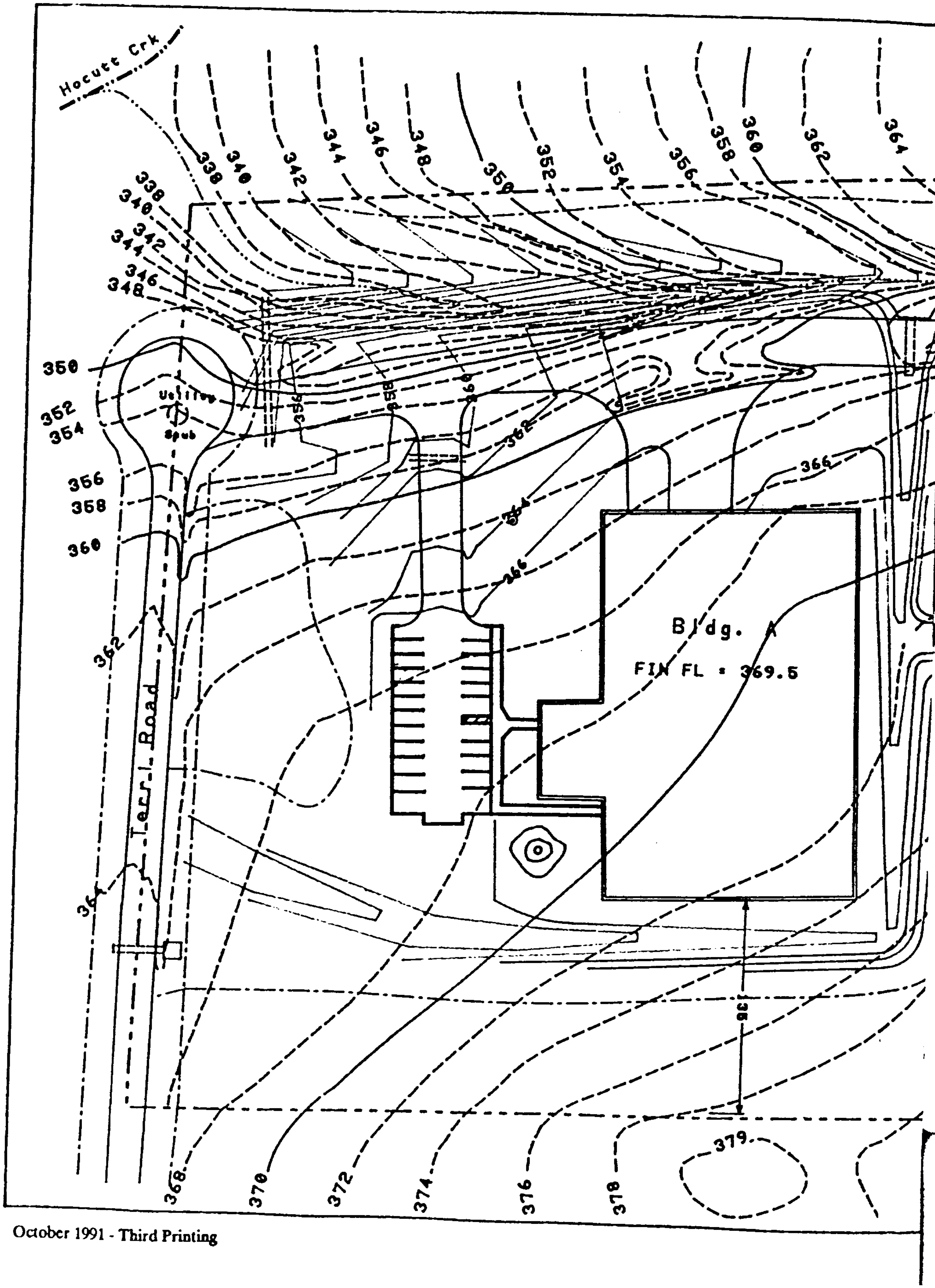

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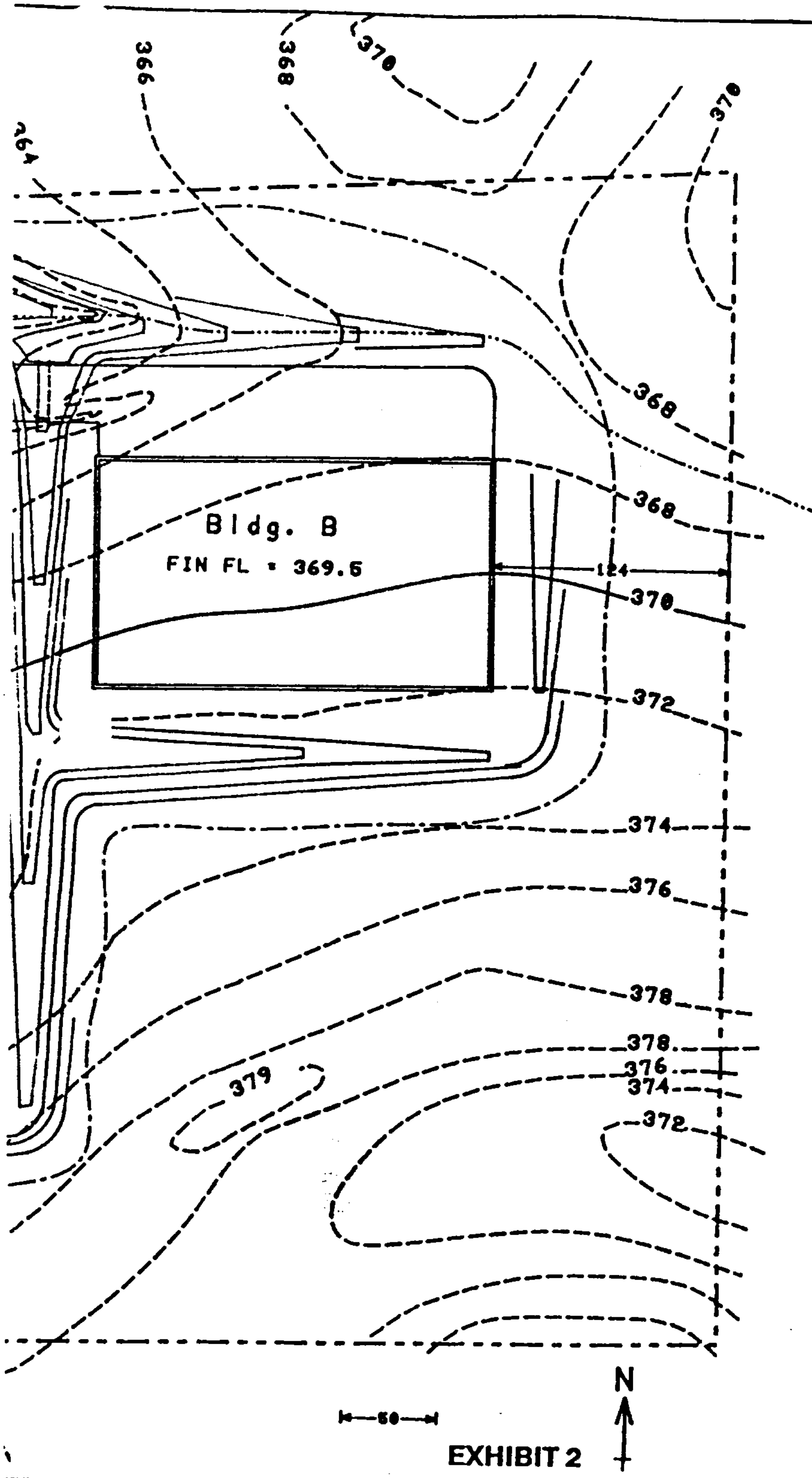

SITE DEVELOPMENT PLAN

Natural Contour
Finished Grade
Property Boundary
Project Development
Limits of Grading

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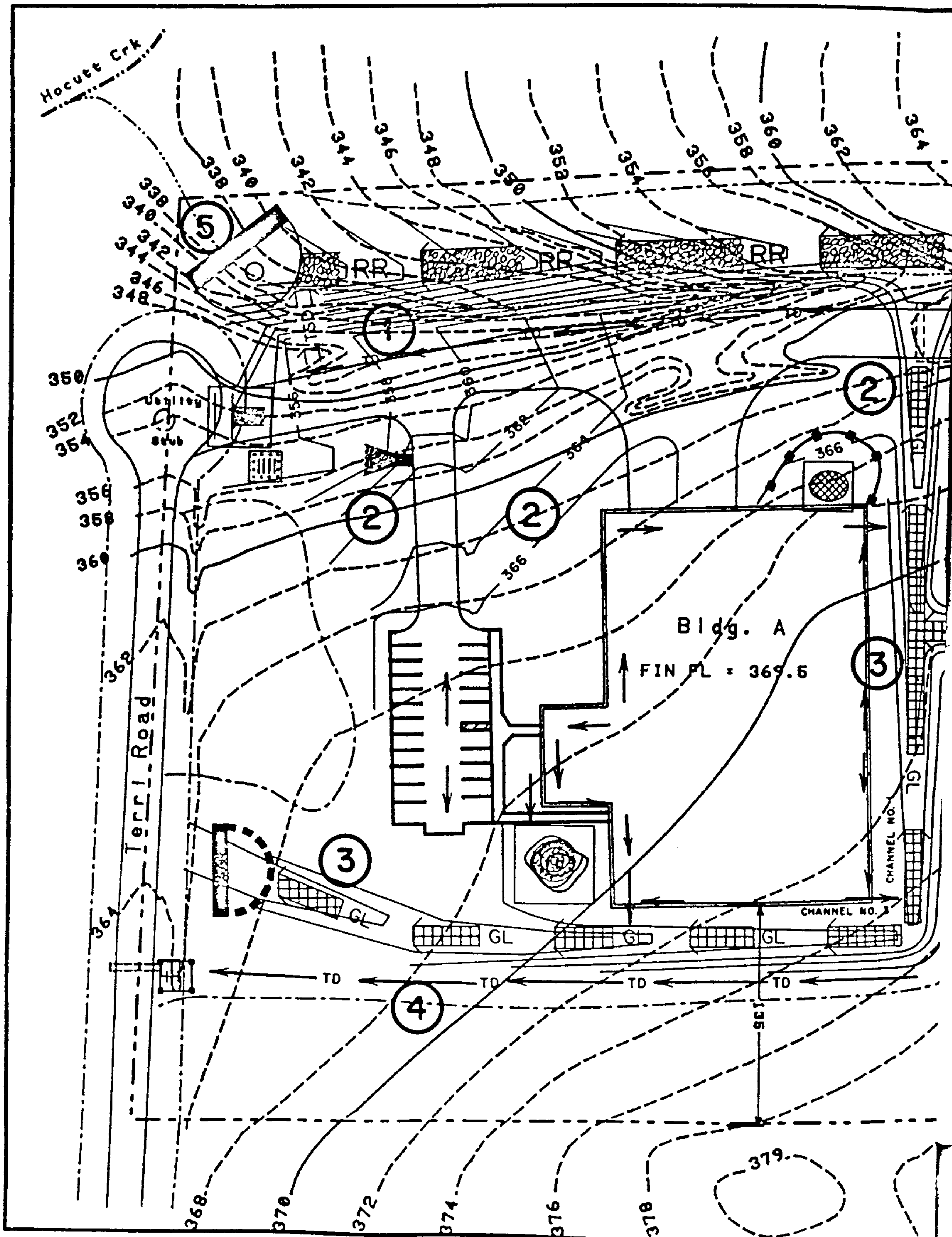

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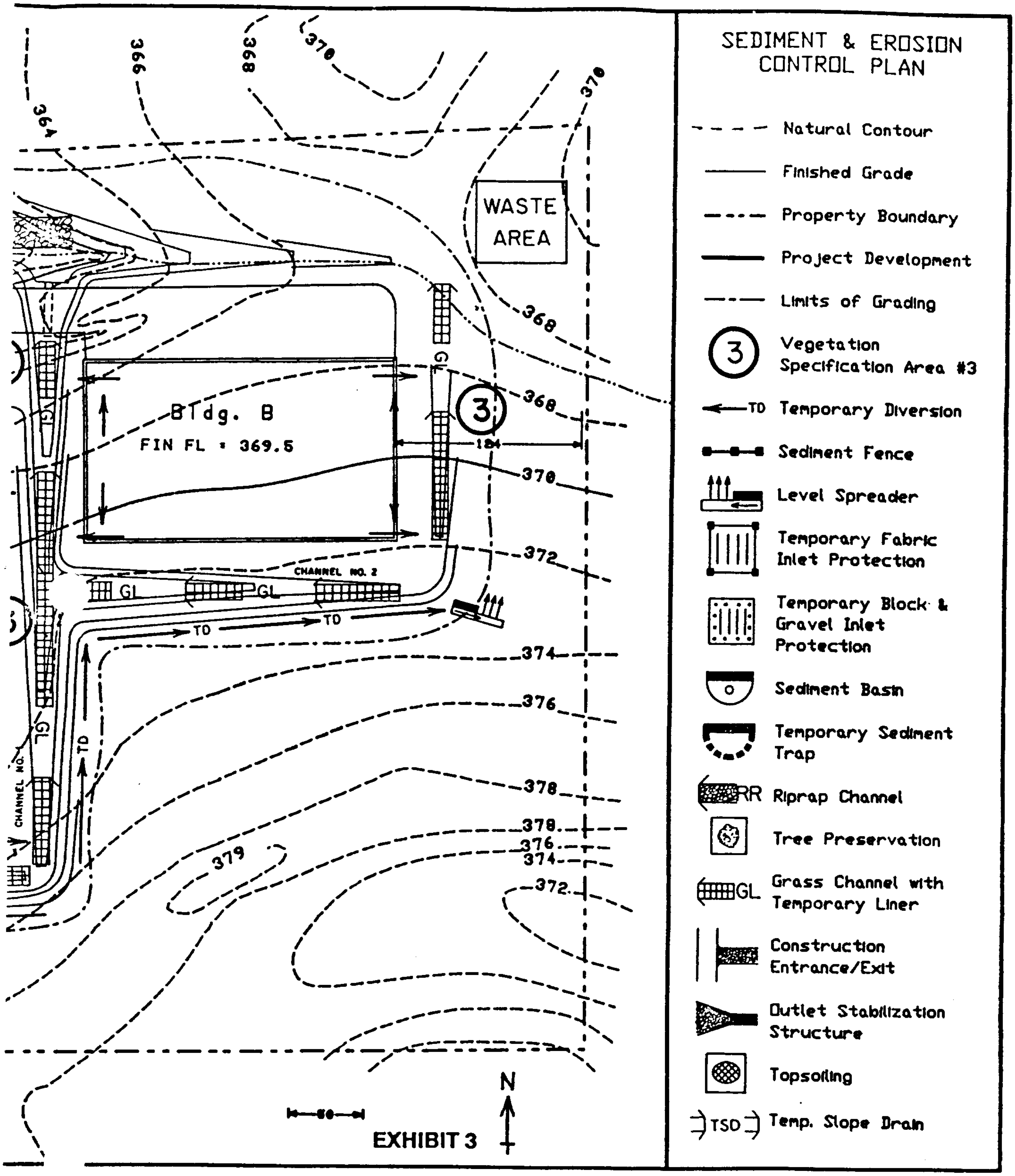

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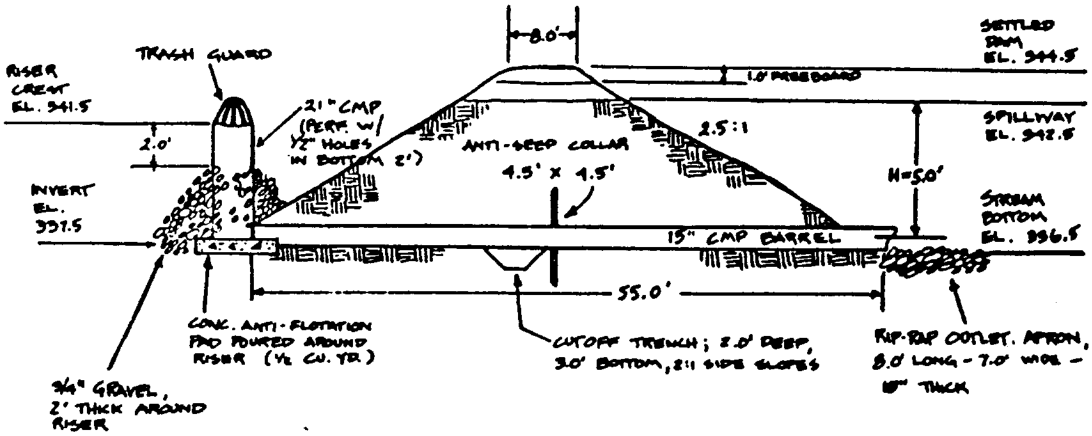
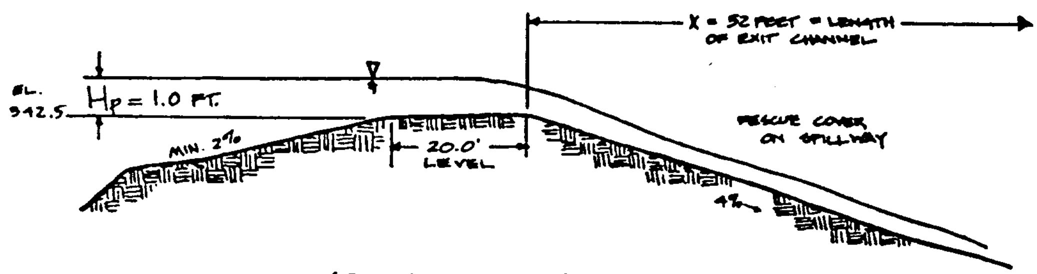
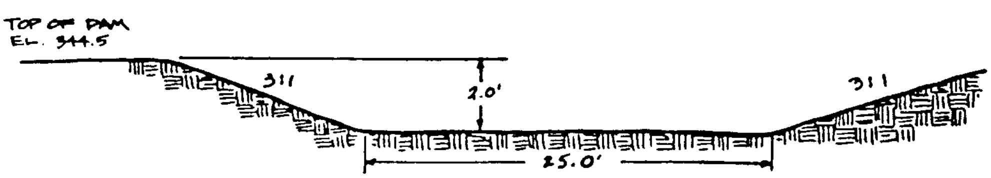
DETAIL DRAWINGS AND SPECIFICATIONS

1. SEDIMENT BASIN





SPILLWAY PROFILE



SPILLWAY: CROSS SECTION AT CONTROL SECTION

(1.) CONSTRUCTION SPECIFICATIONS:

1. CLEAR AND GRUB FOUNDATION FOR EMBANKMENT AND EXCAVATE THE AREA FOR THE RIPRAP OUTLET PAD. AREA TO BE 8.0' LONG, 7.0' WIDE AND 1.5' DEEP. (NOTE: THIS EXCAVATION WILL SERVE AS A SEDIMENT TRAP WHILE STRUCTURE IS BEING BUILT.)

2. EXCAVATE CUTOFF TRENCH ALONG EMBANKMENT CENTERLINE AND UP ABUTMENTS TO ELEVATION 544.0 AS SHOWN. KEEP TRENCH DRY WHEN BACKFILLING AND COMPACTING.

3. USE SEDIMENT POOL AREA AS SOURCE OF FILL MATERIAL FOR THE DAM. MATERIAL SHOULD BE CLEAN MINERAL SOIL, FREE OF ROOTS, WOODY MATERIAL, ROCKS OR OTHER OBJECTIONABLE MATERIAL. SCARIFY FOUNDATION AND PLACE FILL IN LAYERS NOT TO EXCEED 8" OVER THE ENTIRE LENGTH OF DAM. COMPACT BY HEAVY WHEEL EQUIPM NT. THE ENTIRE SURFACE OF EACH LAYER MUST BE TRAVERSED BY AT LEAST ONE WHEEL OF THE COMPACTION EQUIPMENT. THE FILL MATERIAL MUST BE MOIST BUT NOT SO WET THAT WATER CAN BE SQUEEZED FROM IT.

4. PERFORATE 24" CMP RISER WITH ½" HOLES SPACED 3" APART IN EACH OUTSIDE VALLEY TO WITHIN 2.0' OF THE TOP. SECURE TRASH RACK TO RISER TOP. MAXIMUM OPENING BETWEEN BARS OF RACK NOT TO EXCEED 3".

5. SECURELY ATTACH THE RISER TO THE BARREL AND ALL OTHER PIPE JOINTS WITH ROD AND LUG CONNECTOR BANDS WITH RUBBER GASKETS TO ASSURE WATER TIGHTNESS. PLACE THE BARREL AND RISER ON A SMOOTH, FIRM FOUNDATION. PLACE FILL AROUND THE PIPE IN 4" LAYERS AND HAND COMPACT. TAKE CARE NOT TO RAISE THE PIPE FROM FIRM CONTACT WITH ITS FOUNDATION WHEN COMPACTING UNDER PIPE HAUNCHES.

6. SECURE ONE STANDARD CORRUGATED METAL ANTI-SEEP COLLAR AROUND BARREL. MAKE SURE CONNECTION IS WATERTIGHT. HAND COMPACT AROUND ANTI-SEEP COLLAR.

7. PLACE A MINIMUM OF 2 FT. OF HAND COMPACTED BACKFILL OVER PIPE BEFORE CROSSING IT WITH CONSTRUCTION EQUIPMENT.

8. ANCHOR RISER IN PLACE WITH 1/2 YD³ CONCRETE PAD POURED AROUND RISER.

9. PLACE 3/4" GRAVEL (D.O.T. #5 WASHED STONE) OVER THE PERFORATED HOLES APPROXIMATELY 2" THICK.

10. INSTALL EMERGENCY SPILLWAY IN UNDISTURBED SOIL TO THE LINES AND GRADES SHOWN IN DRAWINGS.

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11. PLACE CLASS A EROSION CONTROL STONE OVER FILTER FABRIC ON LEVEL GRADE FOR RIPRAP APRON AT PIPE OUTLET. TOP OF RIPRAP TO BE SAME ELEVATION AS OUTLET CHANNEL BOTTOM. NO OVERFALL.

12. CLEAR SEDIMENT POOL AREA TO ELEVATION 341.5 AFTER THE EMBANKMENT IS COMPLETE.

13. VEGETATE ALL DISTURBED AREAS (EXCEPT THE SEDIMENT POOL) IN ACCORDANCE WITH THE VEGETATIVE PLAN.

14. SEDIMENT TO BE REMOVED FROM BASIN WHEN THE LEVEL IS WITHIN 2.0' OF THE TOP OF THE RISER. (SAME LEVEL AS TOP OF GRAVEL.)

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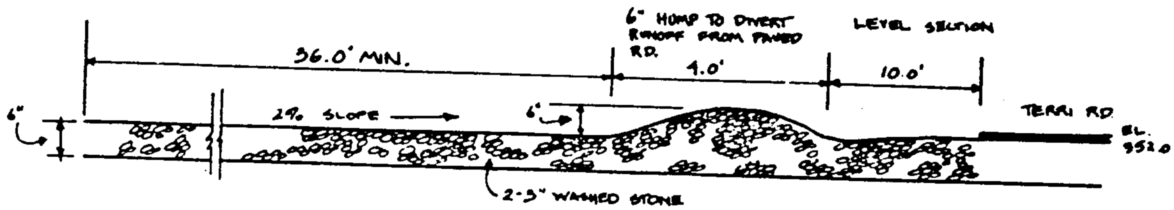
2. TEMPORARY GRAVEL CONSTRUCTION ENTRANCE



GRAVEL ENTRANCE / EXIT : WIDTH — 15.0', FLARED TO 25.0' AT ROAD
LENGTH — 50.0'
GRADE — 2.0%

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(2.) CONSTRUCTION SPECIFICATIONS

1. CLEAR THE ENTRANCE / EXIT AREA OF ALL VEGETATION, ROOTS, AND OTHER OBJECTIONABLE MATERIAL.

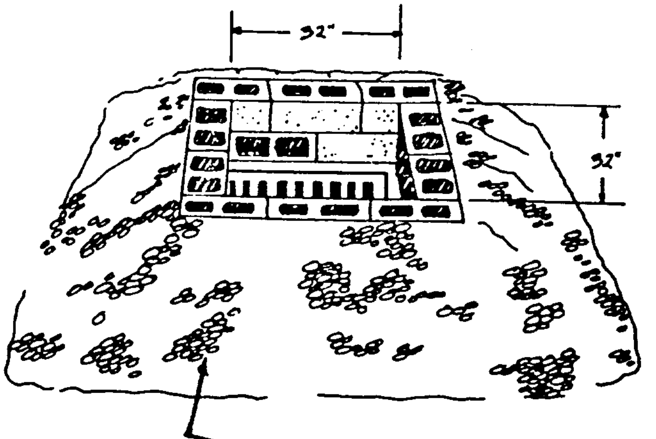
2. GRADE THE ROAD FOUNDATION SO THAT THE ENTRANCE / EXIT WILL HAVE A CROSS SLOPE TO THE SOUTH AND ALL RUNOFF WILL DRAIN TO THE BLOCK AND GRAVEL DROP INLET PROTECTION STRUCTURE.

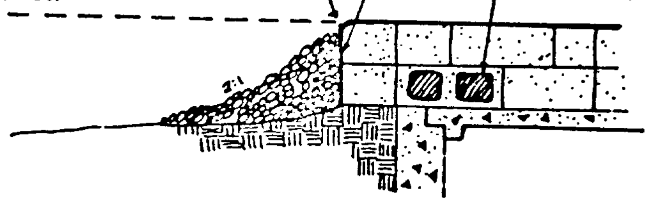
3. PLACE STONE TO THE DIMENSIONS, GRADE AND ELEVATION SHOWN.

4. USE WASHED STONE 2" TO 3" IN SIZE.

NOTE : MAINTAIN THE GRAVEL PAD IN A CONDITION TO PREVENT MUD OR SEDIMENT FROM LEAVING THE SITE. SHOULD MUD BE TRACKED OR WASHED ONTO TERRI ROAD, IT MUST BE REMOVED IMMEDIATELY.

3. TEMPORARY BLOCK AND GRAVEL DROP INLET PROTECTION





(3.) CONSTRUCTION SPECIFICATIONS

1. LAY CONCRETE BLOCKS ON FIRM, SMOOTH FOUNDATION EXCAVATED 3" BELOW STORM DRAIN TOP. PLACE BLOCKS AGAINST DRAIN INLET FOR LATERAL SUPPORT.

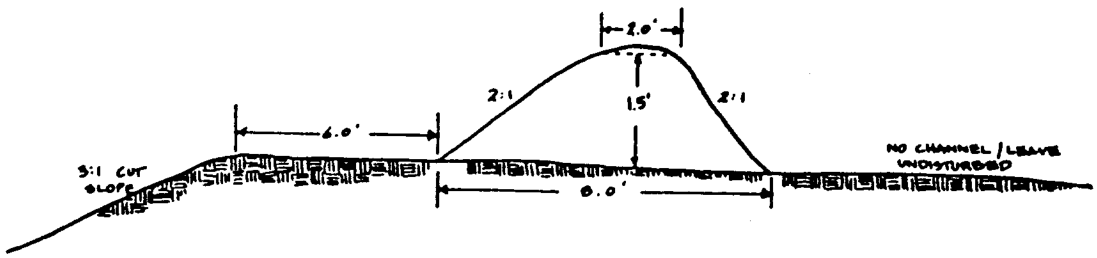
2. PLACE AT LEAST ONE CONCRETE BLOCK ON ITS SIDE IN EACH BOTTOM ROW OF BLOCKS.

3. PLACE WIRE MESH WITH ½" OPENINGS OVER ALL BLOCK OPENINGS USED FOR DRAINAGE.

4. USE D.O.T. #57 WASHED STONE TO REDUCE FLOW RATE BUT ALLOW DRAINAGE. PLACE STONE ON 2:1 SLOPE TO WITHIN 3" OF TOP OF BLOCK.

5. ANY SOIL LEFT EXPOSED BETWEEN THE BLOCK AND CONCRETE DRAIN INLET SHOULD BE FILLED WITH 3" DIAMETER STONE TO PREVENT WASHING WHEN WATER FLOWS OVER BLOCKS INTO DRAIN.

4. TEMPORARY DIVERSIONS



TYPICAL X-SECTION DIVERSION #1 & #2

DIVERSION #1 — GRADE = 2%
LENGTH = 450'

DIVERSION #2 — GRADE = 0.5%
LENGTH = 400'

(4.) CONSTRUCTION SPECIFICATIONS

1. REMOVE ALL TREES, BRUSH & STUMPS FROM DIVERSION FOUNDATION.
2. CONSTRUCT RIDGE TO FULL DIMENSIONS SHOWN — ALLOW 10% FOR SETTLING.
3. COMPACT RIDGE BY WHEELS OF CONSTRUCTION EQUIPMENT.
4. ENSURE THAT THE TOP OF THE DIVERSION IS ON DESIGN GRADE OR HIGHER AT ALL POINTS.
5. SEED AND MULCH IMMEDIATELY AFTER CONSTRUCTION. SEE VEGETATIVE PLAN.

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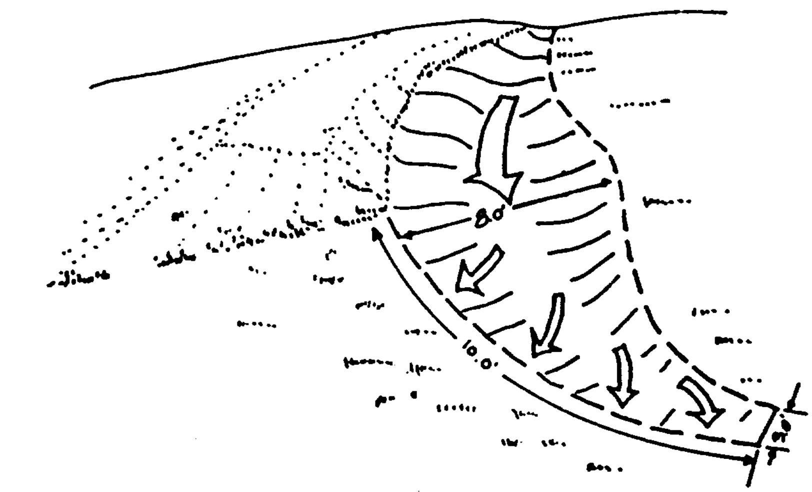
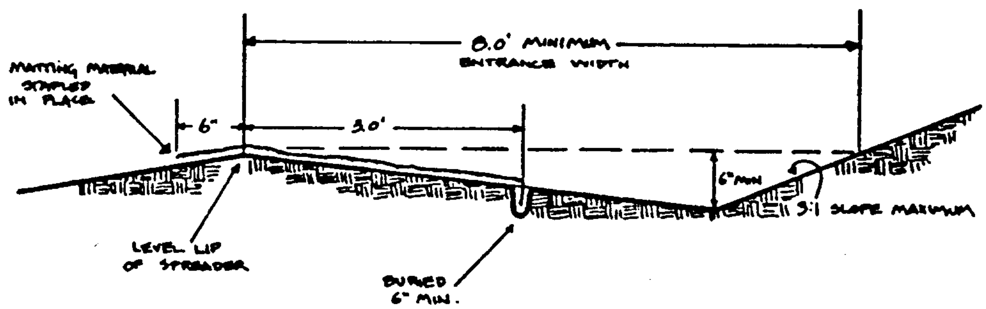
5. LEVEL SPREADER





CROSS SECTION

(5.) CONSTRUCTION SPECIFICATIONS

1. FIBERGLASS MATTING, 4.0 FT. WIDE, SHOULD EXTEND 6" OVER THE LEVEL LIP AND BE BURIED 6" DEEP AT THE LOWER EDGE.

2. ENSURE THAT THE SPREADER LIP IS LEVEL THROUGHOUT ITS LENGTH.

3. CONSTRUCT THE LEVEL SPREADER ON UNDISTURBED SOIL (NOT ON FILL.)

4. CONSTRUCT A TRANSITION SECTION FROM THE DIVERSION TO BLEND SMOOTHLY TO THE WIDTH AND DEPTH OF THE SPREADER.

5. IMMEDIATELY AFTER CONSTRUCTION, APPROPRIATELY SEED AND MULCH THE ENTIRE DISTURBED AREA OF THE SPREADER. SEE VEGETATIVE PLAN.

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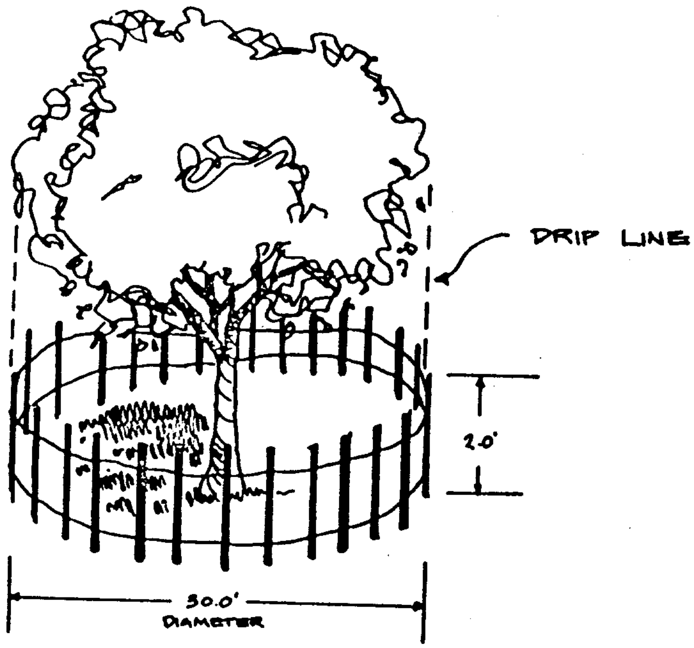
6. TREE PRESERVATION & PROTECTION



NOTE: SEDIMENT FENCE MATERIAL MAY BE USED TO BUILD FENCE.

• DRIVE STAKES FIRMLY INTO GROUND – AT LEAST 12"

7. LAND GRADING

1. FINISHED LAND SURFACES WILL BE GRADED AS SHOWN ON SITE DEVELOPMENT PLAN.
2. CUT SLOPES WILL BE 3:1 OR FLATTER FOR MAINTENANCE BY MOWING AND ROUGHENED FOR VEGETATIVE ESTABLISHMENT.
3. THE HIGH FILL SLOPE ON THE NORTH WILL NOT BE STEEPER THAN 2:1 AND ROUGHENED BY GROOVING ACROSS THE SLOPE.
4. TOPSOIL WILL BE REMOVED FROM AREAS TO BE GRADED AND FILLED AND IT WILL BE STOCKPILED IN LOCATIONS SHOWN.
5. AREAS TO BE FILLED WILL BE CLEARED AND GRUBBED.
6. FILL WILL BE PLACED IN LAYERS NOT TO EXCEED 9" AND COMPACTED AS REQUIRED IN THE SPECIFICATIONS FOR THE DEVELOPMENT PLAN (NOT A PART OF SEDIMENT CONTROL PLAN.)

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7. FROZEN MATERIAL OR SOFT, HIGHLY COMPRESSIBLE MATERIAL WILL NOT BE USED AS FILL.

8. FILL WILL NOT BE PLACED ON A FROZEN SURFACE.

9. ROAD AND PARKING SURFACES WILL BE SLOPED AS SHOWN ON SITE DEVELOPMENT PLAN TO CONTROL RUNOFF.

10. LAND ADJOINING PAVED AREAS WILL BE SLOPED NO STEEPER THAN 6:1 AND GRADED TO DRAIN AS SHOWN.

11. SURFACE RUNOFF FROM BUILDINGS WILL BE COLLECTED IN GUTTERS AND PIPED TO CHANNELS 1, 2, 3 AND 4.

12. DIVERSIONS WILL BE INSTALLED ABOVE CUT SLOPES PRIOR TO LAND CLEARING AND GRADING.

13. A DIVERSION WILL BE MAINTAINED AT ALL TIMES ABOVE THE FILL SLOPE TO PREVENT OVERFLOW ON THIS STEEP AREA.

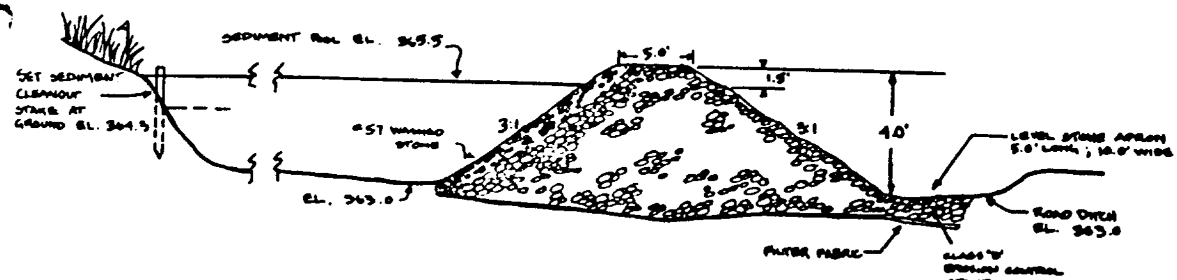
14. CUTTING AND FILLING WILL BE DONE AS A CONTINUOUS OPERATION UNTIL FINAL GRADE IS REACHED. SHOULD GRADING BE TEMPORARILY DISCONTINUED, A TEMPORARY DIVERSION WILL BE CONSTRUCTED ACROSS THE MIDDLE OF THE DISTURBED AREA TO BREAK UP THE LONG SLOPE TO THE NORTH.

15. AS SOON AS FINAL GRADES ARE REACHED THE GRADED AREAS WILL BE STABILIZED IN ACCORDANCE WITH THE VEGETATIVE PLAN.

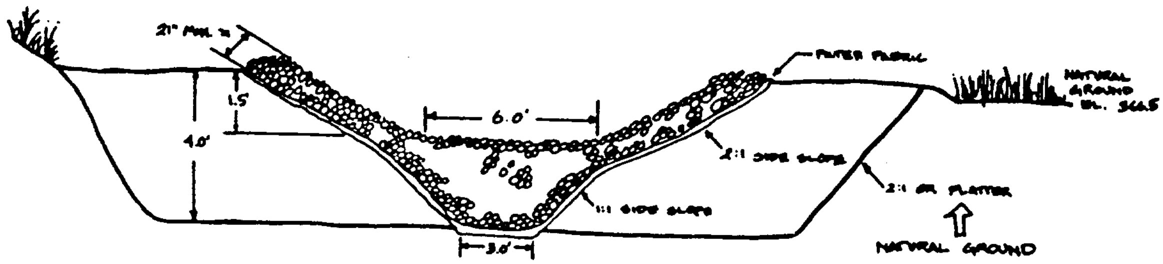
16. AN UNDISTURBED AREA WILL BE LEFT AS A BUFFER AROUND THE ENTIRE GRADED SITE EXCEPT AT ROAD ENTRANCE AND CHANNEL #3 OUTLET.

17. WHEN THE DEVELOPED SITE HAS BEEN PROPERLY STABILIZED, ALL THE TEMPORARY SEDIMENT AND EROSION CONTROL MEASURES WILL BE REMOVED, THE DISTURBED AREA GRADED TO BLEND WITH THE SURROUNDING AREA, AND VEGETATED.

8. TEMPORARY SEDIMENT TRAP



CROSS SECTION



STONE SECTION

(8.) CONSTRUCTION SPECIFICATIONS

1. CLEAR, GRUB AND STRIP THE AREA UNDER THE EMBANKMENT OF ALL VEGETATION AND ROOT MAT.
2. CLEAR POND AREA BELOW ELEVATION 365.5
3. USE FILL MATERIAL FREE OF ROOTS, WOODY VEGETATION AND ORGANIC MATTER. PLACE FILL IN LIFTS NOT TO EXCEED 9" AND MACHINE COMPACT.
4. CONSTRUCT DAM AND STONE SPILLWAY TO DIMENSIONS, SLOPES AND ELEVATIONS SHOWN.
5. ENSURE THAT THE SPILLWAY CREST IS LEVEL AND AT LEAST 1.5' BELOW THE TOP OF THE DAM AT ALL POINTS.
6. STONE USED FOR SPILLWAY SECTION — CLASS "B" EROSION CONTROL STONE.

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7. STONE USED ON INSIDE SPILLWAY FACE TO CONTROL DRAINAGE — D.O.T. # 57 WASHED STONE.

8. EXTEND STONE OUTLET SECTION TO VEGETATED ROAD DITCH ON ZERO GRADE WITH TOP ELEVATION OF STONE LEVEL WITH BOTTOM OF DRAIN.

9. ENSURE THAT THE TOP OF THE DAM AT ALL POINTS IS 0.5' ABOVE NATURAL SURROUNDING GROUND.

10. STABILIZE THE EMBANKMENT AND ALL DISTURBED AREA ABOVE THE SEDIMENT POOL AS SHOWN IN THE VEGETATION PLAN.

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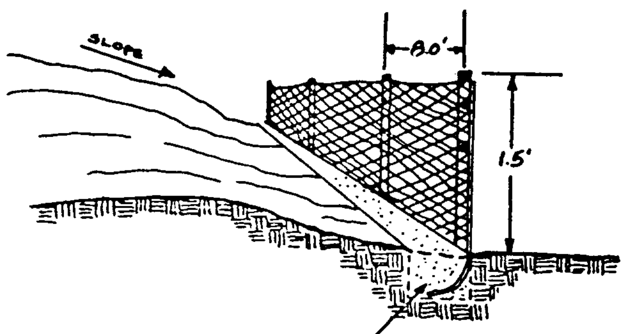
9. SEDIMENT FENCE



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(9.) CONSTRUCTION SPECIFICATIONS

1. CONSTRUCT SEDIMENT FENCE ON LOW SIDE OF TOPSOIL STOCKPILE TO PREVENT SEDIMENT FROM BEING WASHED INTO THE DRAINAGE SYSTEM. FENCE TO EXTEND AROUND APPROXIMATELY 70% OF THE PERIMETER OF THE STOCKPILE.

2. LOCATE POSTS DOWNSLOPE OF FABRIC TO HELP SUPPORT FENCING.

R0039543

3. BURY TOE OF FENCE APPROXIMATELY 8" DEEP TO PREVENT UNDERCUTTING

4. WHEN JOINTS ARE NECESSARY, SECURELY FASTEN THE FABRIC AT A SUPPORT POST WITH OVERLAP TO THE NEXT POST.

5. FILTER FABRIC TO BE OF NYLON, POLYESTER, PROPYLENE OR ETHYLENE YARN WITH EXTRA STRENGTH — 50 LB/LIN. IN. (MINIMUM) — AND WITH A FLOW RATE OF AT LEAST 0.3 GAL./FT² / MINUTE. FABRIC SHOULD CONTAIN ULTRAVIOLET RAY INHIBITORS AND STABILIZERS.

6. POST TO BE 4" DIAMETER PINE WITH A MIMUMUM LENGTH OF 4' FEET.

NOTE: IF HIGH CUT SLOPES ADJOINING CHANNELS 1, 2, AND 3 ARE NOT ADEQUATELY STABILIZED BEFORE CHANNEL IS CONSTRUCTED, A SEDIMENT FENCE SHOULD BE LOCATED ON THE CHANNEL BERM TO PREVENT SEDIMENT FROM ENTERING THE CHANNEL SYSTEM. THE FENCE SHOULD BE INSTALLED AS SHOWN ABOVE ALONG THE ENTIRE UNSTABLE AREA ADJOINING THE CHANNEL.

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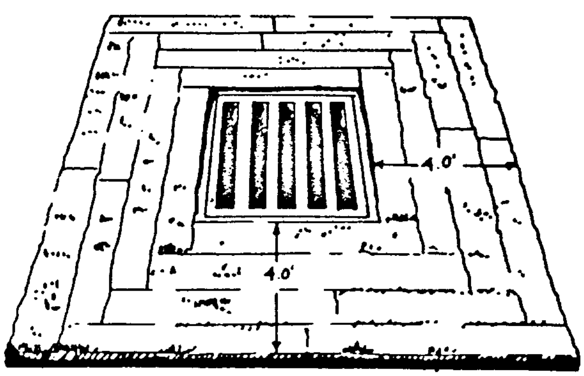
10. SOD DROP INLET PROTECTION

AFTER THE CONTRIBUTING DRAINAGE AREA HAS BEEN PERMANENTLY STABILIZED, THE BLOCK AND GRAVEL STRUCTURE WILL BE REMOVED AND PERMANENT SOD LAID AROUND THE DROP INLET.



FOUR 1-FOOT WIDE STRIPS OF TALL FESCUE SOD ON EACH SIDE OF THE DROP INLET

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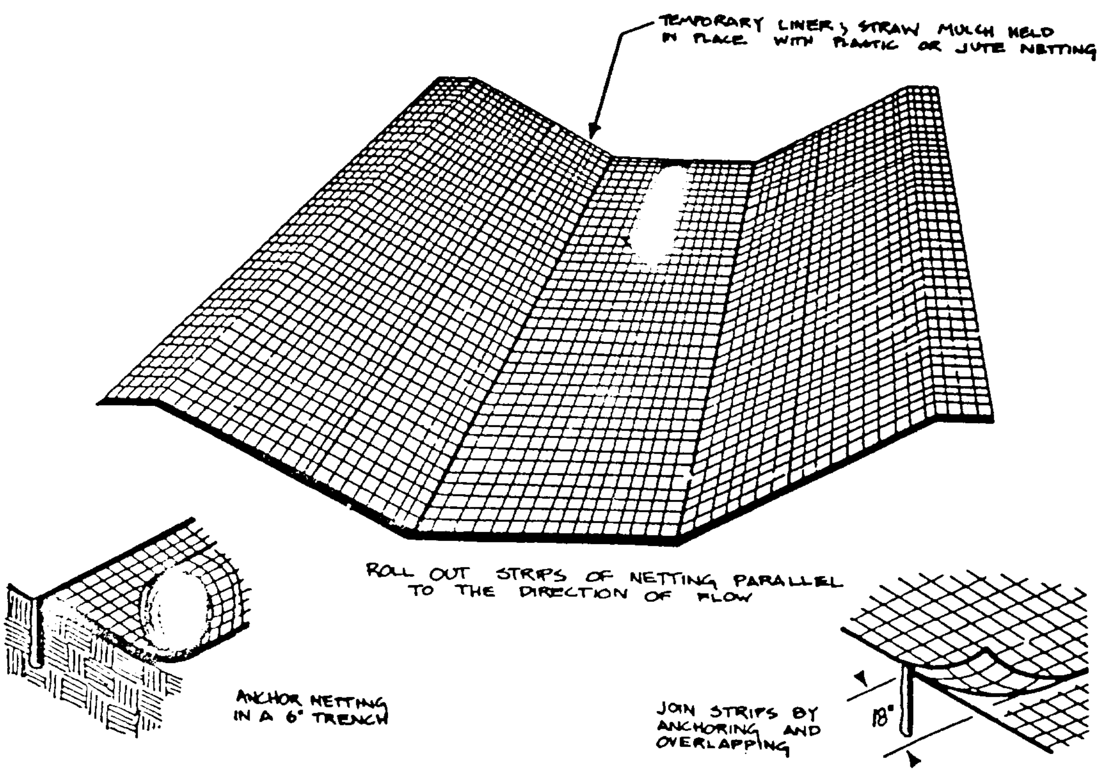
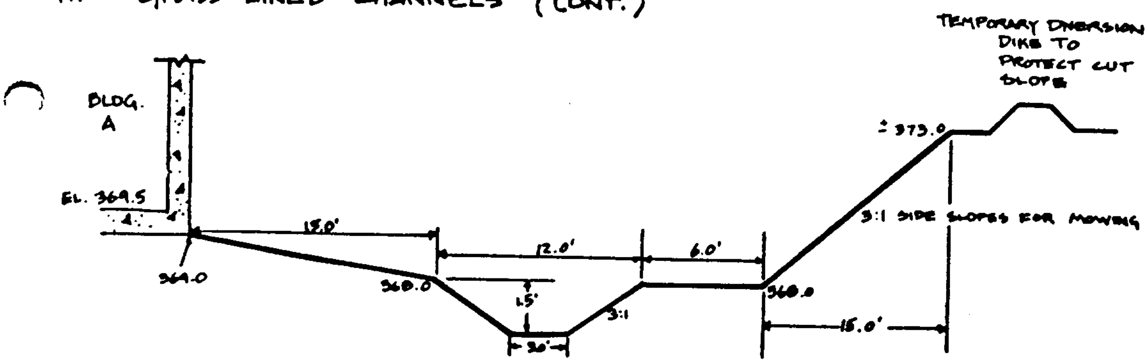
(10.) CONSTRUCTION SPECIFICATIONS

1. RAKE SOIL SURFACE TO BREAK GROUND CRUST ; LEAVE SURFACE UNIFORM AND WATER LIGHTLY.
2. LAY SOD IN A STAGGERED PATTERN AS SHOWN WITH STRIPS BUTTED TIGHTLY AGAINST EACH OTHER.
3. BUTTING — ANGLED ENDS CAUSED BY CUTTING MUST BE MATCHED CORRECTLY.
4. ROLL SOD TO PROVIDE FIRM SOIL CONTACT.
5. IRRIGATE UNTIL SOIL IS WET TO ABOUT 4" BELOW THE SOD.
6. KEEP SOD MOIST UNTIL SOD TAKES ROOT.

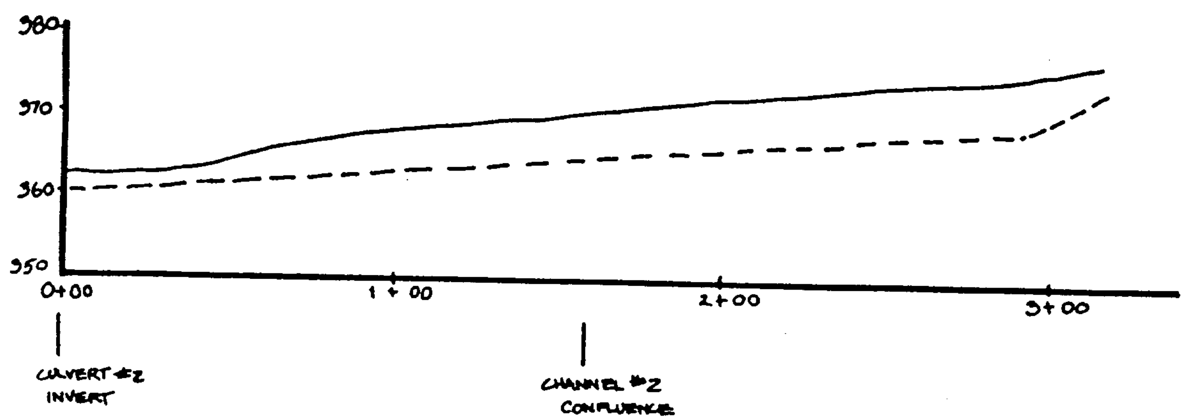
11. GRASS-LINED CHANNELS



11. GRASS-LINED CHANNELS (CONT.)



TYPICAL CROSS SECTION;
ALL CHANNELS (DEPTH AND TOP WIDTH WILL VARY BASED ON GROUND ELEVATION)



PROFILE – CHANNEL #1

CHANNEL #1
GRADE : 2%
LENGTH : 360'
BEGINNING GRADE EL : 359.5
– AT OUTLET-INVERT OF CULVERT #2

CHANNEL #2
GRADE : 1.75%
LENGTH : 230'
BEGINNING GRADE EL : 362.7
– AT INTERSECTION W/ CHANNEL #1

CHANNEL #3
GRADE : 1%
LENGTH : 450'
BEGINNING GRADE ELEVATION : 362.0
– CULVERT INVERT UNDER TERRI ROAD

CHANNEL #4
GRADE : 1.1%
LENGTH : 160'
BEGINNING GRADE EL. : 369.8
– AT OUTLET - EXISTING STABLE CHANNEL BOTTOM

(11.) CONSTRUCTION SPECIFICATIONS

1. EXCAVATE THE CHANNEL AND SHAPE IT TO AN EVEN CROSS-SECTION AS SHOWN. WHEN STAKING INDICATE A 0.2' OVERCUT AROUND THE CHANNEL PERIMETER FOR SILTING AND BULKING.

2. GRADE SOIL AWAY FROM CHANNEL SO THAT SURFACE WATER MAY ENTER FREELY.

3. APPLY LIME, FERTILIZER AND SEED TO THE CHANNEL AND ADJOINING AREAS IN ACCORDANCE WITH THE VEGETATION PLAN.

4. SPREAD STRAW MULCH AT THE RATE OF 100 LB/1000 FT^2.

5. HOLD MULCH IN PLACE IMMEDIATELY AFTER SPREADING WITH A PLASTIC NETTING INSTALLED AS SHOWN.

6. START LAYING THE NET FROM THE TOP OF THE UPSTREAM END OF THE CHANNEL AND UNROLL IT DOWN GRADE. DO NOT STRETCH NETTING.

7. BURY THE UPSLOPE END AND STAPLE THE NET EVERY 12" ACROSS THE TOP END, EVERY 3 FT. AROUND THE EDGES AND ACROSS THE NET SO THAT THE STRAW IS HELD CLOSELY AGAINST THE SOIL, HOWEVER, DO NOT STRETCH THE NETTING WHEN STAPLING.

8. NETTING STRIPS SHOULD BE JOINED TOGETHER ALONG THE SIDES WITH A 3" OVERLAP AND STAPLED TOGETHER.

9. TO JOIN ENDS OF STRIPS, INSERT THE NEW ROLL OF NET IN A TRENCH AS WITH UPSLOPE END AND OVERLAP IT 18" WITH THE PREVIOUSLY LAID UPPER ROLL. TURN UNDER 6" OF THE 18" OVERLAP AND STAPLE EVERY 12" ACROSS THE END.

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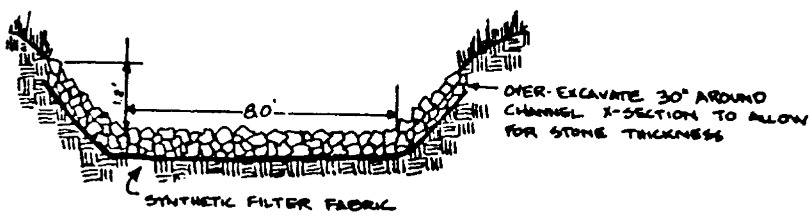
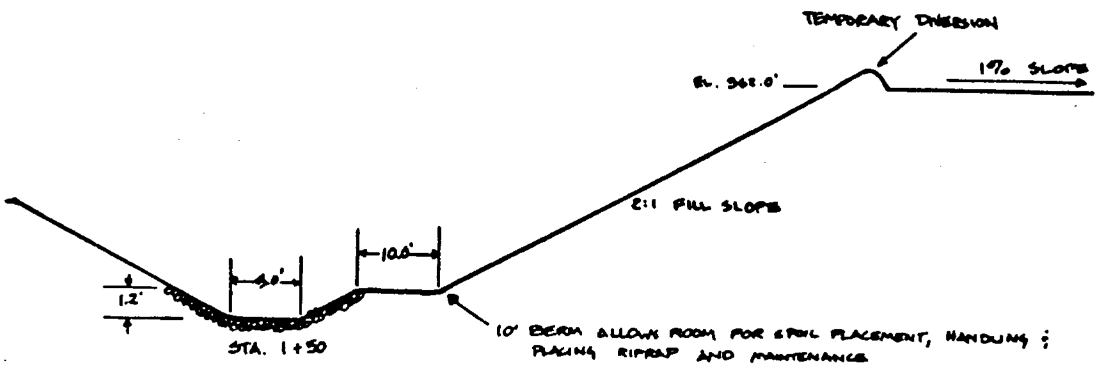
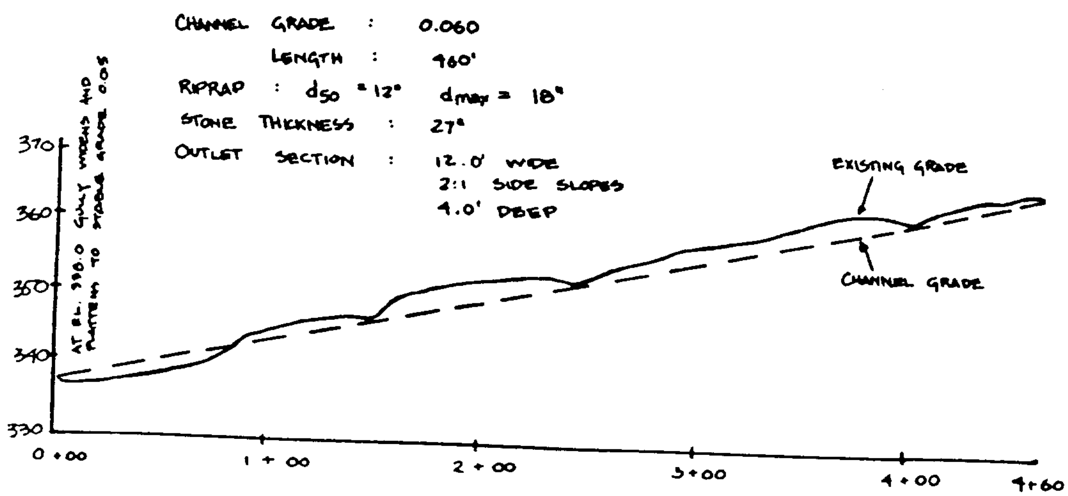
12. RIPRAP CHANNEL



TYPICAL CROSS SECTION



TYPICAL CROSS SECTION



CHANNEL PROFILE

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(12.) CONSTRUCTION SPECIFICATIONS

(1). CLEAR THE FOUNDATION OF ALL TREES, STUMPS, AND ROOTS.

2. EXCAVATE THE BOTTOM AND SIDES OF THE CHANNEL 30" BELOW GRADE AT ALL POINTS TO ALLOW FOR THE PLACEMENT OF RIPRAP AS SHOWN IN THE TYPICAL X-SECTION.

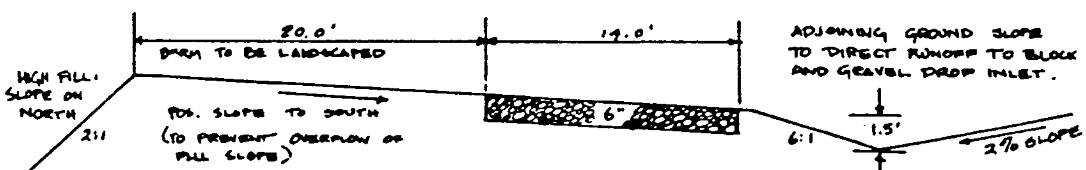
3. INSTALL EXTRA STRENGTH FILTER FABRIC ON THE BOTTOM AND SIDES OF THE CHANNEL FOUNDATION, PLACING THE UPSTREAM FABRIC OVER THE DOWNSTREAM FABRIC WITH AT LEAST A 1.0' OVERLAP ON ALL JOINTS. THE FABRIC IS TO BE SECURELY HELD IN PLACE WITH METAL PINS.

4. PLACE RIPRAP EVENLY TO THE LINES AND GRADES SHOWN ON THE DRAWINGS AND STAKED IN THE FIELD. RIPRAP TO BE PLACED IMMEDIATELY FOLLOWING THE INSTALLATION OF THE FILTER FABRIC.

5. RIPRAP TO MEET SPECIFICATION FOR D.O.T. CLASS 2 RIPRAP.

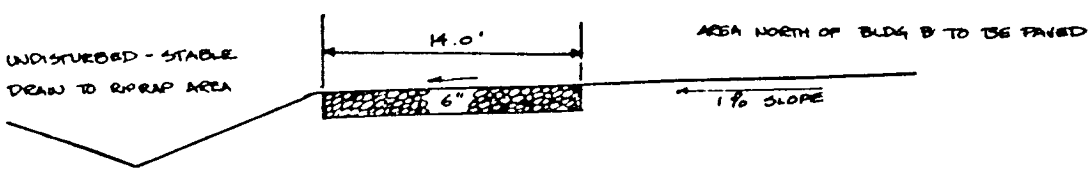
6. VEGETATE ALL DISTURBED AREAS FOLLOWING SPECIFICATIONS SHOWN IN THE VEGETATIVE PLAN.

13. CONSTRUCTION ROAD STABILIZATION



TYPICAL X-SECTION ENTRANCE ROAD

(TERRI RD. EAST TO CHANNEL #1)



TYPICAL X-SECTION ENTRANCE ROAD

(FROM CHANNEL #1 EAST TO EAST END OF BLDG. B)

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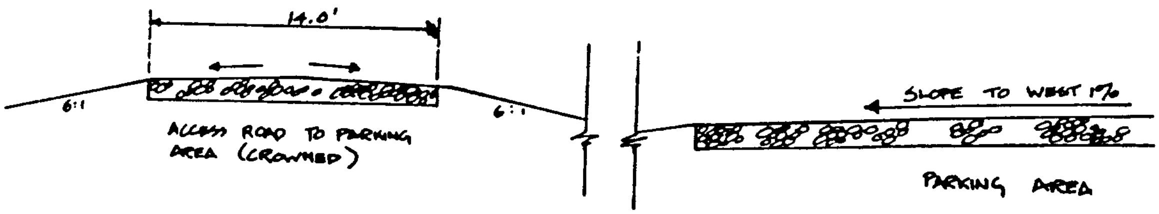
13. CONST. RD. STABILIZATION (CONT.)



TYPICAL CROSS-SECTION ACCESS ROAD

(13) CONSTRUCTION SPECIFICATIONS

1. CLEAR ROAD BED AND PARKING AREAS OF ALL VEGETATION, ROOTS AND OTHER OBJECTIONABLE MATERIAL.

2. PROVIDE SURFACE DRAINAGE AS SHOWN.

3. SPREAD 6" COURSE OF D.O.T. "ABC" CRUSHED STONE EVENLY OVER THE FULL WIDTH OF ROAD AND PARKING AREA AND SMOOTH TO AVOID DEPRESSIONS.

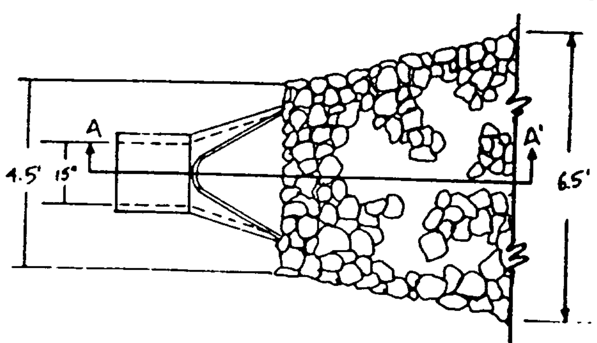
4. VEGETATE ALL DISTURBED AREAS ADJOINING ROADS AND PARKING AS SOON AS GRADING IS COMPLETE IN ACCORDANCE WITH THE VEGETATION PLAN.

14. OUTLET STABILIZATION STRUCTURES

OUTLET PROTECTION FOR CULVERT #1

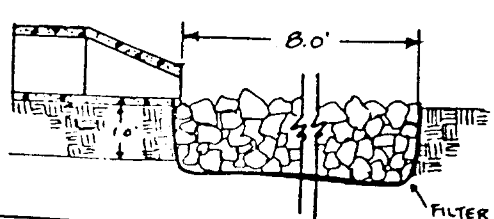
(FOR RIPRAP PROTECTION USE CLASS A OR CLASS B EROSION CONTROL STONE)

PLAN



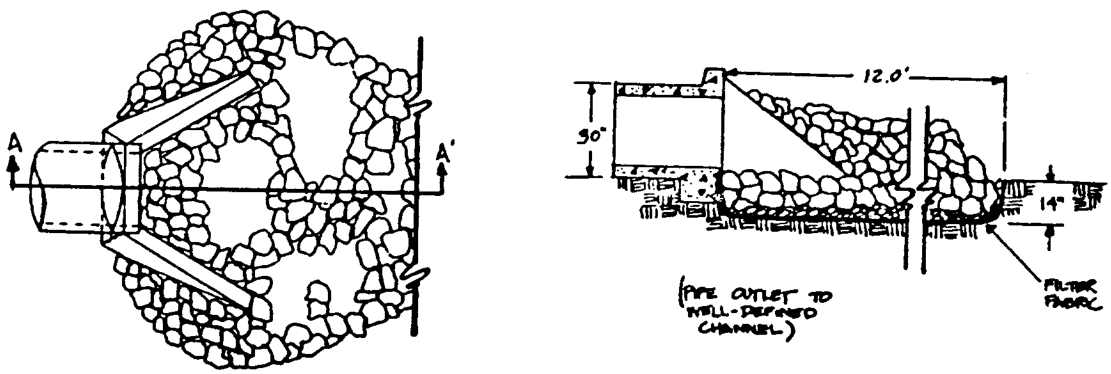
NOTE: APRON TO BE PLACED LEVEL WITH THE TOP SURFACE OF RIPRAP AT SAME LEVEL AS SURROUNDING LAND SURFACE — NO OVERFALL SHOULD EXIST.

SECTION A-A'



OUTLET PROTECTION FOR CULVERT #2

(LINE CHANNEL TO TOP OF BANKS FOR A DISTANCE OF 12.0' DOWNSTREAM. USE CLASS B EROSION CONTROL STONE.)



PLAN

SECTION A-A'

NOTE: APRON TO BE PLACED LEVEL WITH THE TOP SURFACE OF RIPRAP AT SAME ELEVATION AS SIDES AND BOTTOM OF CHANNEL. NO CHANNEL OVERFALL OR RESTRICTION IN CHANNEL CROSS-SECTION SHOULD EXIST.

(14.) CONSTRUCTION SPECIFICATIONS

1. EXCAVATE BELOW CHANNEL OUTLET AND WIDEN CHANNEL TO THE REQUIRED RIPRAP THICKNESS FOR EACH APRON. FOUNDATION TO BE CUT TO ZERO GRADE AND SMOOTHED.

2. PLACE FILTER CLOTH ON BOTTOM AND SIDES OF PREPARED FOUNDATION. ALL JOINTS TO OVERLAP A MINIMUM OF 1.0'.

3. EXERCISE CARE IN RIPRAP PLACEMENT TO AVOID DAMAGE TO FILTER FABRIC.

4. PLACE RIPRAP ON ZERO GRADE — TOP OF RIPRAP TO BE LEVEL WITH EXISTING OUTLET — NO OVERFALL AT ENDS.

5. RIPRAP TO BE HARD, ANGULAR, WELL GRADED CLASS B EROSION CONTROL STONE.

6. IMMEDIATELY AFTER CONSTRUCTION STABILIZE ALL DISTURBED AREAS WITH VEGETATION AS SHOWN IN VEGETATIVE PLAN.

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15. SURFACE ROUGHENING

A. — 2:1 FILL SLOPE

1. PLACE FILL IN LIFTS NOT TO EXCEED 9" AND COMPACT.
2. LEAVE FACE OF FILL SLOPE LOOSE AND UNCOMPACTED — 4-6" DEEP — DO NOT BACK BLADE IN FINAL GRADING.
3. GROOVE ON CONTOUR — GROOVES APPROX. 3" DEEP + 12" APART.
4. VEGETATE IMMEDIATELY AFTER GROOVING.

B. — 3:1 CUT SLOPE

1. GROOVE BY DISCING TO EVEN SURFACE FOR MAINTENANCE BY MOWING.
2. GROOVES APPROX. 1" - 2" DEEP AND 10" APART.
3. VEGETATE IMMEDIATBLY AFTER DISCING. SEE VEGETATIVE PLAN.

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VEGETATIVE PLAN

Seedbed Preparation (SP)

SP-1 Fill slopes 3:1 or steeper to be seeded with a hydraulic seeder (permanent seedings)

1) Leave the last 4-6 inches of fill loose and uncompacted, allowing rocks, roots, large clods and other debris to remain on the slope.

2) Roughen slope faces by making grooves 2-3 inches deep, perpendicular to the slope.

3) Spread lime evenly over slopes at rates recommended by soil tests.

SP-2 Fill slopes 3:1 or steeper (temporary seedings)

1) Leave a loose, uncompacted surface. Remove large clods, rocks, and debris which might hold netting above the surface.

2) Spread lime and fertilizer evenly at rates recommended by soil tests.

3) Incorporate amendments by roughening or grooving soil surface on the contour.

SP-3 High-maintenance turf

1) Remove rocks and debris that could interfere with tillage and the production of a uniform seedbed.

2) Apply lime and fertilizer at rates recommended by soil tests; spread evenly and incorporate to a depth of 2-4" with a farm disk or chisel plow.

3) Loosen the subgrade immediately prior to spreading topsoil by disking or scarifying to a depth of at least 2 inches.

4) Spread topsoil to a depth of 2-4 inches and cultipack.

5) Disk or harrow and rake to produce a uniform and well-pulverized surface.

6) Loosen surface just prior to applying seed.

SP-4 Gentle or flat slopes where topsoil is not used.

1) Remove rocks and debris.

2) Apply lime and fertilizer at rates recommended by soil tests; spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.

3) Break up large clods and rake into a loose, uniform seedbed.

4) Rake to loosen surface just prior to applying seed.

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Seeding Methods (SM)

SM-1 Fill slopes steeper than 3:1 (permanent seedings)

Use hydraulic seeding equipment to apply seed and fertilizer, a wood fiber mulch at 45 lb/1,000 ft^2, and mulch tackifer.

SM-2 Gentle to flat slopes or temporary seedings

1) Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.

2) Rake seed into the soil and lightly pack to establish good contact.

Mulch (MU)

MU-1 Steep slopes (3:1 or greater)

In mid-summer, late fall or winter, apply 100 lb/1,000 ft^2 grain straw, cover with netting and staple to the slope. In spring or early fall use 45 lb/1,000 ft^2 wood fiber in a hydroseeder slurry.

MU-2 High-maintenance vegetation and temporary seedings

Apply 90 lb/1,000 ft^2 (4000 lb/acre) grain straw and tack with 0.1 gal/yd^2 asphalt (11 gal/1,000 ft^2).

MU-3 Grass-lined channels

Install excelsior mat in the channel, extend up the channel banks to the highest calculated depth of flow, and secure according to manufacturer's specifications.

On channel shoulders, apply 100 lb/1,000 ft^2 grain straw and anchor with 0.1 gal/yd^2 (11 gal/1,000 ft^2) asphalt.

Maintenance (MA)

MA-1 Refertilize in late winter or early spring the following year. Mow as desired.

MA-2 Keep mowed to a height of 2-4 inches. Fertilize with 40 lb/acre (1 lb/1,000 ft^2) nitrogen in winter and again the following fall.

MA-3 Inspect and repair mulch and lining. Refertilize in late winter of the following year with 150 lb/acre 10-10-10 (3.5 lb/1,000 ft^2). Mow regularly to a height of 3-4 inches.

MA-4 Topdress with 10-10-10 fertilizer if growth is not fully adequate.

MA-5 Topdress with 50 lb/acre (1 lb/ 1,000 ft^2) nitrogen in March. If cover is needed through the following summer, overseed with 50 lb/acre Kobe lespedeza.

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TABLE 1: VEGETATIVE PLAN[1]

Area No.[2]	Description	Season[3]	Seeding Mixture: Permanent lb/ac	Seeding Mixture: Temporary lb/ac	Seedbed Preparation	Seeding Method	Mulch	Maintenance	Notes
1	Steep slopes (3:1); low maintenance	Spring or fall	Tall fescue 100 Kobe lespedeza 10 Bahiagrass 25 Rye grain 40		SP-1	SM-1	MU-1	MA-1	Permanent mixture also used for low-maint. areas (4). Overseed winter plantings of rye with Kobe lespedeza in March if grading is not complete.
		Summer		German millet 40	SP-2	SM-2		MA-5	
		Winter		Rye grain 120					
2	High-maintenance turf	Spring		Rye grain 120 Kobe lespedeza 50	SP-3	SM-2	MU-2	MA-4	Tall fescue can be seeded in spring - increase rate to 250 lb/ac. Temp. seeding for fall is the same as for winter.
		Summer		German millet 40					
		Fall	Tall fescue blend 200					MA-2	
		Winter		Rye grain 120				MA-5	
3	Grassed channels with side slopes 3:1	Fall – Spring	Tall fescue 200 Rye grain 40		SP-4	SM-2	MU-3	MA-3	
		Summer	Tall fescue 200 German millet 10						
4	Low-maintenance areas	Spring or Fall	Tall fescue 100 Kobe lespedeza 10 Bahiagrass 25 Rye grain 40		SP-4	SM-2	MU-2	MA-1	For temporary seeding in spring or fall see 5 below.
		Summer	Tall fescue 100 Kobe lespedeza 10 Bermudagrass 15 German millet 10					MA-5	Use these specs for temporary diversions
		Winter		Rye grain 120					
5	Areas requiring cover for less than 1 year	Spring		Rye grain 120 Kobe lespedeza 50	SP-4	SM-2	MU-2	MA-4	Treat temporary diversion as low-maintenance, permanent (area 4)
		Summer		German millet 40					
		Fall & Winter		Rye grain 120 Kobe lespedeza 50				MA-5	Include topsoil stockpiles here

1 Column entries for seedbed preparation, seeding method, mulch, and maintenance refer to Attachment 1.
2 Area numbers are designated on map.
3 Spring (Feb. 1 - Apr. 15), Summer (Apr. 15 - Aug. 20), Fall (Aug. 20 - Oct. 25), Winter (Oct. 25 - Jan.).

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SECTION 7
MAINTAINING EROSION AND SEDIMENT CONTROL MEASURES

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Prepared by:

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Maintaining Vegetative Measures

Maintaining vegetation for soil protection or other uses is needed to keep the system functioning. Proper maintenance defers or prevents impairment of plant cover. It is usually less costly to carry on a maintenance program than it is to make repairs after prolonged neglect.

Maintenance should occur on a regular basis, consistent with favorable plant growth, soil and climatic conditions. This involves regular seasonal work for mowing, fertilizing, liming, watering, pruning, fire controls, weed and pest control, reseeding and timely repairs. It also requires prompt removal of debris, protection of vegetation from unintended uses or traffic and special attention to critical areas. Well maintained vegetation provides a comfortable margin of reserve that will carry through emergencies. A preventive maintenance program anticipates requirements and accomplishes work when it can be done with the least effort and expense.

The degree of preventive maintenance depends upon the category of vegetation and land: improved, semi-improved and unimproved grounds. Greater maintenance is required for improved grounds than unimproved grounds. Regardless of the category, vegetative cover requires a certain degree of management or the desired function of the vegetation will be defeated.

Mowing is a recurring practice and its intensity depends upon the function of the ground cover. On improved areas, such as lawns, certain recreation fields and picnic areas, mowing will be frequent. On semi-improved areas, mowing will be less frequent. On unimproved areas, mowing may occur once every three years as required to eliminate invading woody vegetation.

The application of fertilizer will follow a like pattern. On improved areas, fertilizer amounts should be in sufficient quantities to keep cover healthy and vigorous without over stimulation of growth. On semi-improved grounds, the rate of fertilizer application is usually about 1/2 the rate applied on improved areas. Unimproved areas should receive limited fertilizer applications as required to produce enough growth to prevent undue erosion.

Lime should be applied to maintain the desired level of soil reaction. On improved grounds, amounts of lime may be applied to maintain the optimum pH range. On semi-improved and unimproved areas, the pH may be maintained at a lower level than optimum.

Weeds and brush frequently invade grass cover as a direct result of inadequate maintenance. Amount of weeds or brush that can be tolerated in any protective planting depends upon the land category and its intended use. On improved areas few or no weeds or undesirable brush should be tolerated. This tolerance may become proportionately greater as land category declines. Drainageways are subject to rapid infestation of weeds and woody plants. These should be eradicated or cut back since they often reduce drainageway efficiency. Control of weeds or brush is accomplished by using herbicides, mechanical methods, soil sterilants and, perhaps, selective removal by hand.

Pest and disease control requirements are usually more intensive on improved areas. Most insects, such as grubs, army worms, beetles and ants, feed on grass roots, stems and leaves and may cause considerable damage in a short period of time if not controlled early. Rodents, such as field mice, moles, and woodchucks, may damage vegetation and create hazards by burrowing and throwing up mounds on earthen structures. Insects and rodents should be kept under reasonable control.

Diseases of herbaceous and woody plants are usually of minor importance where adapted species have been used and reasonably good management is practiced.Trees that have been destroyed by disease or seriously damaged by insects should be removed. Removal of such trees is essential because diseases and insect infestations will likely spread to other plants.

Dry vegetation constitutes a fire hazard. The taller the vegetation, the greater the hazard. Herbaceous vegetation on improved ground may be less subject to serious fire since it is kept well mowed and probably well watered. Tree and shrub areas on improved ground also undergo fairly intensive management. Debris, such as fallen trees and branches, is usually removed without undue delay and litter is occasionally cleared away. These practices reduce fire hazards considerably. On unimproved grounds, vegetation is usually allowed to grow tall. Mowing and removing residue on occasion may help prevent fires in such areas. In g-neral, grass fires in New York State are not critical. Judicious care, consistent with land category and purpose of vegetation usually will help prevent fires.

Temporary seedings should be inspected every 30 days. Areas damaged should be reseeded and remulched.

Protective coverings and their anchoring methods should be inspected to determine whether or not the cover is in place at the proper density and properly anchored. Where commercially available netting of either paper and plastic or jute mesh is applied, check for damage by vandalism, fire or loss of anchoring. All areas should be inspected to determine if rilling is occurring beneath the protective cover. Where this is occurring, the area should be regraded and recovered.

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Maintaining Structural Measures

Structural measures must be maintained to be effective. In general, these measures must be periodically inspected to insure structural integrity, detect vandalism damage, and for cleaning and repair whenever necessary. During construction, all structures should be inspected weekly and after every rain. After construction, inspections should be made at least semi-annually and after every heavy rain.

An improperly applied control measure, or one that is not properly maintained, invites failure and can create more damage than if no measures had been taken. One excellent time to check on the performance of all project control measures is during a rainstorm. The experience gained by this type of inspection is valuable to both the contractor and the project inspection team.

A comprehensive program should be outlined for the use of those who have maintenance responsibility. Maintenance items should include, but not be limited to, those shown for each of the following measures.

Sediment Basins

The most obvious maintenance required for these structures is the requirement for periodic cleanout. Cleanout may be done after one foot of silt is deposited or, in instances where proper hydraulics can be maintained, as much as 50 percent of capacity may be filled before cleanout is necessary.

Temporary pool outlets constructed of filter fabric covered stone should be inspected for tears in the fabric or clogging of the filter cloth with silt or debris. Silt can be removed from woven filter cloth with a stiff brush.

Embankments must be inspected for cracks, excessive seepage, rodents and undesirable vegetative growth. The principal and emergency spillways must be cleaned of obstructions and inspected for structural integrity. The outlets below the spillways must be inspected for erosion and obstructions to flow removed.

Diversions and Channels

The various types of temporary and permanent diversions and channels perform similar functions and must be maintained to insure that they perform satisfactorily. The channel cross-section must be inspected to insure that the side slopes remain stable. Check for points of scour, rodent holes, and breaches. The channel bottom must be inspected for erosion or excessive scour, deposition of sediment or other obstructions. If the channels are lined, the linings should be checked for structural integrity. Cracking, spalling, or other physical deterioration of the lining must be repaired. Inlets and outlets are to be checked to insure that they remain adequate, show no sign of erosion or loss of structural integrity.

Grade Stabilization Structures

Temporary structural measures of reducing velocities include barriers of hay or straw bales, brush or brush and fabric, and fabric and fence. Permanent check dams of timber, timber and stone, concrete or sheet piling are also utilized. In all instances it is important that the structure: (1) maintain its integrity, (2) is not by passed by an erosion channel, and (3) does not develop excessive scour at its base or excess sediment at its top.

Lined Waterway or Outlet

Channel linings other than vegetation must be inspected for undermining, cracking, spalling, plugging of weep holes, and channel obstructions. Inlets and outlets should be inspected for scour and obstructions.

Lining of channel sidewalls and floor by stone, concrete or fabric are common stabilization practices. Temporary channels may be lined by fabric or plastic which should be properly anchored. Check anchoring and inspect the fabric or plastic for tears. Permanent linings must be inspected for integrity, protection replaced where necessary and the channel cleared of debris and obstructions. Inlet and outlet areas should be checked for scour.

Traffic Control

Where markers or fencing are utilized for traffic control, inspect periodically to insure that they are properly placed, and functioning properly. Traffic must be kept off all structural erosion control measures at all times. Where traffic must cross a structural measure, a crossing should be constructed.

Pollution Control During Construction

Inspect to insure that dust control measures are utilized, where necessary. All maintenance work on equipment should be done in a safe area. Maintenance items such as cans, boxes, and cartridges should be stored in a suitable building. Following use, all such items should be disposed of in a safe manner and at a suitable site.

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SECTION 8
GUIDELINES FOR ESTIMATING SEDIMENT YIELDS FOR URBAN CONSTRUCTION AREAS

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GUIDELINES FOR ESTIMATING SEDIMENT YIELDS FOR URBAN CONSTRUCTION AREAS

1. An approximation of the quantities of sediment yield resulting from uncontrolled urban construction activities can be made by use of an equation. The values thus obtained can be useful in estimating the sediment capacity requirements needed for desilting basins or sediment traps.

2. The equation does not provide for quantities of sediment contributed through bedload movement. Volumes of bedload sediment are assumed to be equal to the quantity of suspended sediment carried through the structure outlet; therefore, the trap efficiency of the structure is not computed.

3. The results obtained by use of the equation may be applied generally in New York State only after an adjustment is made to reflect the variation in rainfall and erosion potential of soils within the region.

   To accomplish this, iso-erodent values for various areas are obtained from Figure 8-1[1]. Correction values to be used in the equation for different iso-erodent values are given in Table 8.1.

   Also, the average value of 60 pounds per cubic foot of submerged sediment is used in converting tons to acre feet for sediment storage design purposes (60 pounds per cubic foot equals 1320 tons per acre foot).

Table 8-1

Iso-Erodent Value	Correction Factor Used in Equation
300	1.56
250	1.47
200	1.34
150	1.12
125	0.94
100	0.76
75	0.57

4. The equation was derived from a limited amount of data obtained by short term measurements. Therefore, it is considered to be of a tentative nature and subject to change.

   The equation relates sediment yield to the area under construction as follows:

   $$V = ((C \times A)/1320) \times (222{,}000/A)^{0.715}$$

   Where: V = acre feet, required sediment storage per year.

   A = uncontrolled drainage area under construction expressed in square miles.

   C = iso-erodent correction factor.

Example:

Given: Drainage area of a site under construction equals 0.5 square miles (320 acres). For areas within the range of iso-erodent value 100, the correction for use in equation is 0.76 (see Table 6.1)

Equation is:

$$V = ((C \times A)/1320) \times (222{,}000/A)^{0.715}$$
$$= ((0.76 \times 0.5)/1320) \times (222{,}000/0.5)^{0.715}$$
$$= 0.000288 \times (444{,}000)^{0.715}$$
$$= 0.000288 \times 10{,}898$$
$$= 3.14 \text{ acre-feet}$$

The present form of the equation is designed for use within the general area of New York State. One of the factors in this equation is limited to a range of conditions generally predominating in this area and another factor is limited to a specific condition.

The factors referred to are "C" and "1320" in the portion of the equation represented by the term (CA/1320).

The factor "1320" represents tons per acre foot of sediment having an average dry weight of 60 pounds per cubic foot.

Figure 8.2, page 8.4 is useful in determining the appropriate tons per acre foot factor for use in the equation according to various dry unit weights of sediments.

For example in an area where the average dry weight of sediments is 50 pounds per cubic foot, the factor used in the equation would be 1080 tons per acre foot.

The following sources of information and data were used in analyzing sediment yield from urban construction areas. The data include yields from housing developments, industrial and commercial sites, and highway construction areas:

SCS Sedimentation Survey of Wilde Lake, Columbia, Maryland, unpublished. (Form SCS-34, Reservoir Sedimentation Survey, on file at NTC, SCS, Chester, Pennsylvania.)

Dawdy, David R. Knowledge of Sedimentation in Urban Environments, Journal of the Hydraulics Division, ASCE, Volume 93, No. HY-6, Proc. Paper 5595, November 1967, pp. 235-245.

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Vice, R.B., Guy, H.P., and Ferguson, G.E. Sediment Movement in an Area of Suburban Highway Construction, Scott Run Basin, Fairfax County, Virginia, 1961-1964, USGA Water Supply Paper 1591-E, 1969.

Guy, H.P., Ferguson, G.E. Sediment in Small Reservoirs Due to Urbanization, Journal of the Hydraulics Division, ASCE, Volume 88, No. HY-2, Proc. Paper 3070, March 1962, pp. 27-37.

Leopold, Luna B. Hydrology for Urban Land Planning - A Guidebook on the Hydrologic Effects of Urban Land Use, USGS Circular 554, 1968. FIGURE 6.2 Soil Weight Conserion Chart

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FIGURE 8.1
Average Annual Iso-Erodent Values

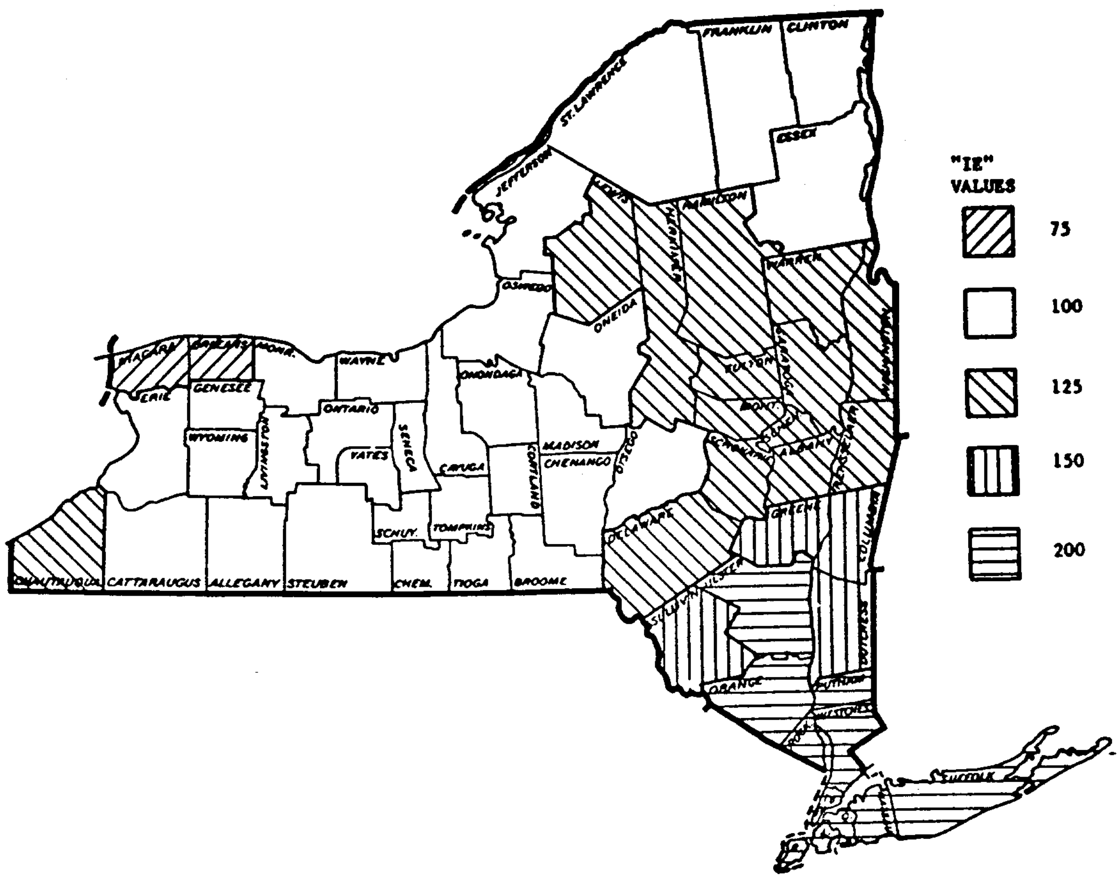
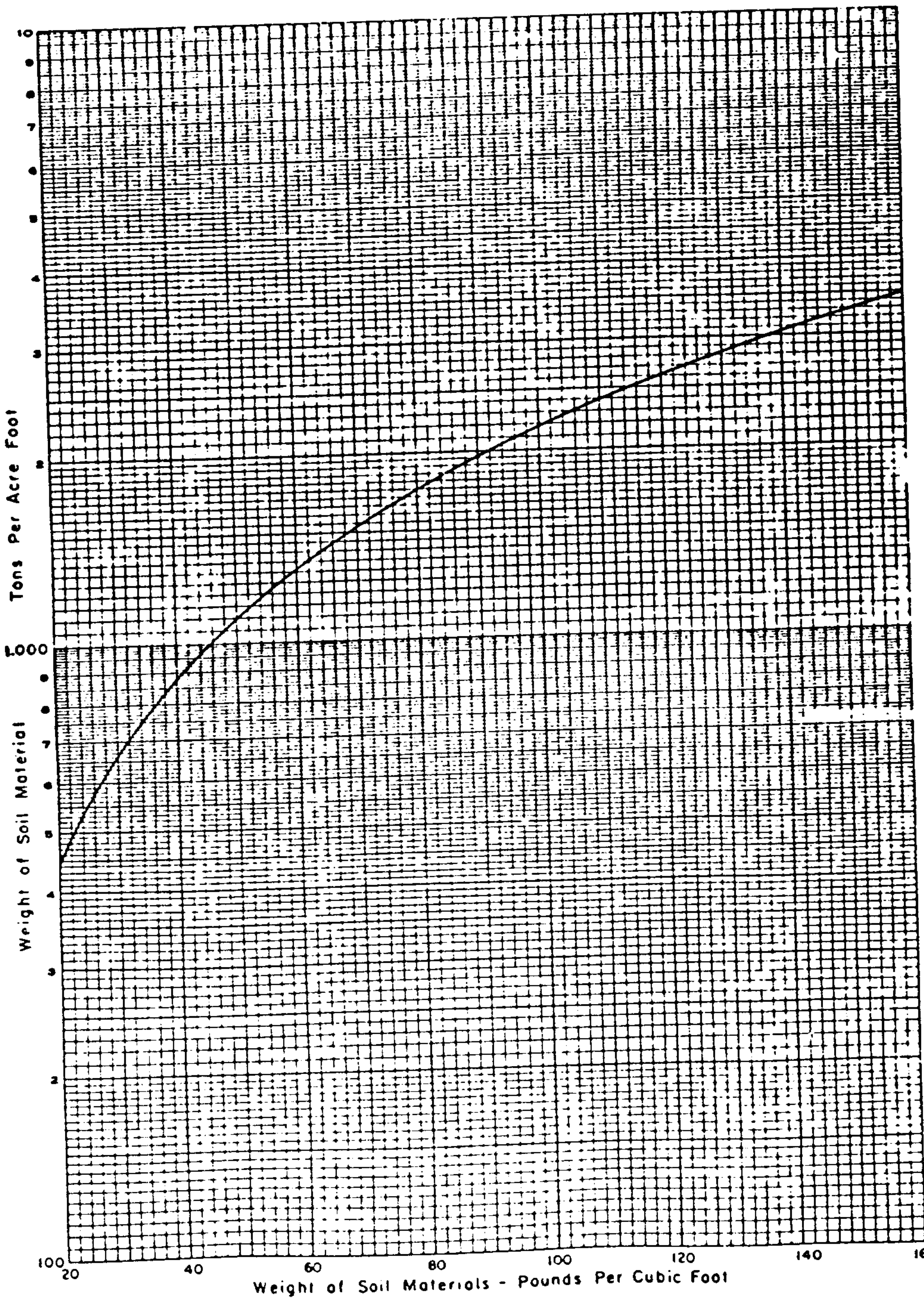


FIGURE 8.2
Soil Weight Conversion Chart



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SECTION 9
BENEFIT-COST GUIDELINES

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BENEFIT-COST GUIDELINES

Analyzing Benefits and Costs

Benefit-Cost Analysis is a technique to determine whether the measure will result in more benefits than it will cost.

For the purposes of making a benefit-cost analysis, the time period associated with erosion and sedimentation is considered to extend from the first disturbance of the land up to the time of establishing effective erosion control.

Ascribing Effects to Treatment Measures

The generally accepted basis for attributing effects of treatment measures on a comparable basis is the "with" and "without" approach. The approach compares the expected difference in damages between what is expected if no controls are used and what is expected if a measure is installed. The total difference in expected damage is the estimated benefit of the measure.

Sediment damages may be related to (1) deposition of eroded materials on flood plains, in channels, reservoirs, residences, utilities and other properties that require the removal and disposition of materials, and the repairing of damaged facilities and (2) swamping damage which adversely affects existing features or limits potential improvement of land caused by a rise in the ground water table or by impairing surface drainage.

Sediment resulting from construction sites could be deposited along a stream and cause individual landowners to pay for its removal. Sediment could also destroy aesthetic values of a stream (clean water vs muddy water) and adversely impact on stream fisheries and micro-organisms.

In municipal and industrial uses where water is pumped directly from a river or reservoir, slugs of sediment associated with excessive rainfall may pose severe water quality problems. Turbidity may be increased, necessitating increased treatment which raises the cost of operations. Sediment may also be deposited in storm drains, reducing their ability to control flooding. This increases flood damage and requires the cleanout of sediment from the storm drain systems.

Pricing Treatment Measures and Benefits

Prices applied should reflect values expected to prevail at the time of occurrence. Current prices are used for installation costs of treatment measures. Projected normalized prices (based on past prices and trends) should be used for estimating future values (benefits, operations and maintenance costs and replacement costs) for permanent type measures only.

Period of Analysis and Evaluation

The period of analysis in years should equal the economic life (need for a measure) or the physical life of treatment measures, whichever is less. The benefits considered over the evaluation period include those accruing over the period.

The annual costs of permanent measures chargeable to the evaluation period include the amortized installation costs and the future annual operation, maintenance and replacement costs necessary to provide the benefits over the evaluation period. The amortization rate should be based of prevailing local interest rates at the time of installation.

Appraisal of Damages and Treatment Costs

Many people are affected by the damages resulting from erosion and sedimentation. Also, many persons are benefited by its prevention, reduction or mitigation.

Costs will be incurred to: (1) install treatment measures; or (2) correct damages; or (3) a combination of the two.

Treatment Measures

Treatment measures on developing sites are frequently temporary - generally lasting only one or two construction seasons. Benefits and costs for temporary measures can be compared directly using current prices.

Permanent measures are planned to trap sediment and control erosion and runoff during and beyond the construction period. The prevention of sediment damages can be accomplished by either or both of two methods:

1. Stabilizing sediment source areas by applying conservation erosion control measures.
2. Trapping sediment before it leaves the construction area.

Some of the potential benefits from preventing downstream sediment transport and deposition include:

1. Prevention or reduction in cost of removal and disposition of sediment from properties.
2. Prevention or reduction in damage to property.
3. Prevention of water quality impairment.

Some permanent measures may be retained to provide long-term benefits.

For example, a sediment basin may be cleaned out after construction is finished and utilized for aesthetics, recreation or fish.

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Benefits and costs for permanent measures need to be converted by discounting and amortizing to average annual figures for comparison.

Benefit-Cost Analysis

A simple equation for determining the benefits of controlling sediment is:

$$B = (S \times Y) - [C + (S \times Y)(1.00 - P)]$$

Where: B = Benefits in dollars.

S = Cubic yards of sediment expected to move off the site if no control measures are applied.

Y = Cost in dollars per yard to recover and dispose of sediment that has moved off the site.

C = Estimated cost of temporary measures to be installed.

P = Estimated effectiveness of proposed measures expressed as a decimal.

Example

This example illustrates the methodology of a benefit-cost analysis:

Given: A construction site of 78 acres, which without erosion control measures will yield about 5 acre feet or 8,000 cubic yards of sediment (S) to the lower end of the site. There is a channel with several culverts located below the site and it is assumed all the sediment would be deposited in it. It would be necessary to remove all the additional sediment in order to maintain the capacity of the channel and avoid increased hazard to flooding. The cost of removing and disposing the sediment is estimated at $2.00 per cubic yard (Y).

With temporary erosion control measures, including a sediment basin, in place during the one year construction period, sediment delivered to the channel will be reduced 90 percent (P). The cost of the measures would be as follows, (no amortization is required since costs and benefits are incurred in a similar one year period):

1. Land grading measures $2,000
2. Temporary sediment basin............... $3,000

a. Construction..........$1,500
b. Maintenance..........$1,000
c. Restoration............$500

Total Cost (C).........$5,000

The "without treatment" condition reveals damages in the form of costs to remove sediment. Benefit (costs saved) are derived by subtracting the sediment removal costs under the "with treatment" condition.

1. Without treatment condition
   8,000 cu. yd.(S) x $2.00/cu. yd.(Y) = $16,000(SxY)
2. With treatment condition
   a. Costs (C) described above = ...$5,000
      will control 7,200 cu. yd. (SxP) of the sediment
   b. Removal costs for remaining 800 cu.yd.
      800 x $2.00 = ...$1,600
   c. Total = $6,600
3. Benefits
   $16,000 - $6,600 = ...$9,400 (B)

Using the formula directly, the computations show the same results:

$$B = (S \times Y) - [c + (S \times Y)(1.00 - P)]$$

$$B = (\$8,000 \times 2.00) - [(\$5,000 + (8,000 \times 2.00)(1.00 - 0.90)]$$

$$B = (\$16,000) - (\$5,000 + 1,600)$$

$$B = (\$16,000) - (\$6,600)$$

$$B = \$9,400$$

In this example, the more economical approach would be to install treatment measures rather than correct damages at a later date. A third alternative would be "do nothing" which would result in a higher flood damage hazard that would need evaluation under a more sophisticated analytical model. **Also, in this simple example, water quality issues were not included although society in general, places a value on such issues.**

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3. Soil Conservation Service, USDA. June 1986. Urban Hydrology for Small Watersheds, Technical Release 55, Second Edition, U.S. Government Printing Office, Washington, D.C.
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SECTION 10
ESTIMATING URBAN RUNOFF

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ESTIMATING URBAN RUNOFF

INTRODUCTION

The increased amount of erosion occurring with the conversion of rural land to urban greatly depends on the amount of runoff that occurs. This section addresses what influences runoff and how the volume and rate of runoff is determined. The method and most of the material is reprinted from Urban Hydrology for Small Watersheds[1], TR-55, Soil Conservation Service, June 1986.

FACTORS AFFECTING RUNOFF

Rainfall

Precipitation, whether it occurs as rain or snow, is the potential source of water that may run off the surface of small watersheds. The extent of the storm and the distribution of rainfall during the storm are two major factors which affect the peak rate of runoff.

The storm distribution can be thought of as a measure of how the rate of rainfall (intensity) varies within a given time interval. For example, in a given 24-hour period, a certain amount of precipitation may have been measured. However, this precipitation may have occurred over the entire 24-hour period or in just one hour. These two situations represent two entirely different storm distributions.

The size of the storm is often described by the length of time over which precipitation occurs, the total amount of precipitation occurring and how often this same storm might be expected to occur (frequency). Thus a 10-year, 24 hour storm can be thought of as a storm producing the amount of rain in 24 hours with a 10% chance of occurrence in a year. One day (24 hour) rainfall maps are listed as Exhibit 10.1 at the end of this section for 2, 5, 10, 25, 50 and 100 year frequencies.

Antecedent Moisture Condition

The runoff from a given storm is affected by the existing soil moisture content resulting from the amount of precipitation occurring during the preceding five days (antecedent moisture condition).

Watershed Area

The watershed area or area draining water to the point of interest is usually determined from a topographic map or scaled areal photograph accompanied by a field review locating manmade features that have diverted the flow of water.

Soils

In general, the higher the rate of infiltration, the lower the quantity of stormwater runoff. Fine-textured soils such as clay produce a higher rate of runoff than do coarse-textured soils such as sand. Sites having clay soils may require the construction of more elaborate drainage systems than sites having sandy soils. Exhibit 10.2 contains a list of soils found in New York State and their respective hydrologic soil group.

Surface Cover

The type of cover and its condition affects runoff volume through its influence on the infiltration rate of the soil. Fallow land yields more runoff than forested or grass land for a given soil type.

The foliage and its litter maintain the soil's infiltration potential by preventing the sealing of the soil surface from the impact of the raindrops. Some of the raindrops are maintained on the surface of the foliage, increasing their chance of being evaporated back to the atmosphere. Some of the intercepted moisture is so long draining from the plant down to the soil that it is withheld from the initial period of runoff. Foliage also transpires moisture into the atmosphere thereby creating a moisture deficiency in the soil which must be replaced by rainfall before runoff occurs. Vegetation, including ground litter, forms numerous barriers along the path of the water flowing over the surface of the land which slows the water down and reduces its peak rate of runoff.

Covering areas with impervious material reduces surface storage and infiltration and thus increases the amount of runoff.

Time Parameters

Time is the parameter that is used to distribute the runoff into a hydrograph. The time is based on the velocities of flow through segments of the watershed. The slope of the land in the watershed is a major factor in determining the velocity. Two major parameters are time of concentration (T_c) and travel time of flow through the segments (T_t).

Storage in the Watershed

On very flat surfaces where ponding or swampy areas occur throughout the watershed, a considerable amount of the surface runoff may be retained in temporary storage, thus reducing the rate at which runoff will occur. Storage areas may be created to reduce the rate of runoff in an urbanizing area. These can be effective sediment traps as well as flood detention structures if left permanently in the watershed.

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METHODS OF DETERMINING RUNOFF

Many different methods of computing runoff have been developed. Some of the methods and limitations of each are listed below.

1. The Rational Method establishes an empirical formula, Q = CiA, for computing peak rates of runoff that is commonly used in urban areas. "Q" is the peak runoff rate in cfs, "C" is a runoff coefficient, "i" is the average rainfall intensity in in./hr. and "A" is the drainage area in acres. It is useful for estimating runoff on relatively small areas such as roof tops, parking lots, or others. According to Practices in Detention of Urban Stormwater[2], American Public Works Association Special Report # 43, "use of the rational equation should be limited to drainage areas of less than 20 acres." However, some practitioners totally deplore use of the Rational Method even on the smallest of drainage areas. The most serious drawback of the Rational Method is that it gives only peak discharge and provides no information on the time distribution of the storm runoff. Furthermore the choice of "C" and Time of Concentration "T_c" when choosing "i" in the Rational Method is more an art of judgment than a precise account of the antecedent moisture or a real distribution of rainfall intensity[3]. Modifications of the Rational Method have similar limitations.

2. Computer Program for Project Formulation-Hydrology,[4] SCS-TR-20, utilizes hydrologic soil-cover complexes to determine runoff volumes and unit hydrographs to determine peak rates of discharge. Factors included in the method are 24-hour rainfall amount, a given rainfall distribution, runoff curve numbers, time of concentration, travel time, and drainage area. This procedure probably should not be used for drainage areas more than 20 square miles. It is very useful for large drainage basins especially when there are a series of structures or several tributaries to be studied.

3. The SCS Engineering Field Manual, Chapter 2 procedures for determining peak discharge, is valid for small rural watersheds. The time of concentration for the non-urbanized area is estimated using a formula based on flow length, runoff curve number and average watershed slope. Chapter 2 procedures are applicable to drainage areas that range from 1 to 2000 acres. Tables, figures, exhibits and worksheets are included for a quick and reliable way to estimate peak discharge and runoff for a range of rainfall amounts, soil types, land use and cover conditions.

4. The SCS-TR-55 tabular method is an approximation of the more detailed SCS-TR-20 method. The tabular method can be used for watersheds where hydrographs are needed to measure non-homogeneous runoff, i.e., the watershed is divided into subareas. It is especially applicable for measuring the effects of changed land use in a part of a watershed. It can also be used to determine the effects of structures and combinations of structures, including channel modifications, at different locations in a watershed. The tabular method should not be used when large changes in the curve number occur among subareas within a watershed and when runoff volumes are less than about 1.5 inches for curve numbers less than 60.

For most watershed conditions, however, this procedure is adequate to determine the effects of urbanization on peak rates of discharge for subareas with "T_c" less than two hours.

5. The SCS-TR-55 Graphical Peak Discharge Method calculates peak discharge from hydrograph analyses using TR-20 Computer Program for Project Formulation. This method demonstrates a procedure for estimating depth and peak rates of runoff from small watersheds. The watershed must be hydrologically homogeneous, that is land use, soils, and cover are distributed uniformly throughout the watershed. The time of concentration for the watershed is estimated using the computed flow velocities for the sheet flow, shallow concentrated flow and channel flow. These values may range from 0.1 to 10 hours. This method was selected for inclusion in this manual to use in designing erosion and sediment control measures.

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SCS RUNOFF CURVE NUMBER METHOD

The SCS Runoff Curve Number (CN) method is described in detail in Nation Engineering Handbook - Chapter 4[5], (NEH-4). The SCS runoff equation is

$$Q = \frac{(P-I_a)^2}{(P-I_a)+S} \qquad \text{[Eq. 10.1]}$$

where

Q = runoff (in),

P = rainfall (in),

S = potential maximum retention after runoff begins (in), and

I_a = initial abstraction (in).

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[Eq. 10.2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 10.2 into equation 10.1 gives

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \qquad \text{[Eq. 10.3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by

$$S = \frac{1000}{CN} - 10 \qquad \text{[Eq. 10.4]}$$

Figure 10.1 on Page 10.4 and Table 10.1 on Page 10.3 solve equations 10.3 and 10.4 for a range of CN's and rainfall.

Table 10.1 Runoff Depth for Selected CN's and Rainfall Amounts[1]

(Reprinted from: 210-VI-TR-55, Second ed., June 1986)

Runoff Depth for Curve Number (CN) of-

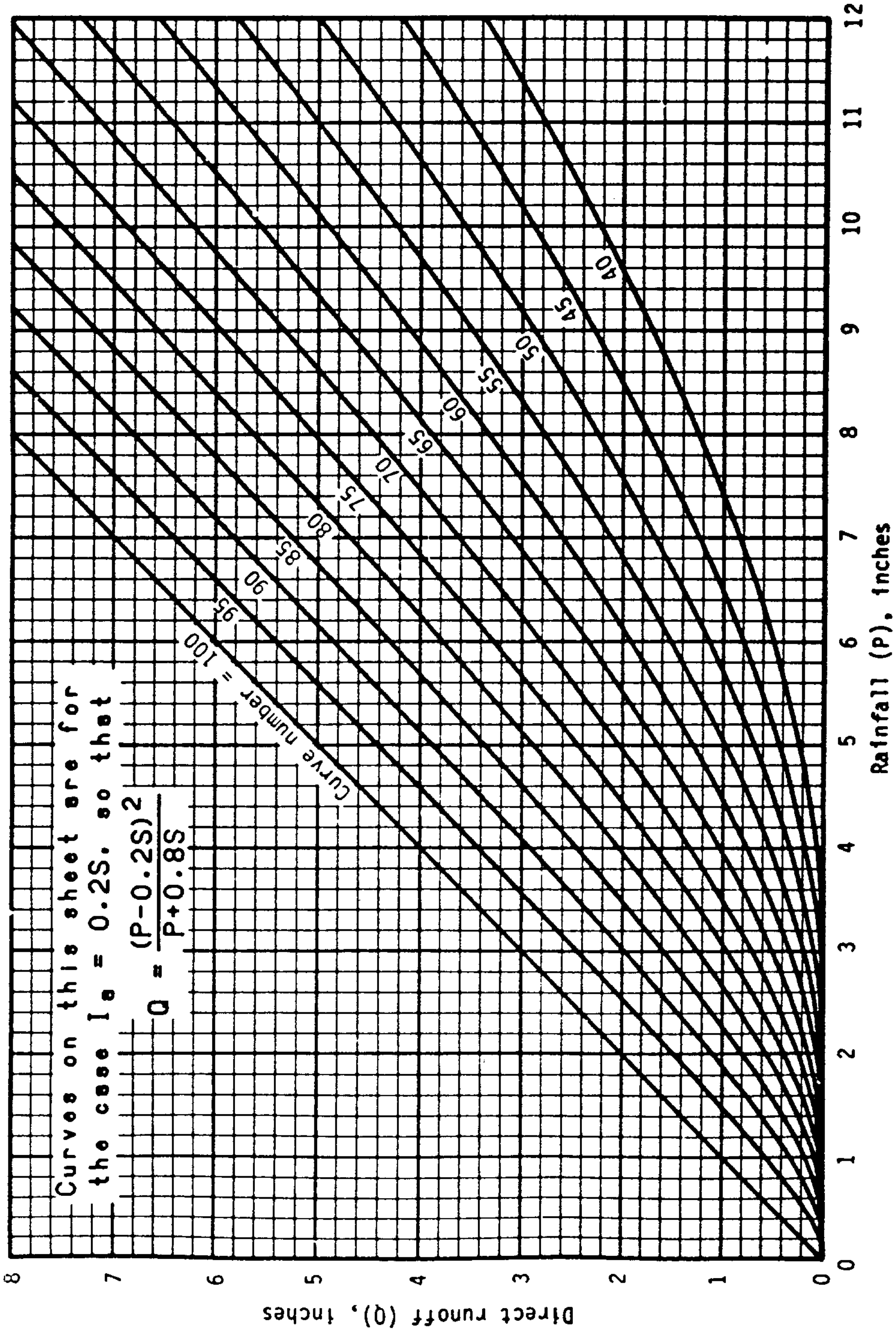
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
						(inches)							
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	0.15	0.27	0.46	0.74	0.99
1.4	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.13	0.24	0.39	0.61	0.92	1.18
1.6	0.00	0.00	0.00	0.00	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.00	0.00	0.00	0.00	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.00	0.00	0.00	0.02	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.00	0.00	0.02	0.08	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.00	0.02	0.09	0.19	0.33	0.51	0.71	0.96	1.25	1.59	1.98	2.45	2.77
3.5	0.02	0.08	0.20	0.35	0.53	0.75	1.01	1.30	1.64	2.02	2.46	2.94	3.27
4.0	0.06	0.18	0.33	0.53	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	0.14	0.30	0.50	0.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	0.24	0.44	0.69	0.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	0.50	0.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	0.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.57	6.22	6.88	7.52	8.16	9.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.82	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

1Interpolate the values shown to runoff depths for CN's or rainfall not shown.

FIGURE 10.1

Solution to Runoff Equation

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)



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FACTORS CONSIDERED IN ESTIMATING RUNOFF CURVE NUMBERS

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 10.2 on Page 10.6 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in Tables 10.2a, 10.2b and 10.2c on Pages 10.7, 10.8 and 10.9 respectively represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Tables 10.2 starting on Page 10.7 assume impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Exhibit 10.2 on page 10.33 of this manual defines the four groups and provides a list of most of the soils in New York State and their group classification. The soils in the area of interest may be identified from a county soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices, see Section 13.

Most urban areas are only partially covered by impervious surfaces; the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in Exhibit 10.2 for determining the HSG classification for disturbed soils.

Cover Type

Tables 10.2 starting on Page 10.7 address most cover types such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

Treatment

Treatment is a cover type modifier (used only in Table 10.2b on Page 10.8) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

Hydrologic Condition

Hydrologic condition indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. Good hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cover type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes in rotations; (d) percent of residue cover; and (e) degree of surface roughness.

Antecedent Runoff Condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in Tables 10.2 starting on page 10.7 are for the average ARC, which is primarily used for design applications. See the SCS NEH-4 and Rallison and Miller[6] for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

Urban Impervious Area Modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas[7]. For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

Connected Impervious Areas

An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into a drainage system.

Urban CN's, Table 10.2a on page 10.7, were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that (a) pervious urban

FIGURE 10.2

Flow Chart for Selecting the Appropriate Figure or Table for Determining Runoff Curve Numbers

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

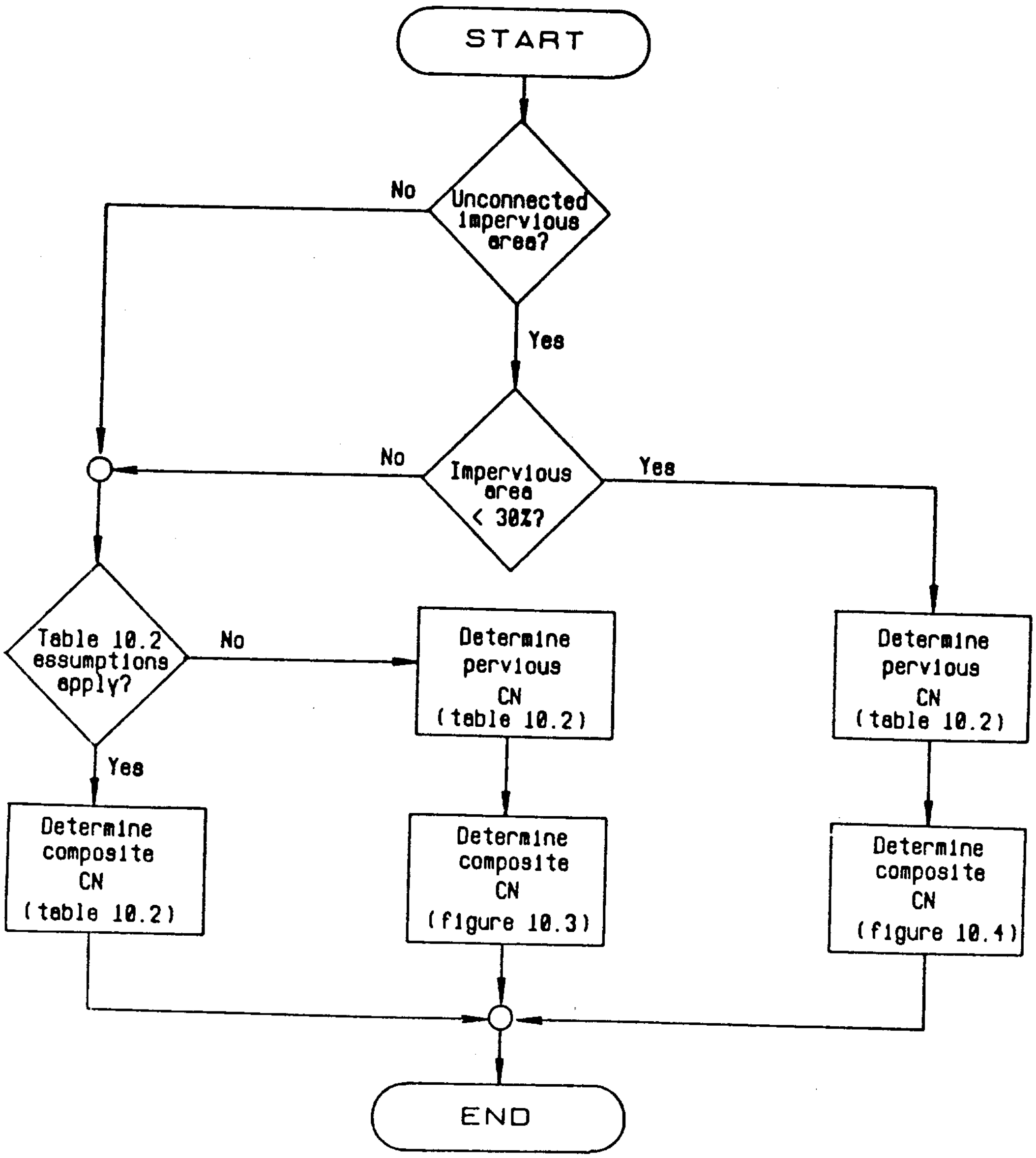

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Table 10.2a - Runoff Curve Numbers for Urban Areas[1]

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

Cover Description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas					
Paved: parking lots, roofs, driveways, etc. (excluding right-of-way]		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right of way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	98
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscape (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with a 1 to 2 inch sand or gravel mulch and basin boarders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses]	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in Table 10.2c).					

1Average runoff condition and $I_a = 0.2S$

[2]The average percent impervious area shown was used to develop composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious area are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using Figure 8.3 or 8.4.

[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4]Composite CN's for natural desert landscaping should be computed using Figure 8.3 or 8.4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 8.3 or 8.4 based on the degree of development (impervious area percentage) and the CN's for newly graded pervious areas.

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Table 10.2b - Runoff Curve Numbers for Cultivated Agricultural Lands[1]

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

Cover description			Curve numbers for hydrologic soil group-			
Cover type	Treatment[2]	Hydrologic condition[3]	A	B	C	D
Fallow	Bare soil	--	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1]Average runoff condition, and Ia = 0.2S.

[2]Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3]Hydrologic condition is based on combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotation, (d) percent of residue cover on the land surface (good-20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 10.2c - Runoff Curve Numbers for Other Agricultural Lands[1]

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

Cover description		Curve numbers for hydrologic soil group-			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range-continous forage for grazing.[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow-continous grass, protected from grazing and generally mowed for hay.		30	58	71	78
Brush--brush--weed--grass mixture with brush the major element[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods-grass combination (orchard or tree farm)[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads-buildings, lanes, driveways, and surrounding lots.	–	59	74	82	86

[1]Average runoff condition, and $I_a = 0.2S$.

[2]Poor: < 50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: > 75% ground cover and lightly or only occasionally grazed.

[3]Poor: <50% ground cover.

Fair: 50 to 75% ground cover.

Good: > 75% ground cover.

[4]Actual curve number is less than 30; use CN = 30 for runoff computations.

[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6]Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

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areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in Table 10.2a on page 10.7.

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in Table 10.2a on page 10.7 are not applicable, use Figure 10.3 on page 10.10 to compute a composite CN. For example, Table 10.2a on page 10.7 gives a CN of 70 for a 1/2-acre lot in hydrologic soil group B, with an assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from Figure 10.3 on page 10.10 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

Unconnected Impervious Areas

Runoff from these area is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use Figure 10.4 on page 10.11 if total impervious area is less than 30 percent or (2) use Figure 10.3 on page 10.10 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of Figure 10.4 on page 10.11 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a 1/2-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and a pervious CN of 61, the composite CN from Figure 10.4 on page 10.11 is 66. If all of the impervious area is connected, the resulting CN (from Figure 10.3 on page 10.10) would be 68.

Figure 10.3

Composite CN with Connected Impervious Area

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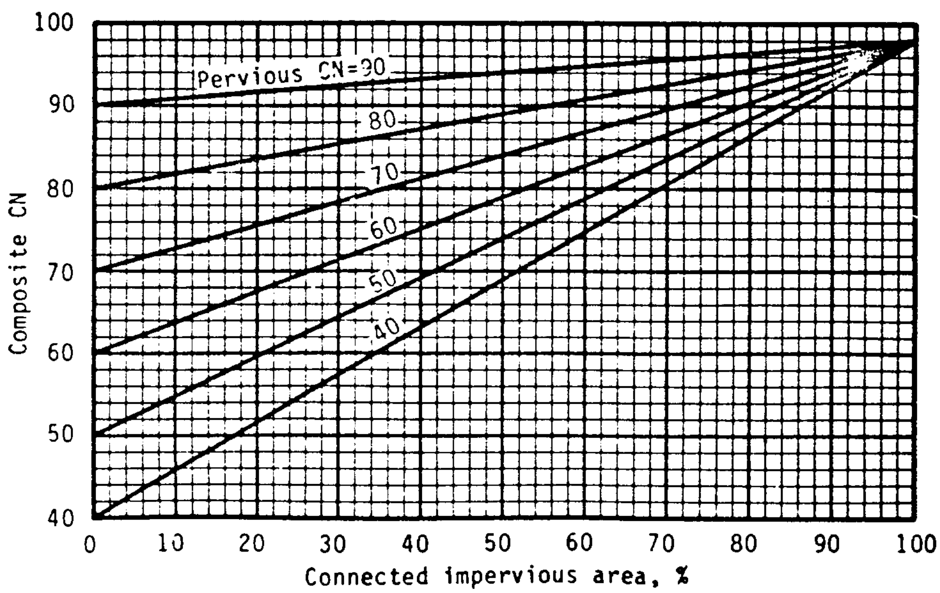

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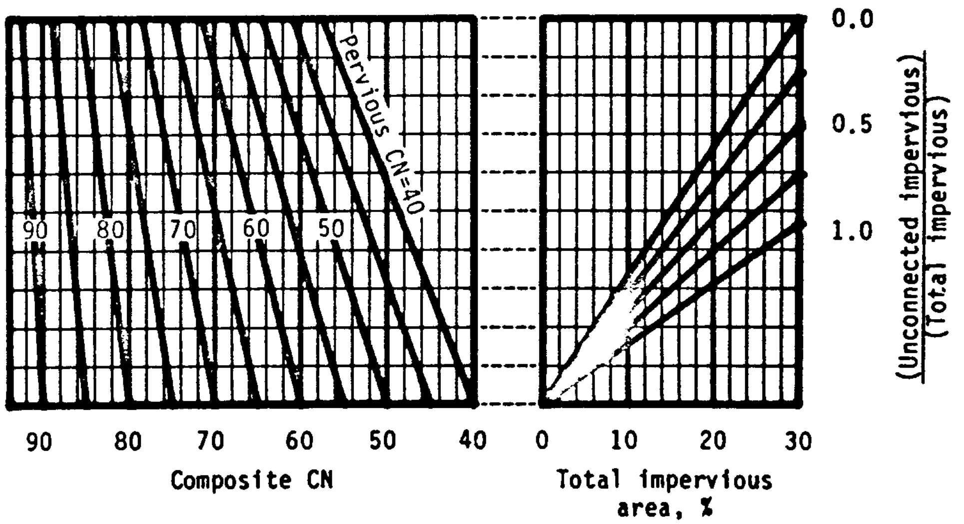
Figure 10.4

Composite CN with Unconnected Impervious Areas and Total Impervious Areas less than 30%

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986) -



Runoff Determination

When CN and the amount of rainfall have been determined for the watershed, determine runoff by using Figure 10.1 on page 10.4, Table 10.1 on page 10.3, or equations 10.3 and 10.4. The runoff is usually rounded to the nearest hundredth of an inch.

Limitations

- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.
- Use the runoff curve number equation with caution when recreating specific features of an actual storm. The equation does not contain an expression for time and, therefore, does not account for rainfall duration or intensity.
- The user should understand the assumption reflected in the initial abstraction term (I_a) and should ascertain that the assumption applies to the situation. I_a, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place. The opposite effect, a greater initial loss, can occur if the impervious areas have surface depressions that store some runoff. To use a relationship other than I_a = 0.2S, one must redevelop equation 10.3, Figure 10.1 on page 10.4, Table 10.1 on page 10.3 and Tables 10.2 on pages 10.7 to 10.9 by using the original rainfall-runoff data to establish new S or CN relationships for each cover and hydrologic soil group.
- Runoff from snowmelt or rain or frozen ground cannot be estimated using these procedures.
- The CN procedure is less accurate when runoff is less than 0.5 inch. As a good check, use another procedure to determine runoff.
- The SCS runoff procedures apply only to direct surface runoff: do not overlook large sources of subsurface flow or high ground water levels that contribute to runoff. These conditions are often related to HSG A soils and forest areas that have

been assigned relatively low CN's in Tables 10.2 on page 10.7 to 10.9. Good judgment and experience based on stream gage records are needed to adjust CN's as conditions warrant.

- When the weighted CN is less than 40, use another procedure to determine runoff.

Examples

Four examples illustrate the procedure for computing runoff curve number (CN) and runoff (Q) in inches. Worksheet 2, Figure 10.5 on page 10.13, is provided to assist TR-55 users. Figures 10.6 through Figure 10.9 on pages 10.14 through 10.17 respectively represent the use of Worksheet 2 for each example. All four examples are based on the same watershed and the same storm event.

The watershed covers 250 acres in Broome County, New York. Seventy percent (175 acres) is a Mardin soil, which is in hydrologic soil group C. Thirty percent (75 acres) is a Tioga soil, which is in group B. The event is a 25 year frequency, 24-hour storm with a total rainfall of 5.5 inches.

Cover type and conditions in the watershed are different for each example. The examples, therefore, illustrate how to compute CN and Q for various situations of proposed, planned, or present development.

Example 1

The present cover type is pasture in good hydrologic condition. See Figure 10.6 on page 10.14 for Worksheet 2 information.

Example 2

Seventy percent (175 acres) of the watershed, consisting of all the Tioga soil and 100 acres of the Mardin soil, is 1/2-acre residential lots with lawns in good hydrologic condition. The rest of the watershed is scattered open space in good hydrologic condition. See Figure 10.7 on page 10.15.

Example 3

This example is the same as example 2, except that the 1/2-acre lots have a total impervious area of 35 percent. For these lots, the pervious area is lawns in good hydrologic condition. Since the impervious area percentage differs from the percentage assumed in Table 10.2, use Figure 10.3 on page 10.10 to compute CN. See Figure 10.8 on page 10.16.

Example 4

This example is also based on example 2, except that 50 percent of the impervious area associated with the 1/2 acre lots on the Mardin soil is "unconnected," that is, it is not directly connected to the drainage system. For these lots, the pervious area CN (lawn, good condition) is 74 and the impervious area is 25 percent. Use Figure 10.4 on page 10.11 to compute the CN for these lots. CN's for the 1/2-acre lots on Tioga soil and the open space on Mardin soil are the same as those in example 2. See Figure 10.9 on page 10.17.

Figure 10.5

Worksheet 2: Runoff Curve Number and Runoff

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Project ______________________ By _____ Date ________

Location ______________________ Checked _____ Date ________

Circle one: Present Developed ______________________

1. Runoff curve number (CN)

Soil name and hydrologic group Exhibit 10.2	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 10.2a	Table 10.2b	Table 10.2c	Area ☐acres ☐mi^2 ☐%	Product of CN x area
				Totals =		

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ______ = ________; Use CN = ☐

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr			
Rainfall, P (24-hour) .... in			
Runoff, Q .... in (Use P and CN with table 10.1, fig. 10.1, or eqs. 10.3 and 10.4.)			

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Figure 10.6

Worksheet 2: Runoff Curve Number and Runoff

Worksheet 2 for Example 1

Project Heavenly Acres By DJL Date 10/1/91

Location Broome County, N.Y. Checked RC Date 10/1/91

Circle one: (Present) Developed

1. Runoff curve number (CN)

Soil name and hydrologic group Exhibit 10.2	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 10.2a	Table 10.2b	Table 10.2c	Area ☒acres ☐mi² ☐%	Product of CN x area
Tioga (B)	Pasture, good condition			61	30	1830
Mardin (C)	Pasture, good condition			74	70	5180
				Totals =	100	7010

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{7010}{100} = 70.1$; Use CN = 70

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25 yr		
Rainfall, P (24-hour) .... in	5.0"		
Runoff, Q .... in (Use P and CN with table 10.1, fig. 10.1, or eqs. 10.3 and 10.4.)	2.04"		

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Figure 10.7

Worksheet 2: Runoff Curve Number and Runoff

Worksheet 2 for Example 2

Project Heavenly Acres By DWL Date 10/1/91

Location Broome County, NY Checked [illegible] Date 10/1/91

Circle one: Present (Developed) 175 Acres Residential

1. Runoff curve number (CN)

Soil name and hydrologic group Exhibit 10.2	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 10.2a	Table 10.2b	Table 10.2c	Area ☒acres ☐mi² ☐%	Product of CN x area
Tioga (B)	½ acre lots, good Condition 25% impervious	70			75	5250
Mardin (C)	½ acre lots, good Condition 25% impervious	80			100	8000
Mardin (C)	Open Space, good Condition	74			75	5550

1/ Use only one CN source per line. Totals = 250 | 18800

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18800}{250} = 75.2$; Use CN = 75

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25 yr		
Rainfall, P (24-hour)	in	5.0"		
Runoff, Q	in	2.45"		

(Use P and CN with table 10.1, fig. 10.1, or eqs. 10.3 and 10.4.)

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Figure 10.8

Worksheet 2: Runoff Curve Number and Runoff

Worksheet 2 for Example 3

Project Heavenly Acres By DWL Date 10/1/91

Location Broome County, NY Checked DE Date 10/1/91

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group Exhibit 10.2	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 10.2a	Table 10.2b	Table 10.2c	Area ☒ acres ☐ mi^2 ☐ %	Product of CN x area
Tioga (B)	1/2 acre lots, good condition 35% impervious	74			75	5550
Mardin (C)	1/2 acre lots, good conditions 35% impervious	82			100	8200
Mardin (C)	Open Space, good condition	74			75	5550
				Totals =	250	19,300

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{19300}{250} = 77.2$; Use CN = 77

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25 yr		
Rainfall, P (24-hour) .... in	5.0"		
Runoff, Q .... in (Use P and CN with table 10.1, fig. 10.1, or eqs. 10.3 and 10.4.)	2.63"		

Figure 10.9

Worksheet 2: Runoff Curve Number and Runoff

Worksheet 2 for Example 4

Project Heavenly Acres By DWL Date 10/1/91

Location Broome County, NY Checked [initials] Date 10/1/91

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (Exhibit 10.2)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 10.2a	Table 10.2b	Table 10.2c	Area ☒ acres ☐ mi² ☐ %	Product of CN x area
Tioga (B)	25% connected impervious 1/2 acre lots, good condition	70			75	5250
Mardin (C)	25% impervious, w/ 50% unconnected 1/2 acre lots, good condition	78			100	7800
Mardin (C)	Open Space, good condition	74			75	5550
				Totals =	250	18,600

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{18600}{250} = 74.4$; Use CN = 74

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25 yr		
Rainfall, P (24-hour) .... in	5.0"		
Runoff, Q .... in (Use P and CN with table 10.1, fig. 10.1, or eqs. 10.3 and 10.4.)	2.37"		

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Time of Concentration and Travel Time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c) which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and the peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors Affecting Time of Concentration and Travel Time

Surface Roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel Shape And Flow Patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel design have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of Travel Time and Time of Concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600\,V} \qquad \text{[Eq. 10.4]}$$

where

T_t = travel time (hr),

L = flow length (ft),

V = average velocity (ft/s), and

3600 = conversion factor from seconds to hours

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t1} + T_{t2} + \ldots T_{tm} \qquad \text{[Eq. 10.5]}$$

where

T_c = time of concentration (hr) and

m = number of flow segments.

Sheet Flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 10.3 on page 10.19 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution[H] to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 10.6]}$$

where

T_t = travel time (hr),

n = Manning's roughness coefficient, Table 10.3 on page 10.19

L = flow length (ft),

P_2 = 2 year, 24 hour rainfall (in), and

s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of Manning's kinematic solution is based on the following:

(1) shallow steady uniform flow,

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Table 10.3 - Roughness coefficients (Manning's n) for sheet flow	
Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover <20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prarie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The values are a composite of information compiled by Engman (1980).

[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3]When selecting n consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

(2) constant intensity of rainfall excess (that part of a rain available for runoff),

(3) rainfall duration of 24 hours, and

(4) minor effect of infiltration on travel time.

Rainfall depth can be obtained from Exhibit 10.1 at the end of this chapter.

Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from Figure 10.10 on page 10.20, in which average velocity is a function of watercourse slope and type of channel. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in Figure 10.10 on page 10.20, use equation 10.4 to estimate travel time for the shallow concentrated flow segment.

Open Channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

Manning's equation is

$$V = \frac{1.49\, r^{2/3} s^{1/2}}{n} \qquad \text{[Eq. 10.7]}$$

where

- V = average velocity (ft/sec),
- r = hydraulic radius (ft) and is equal to a/p_w,
- a = cross sectional flow area (ft^2),
- p_w = wetted perimeter (ft),
- s = slope of the hydraulic grade line (channel slope, ft/ft), and
- n = Manning's roughness coefficient for open channel flow.

Manning's "n" values for open channel flow can be obtained from standard textbooks[9]. After average velocity is computed using equation 10.7, T_t for the channel segment can be estimated using equation 10.4.

Reservoirs or Lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed to determine travel time. This travel time is normally very small and can be assumed as zero.

Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 10.6 was developed for use with the four standard rainfall intensity-duration relationships.
- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate T_c. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.
- The minimum T_c used is 0.1 hour.
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outlet through the culvert.
- Figure 10.11 on page 10.22 provides Worksheet 3 for calculating Time of Concentration (T_c) or travel time (T_t).

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Figure 10.10

Average Velocities for Estimating Travel Time for Shallow Concentrated Flow

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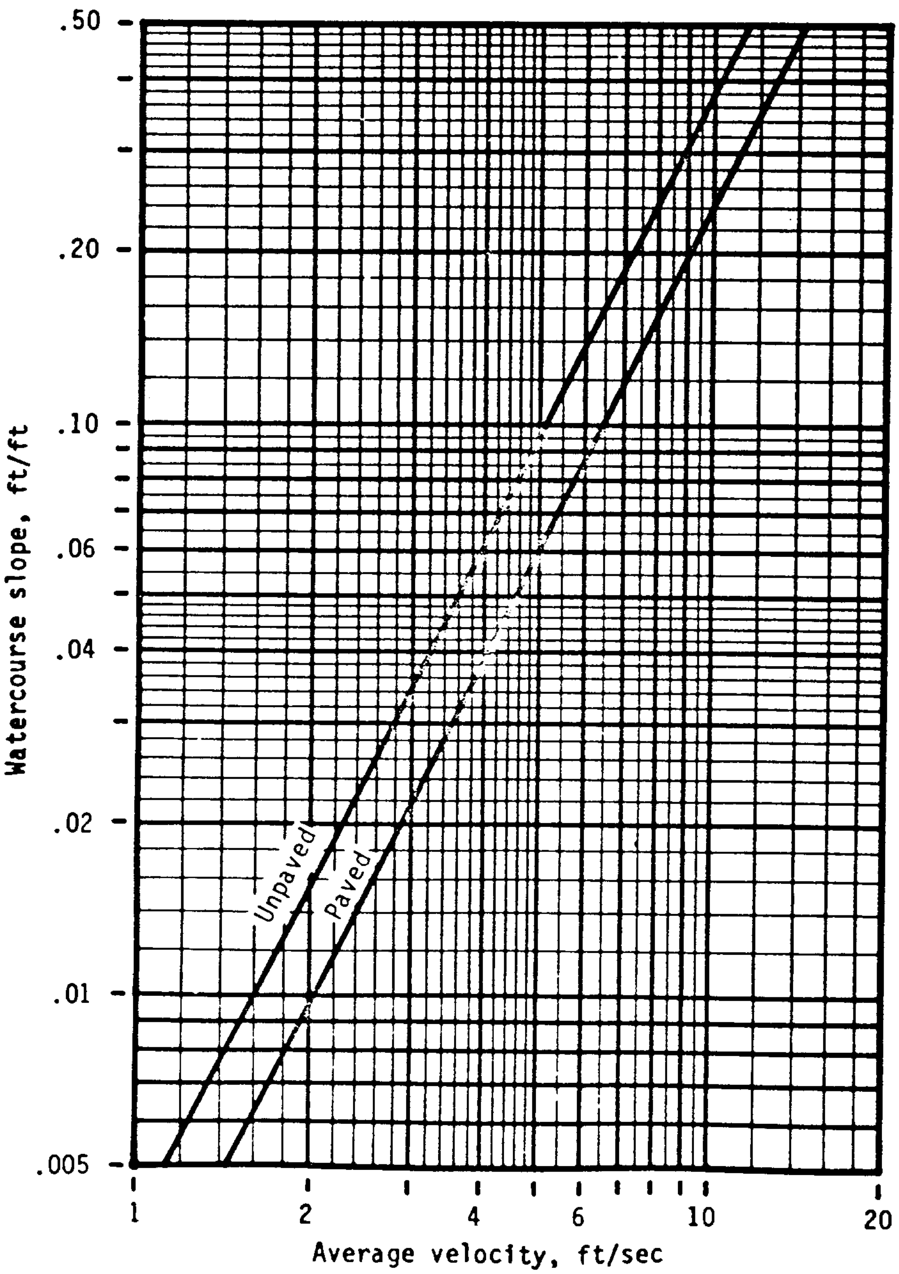

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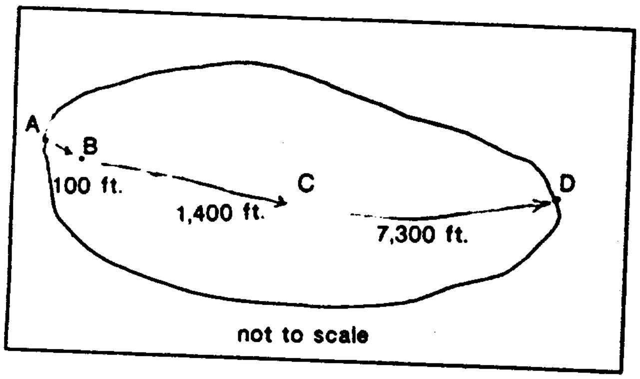
Example

Example 5

The sketch below shows a watershed in Broome County, New York. The problem is to compute T_c at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 2.8 inches.

All three points occur from the hydraulically most distant point (A) to the point of interest (D). To compute T_c, first determine T_t for each segment from the following information:



Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft.

Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1400 ft.

Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 ft^2; wetted perimeter (pw) = 28.2 ft; s = 0.005 ft/ft; and L = 7300 ft.

See Figure 10.12 on page 10.23 for the computations made on worksheet 3 for Example 5.

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Figure 10.11

Worksheet 3: Time of Concentration (T_C) or Travel Time (T_t)

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Project ______________________ By _____ Date _______

Location ______________________ Checked _____ Date _______

Circle one: Present Developed ______________________

Circle one: T_c T_t through subarea ______________________

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)		Segment ID			
1. Surface description (table 10.3)...........					
2. Manning's roughness coeff., n (table 10.3).					
3. Flow length, L (total L $\leq$ 300 ft)	ft				
4. Two-yr 24-hr rainfall, P_2	in				
5. Land slope, s	ft/ft				
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+		=

Shallow concentrated flow		Segment ID			
7. Surface description (paved or unpaved)					
8. Flow length, L	ft				
9. Watercourse slope, s	ft/ft				
10. Average velocity, V (figure 10.10).........	ft/s				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

Channel flow		Segment ID			
12. Cross sectional flow area, a	ft^2				
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr [ ]

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Figure 10.12

Worksheet 3: Time of Concentration (T_C) or Travel Time (T_t)

Worksheet 3 for Example 5

Project: *Heavenly Acres* By: *DWL* Date: *10/1/91*

Location: *Broome County, NY* Checked: *[initials]* Date: *10/1/91*

Circle one: Present (Developed — circled)

Circle one: (T_c — circled) T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

	Segment ID	AB		
1. Surface description (table 10.3)		Dense grass		
2. Manning's roughness coeff., n (table 10.3)		0.24		
3. Flow length, L (total L ≤ 300 ft)	ft	100		
4. Two-yr 24-hr rainfall, P_2	in	3.6		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.30	+	= 0.30

Shallow concentrated flow

	Segment ID	BC		
7. Surface description (paved or unpaved)		Unpaved		
8. Flow length, L	ft	1400		
9. Watercourse slope, s	ft/ft	0.01		
10. Average velocity, V (figure 10.10)	ft/s	1.6		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.24	+	= 0.24

Channel flow

	Segment ID	CD		
12. Cross sectional flow area, a	ft^2	27		
13. Wetted perimeter, p_w	ft	28.2		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.957		
15. Channel slope, s	ft/ft	0.005		
16. Manning's roughness coeff., n		0.05		
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s	2.05		
18. Flow length, L	ft	7300		
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.99	+	= 0.99

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 1.53

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Graphical Peak Discharge Method

The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation-Hydrology". The peak discharge equation used is:

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 10.8]}$$

where

- q_p = peak discharge (cfs);
- q_u = unit peak discharge (csm/in);
- A_m = drainage area (mi^2);
- Q = runoff (in); and
- F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows:

(1) T_c (hr),

(2) drainage area (mi^2),

(3) appropriate rainfall distribution (I, IA, II, or III),

(4) 24-hour rainfall (in), and

(5) CN.

If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak Discharge Computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from Exhibit 10.1 at the end of this chapter. CN and total runoff (Q) for the watershed were computed earlier. The CN is used to determine the initial abstraction (I_a) from Table 10.4 on page 10.24. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in Figures 10.16 and 10.17 on pages 10.28 and 10.29 respectively for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 10.13 on page 10.24 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from Figures 10.16 and 10.17 by using T_c, rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from Table 10.5 on page 10.25 (rounded to the nearest Table value). Use Worksheet 4, Figure 10.14 on page 10.26, to aid in computing the peak discharge using the Graphical method.

Figure 10.13 - Variation of I_a/P for P and CN

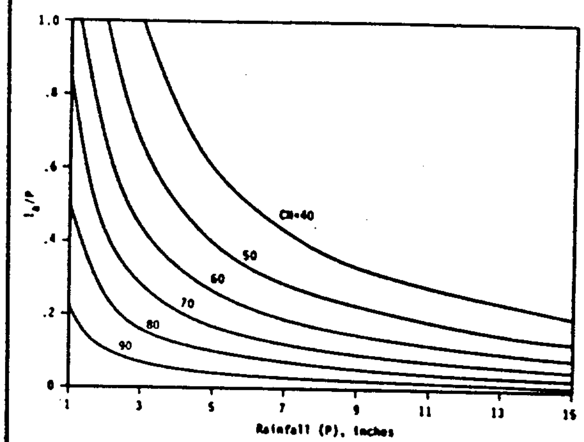

Table 10.4 - I_a Values for Runoff Curve Numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.637	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Table 10.5 - Adjustment factor (F_p) for pond and swamp areas that are spread throughout the watershed	
Percentage of pond and swamp areas	Fp
0.0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

Limitations

- The Graphical method provides a determination of peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method in Technical Release #55. Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.
- The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.
- The watershed may have only one main stream or, if more than one, the branches must have nearly equal T_c's.
- The method cannot perform valley or reservoir routing.
- The F_p factor can be applied only for ponds or swamps that are not in the T_c flow path.
- Accuracy of peak discharge estimated by this method will be reduced if I_a/P values are used that are outside the range given in Figures 10.16 and 10.17. The limiting I_a/P values are recommended for use.
- This method should only be used if the weighted CN is greater than 40.
- When this method is used to develop estimates of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating T_c.
- T_c values with this method may range from 0.1 to 10 hours.

Example

Example 6

Compute the 25-year peak discharge for the 250-acre watershed described in examples 2 and 5. Figure 10.15 on page 10.27 shows how Worksheet 4 is used to compute q_p as 248 cfs.

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Figure 10.14

Worksheet 4: Graphical Peak Discharge

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

Project ______________________ By _____ Date _______

Location ______________________ Checked _____ Date _______

Circle one: Present Developed ______________________

1. Data:

Drainage area .... A_m = ________ mi^2 (acres/640)

Runoff curve number .... CN = ________ (From worksheet 2)

Time of concentration .. T_c = ________ hr (From worksheet 3)

Rainfall distribution type = ________ (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ________ percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	in			
4. Initial abstraction, I_a .... (Use CN with table 10.4.)	in			
5. Compute I_a/P				
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with Figure 10.16)	csm/in			
7. Runoff, Q .... (From worksheet 2).	in			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 10.5. Factor is 1.0 for zero percent pond and swamp area.)				
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs			

Figure 10.15

Worksheet 4: Graphical Peak Discharge

Worksheet 4 for Example 6

Project *Heavenly Acres* By *[initials]* Date *10/1/91*

Location *Broome County, NY* Checked *[initials]* Date *10/1/91*

Circle one: Present (Developed) ____________________

1. Data:

   Drainage area .... A_m = *0.39* mi^2 (acres/640)

   Runoff curve number .... CN = *75* (From worksheet 2)

   Time of concentration .. T_c = *1.53* hr (From worksheet 3)

   Rainfall distribution type = *II* (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = *- -* percent of A_m (*- -* acres or mi^2 covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	*25*		
3.	Rainfall, P (24-hour)	in	*5.0*		
4.	Initial abstraction, I_a .... (Use CN with table 10.4.)	in	*0.667*		
5.	Compute I_a/P		*0.13*		
6.	Unit peak discharge, q_u .... (Use T_c and I_a/P with Figure 10.16)	csm/in	*260*		
7.	Runoff, Q .... (From worksheet 2).	in	*2.45*		
8.	Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 10.5. Factor is 1.0 for zero percent pond and swamp area.)		*1.0*		
9.	Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	*248*		

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Figure 10.16

Unit Peak Discharge (qu) for SCS Type II Rainfall Distribution

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

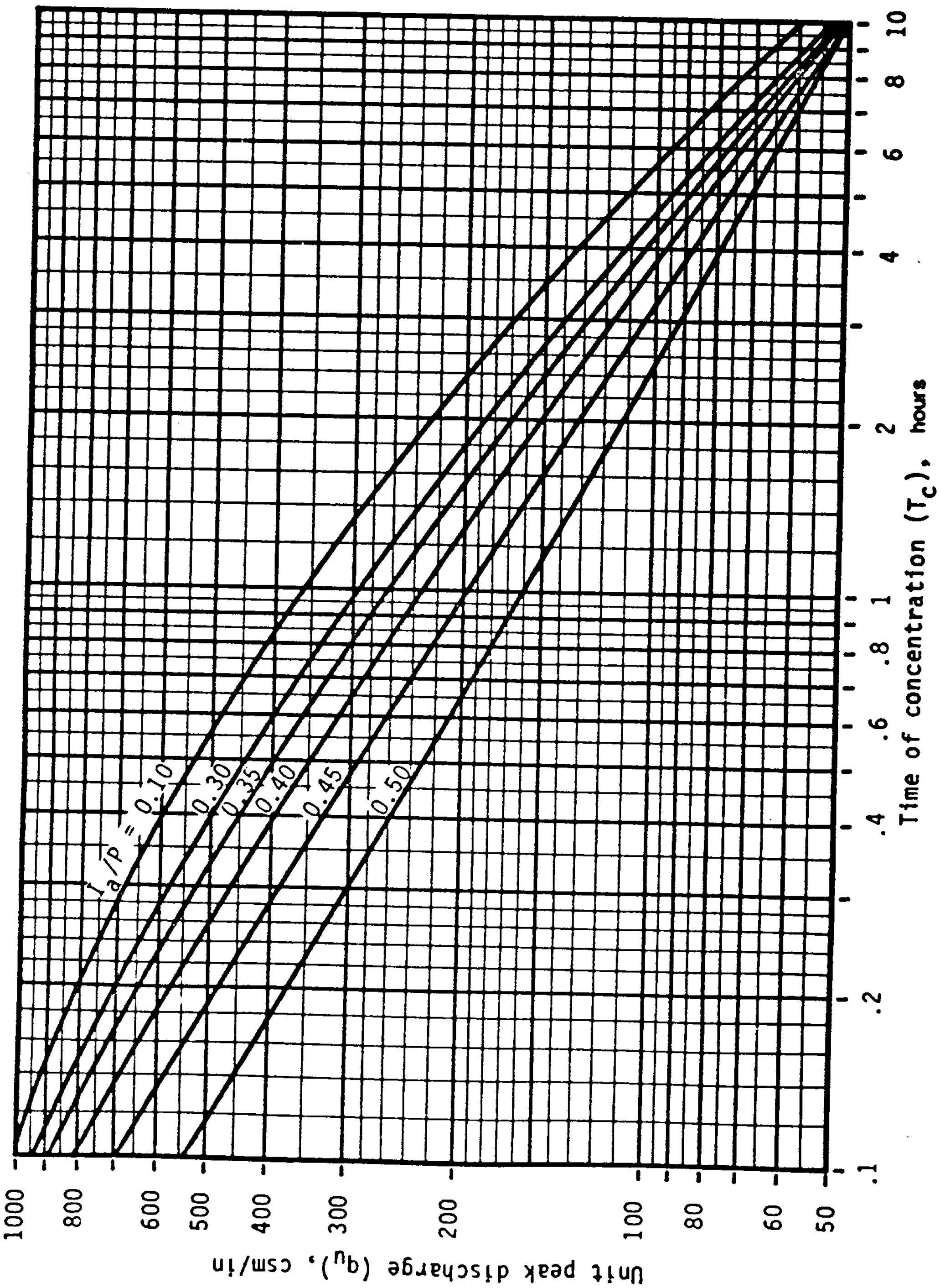

Figure 10.17

Unit Peak Discharge (qu) for SCS Type III Rainfall Distribution

(Reprinted from: 210-VI-TR-55, Second Ed., June 1986)

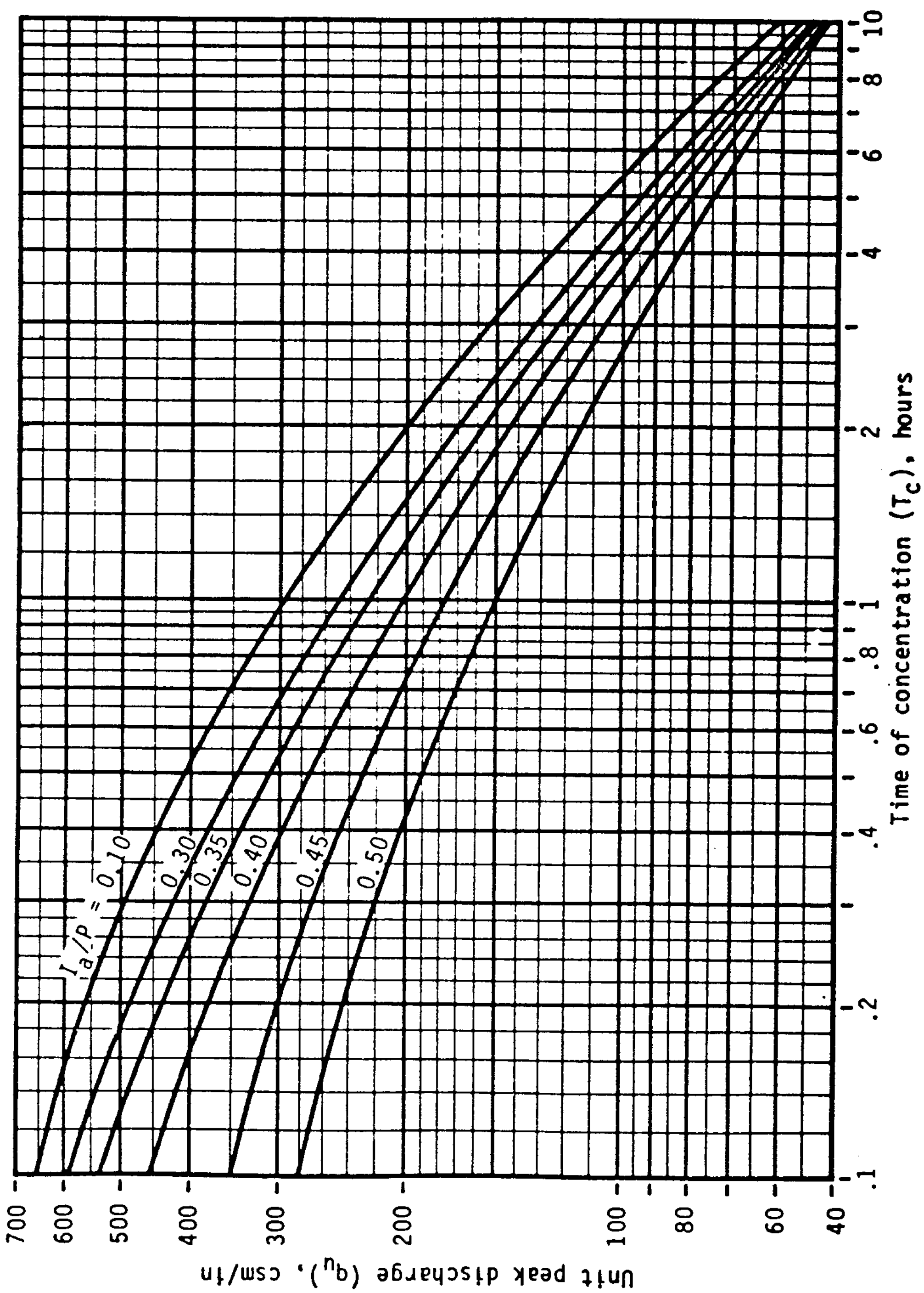

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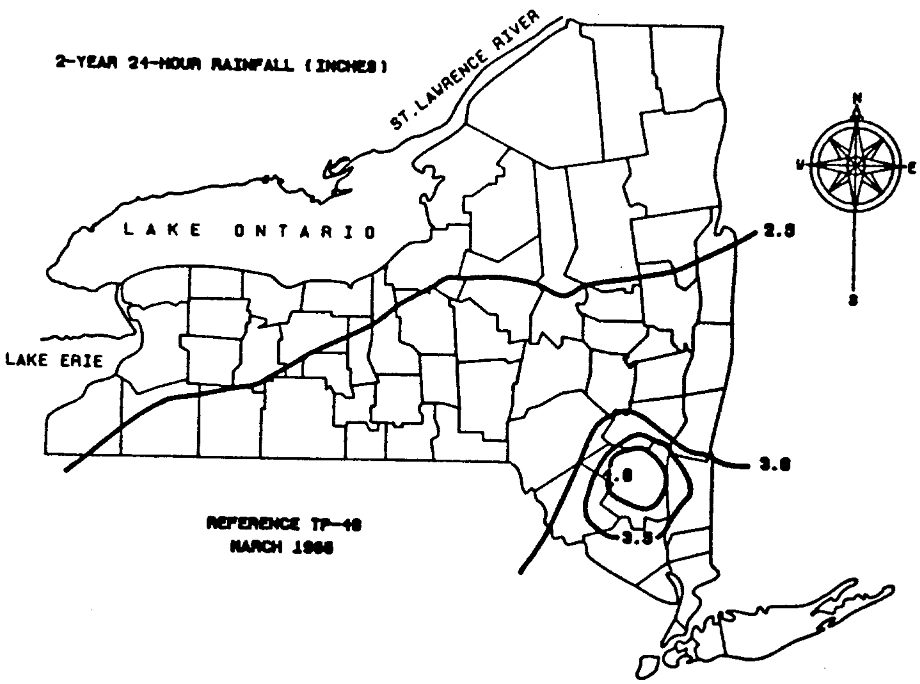
Exhibit 10.1

New York Rainfall Maps for Different Rainfall Frequencies



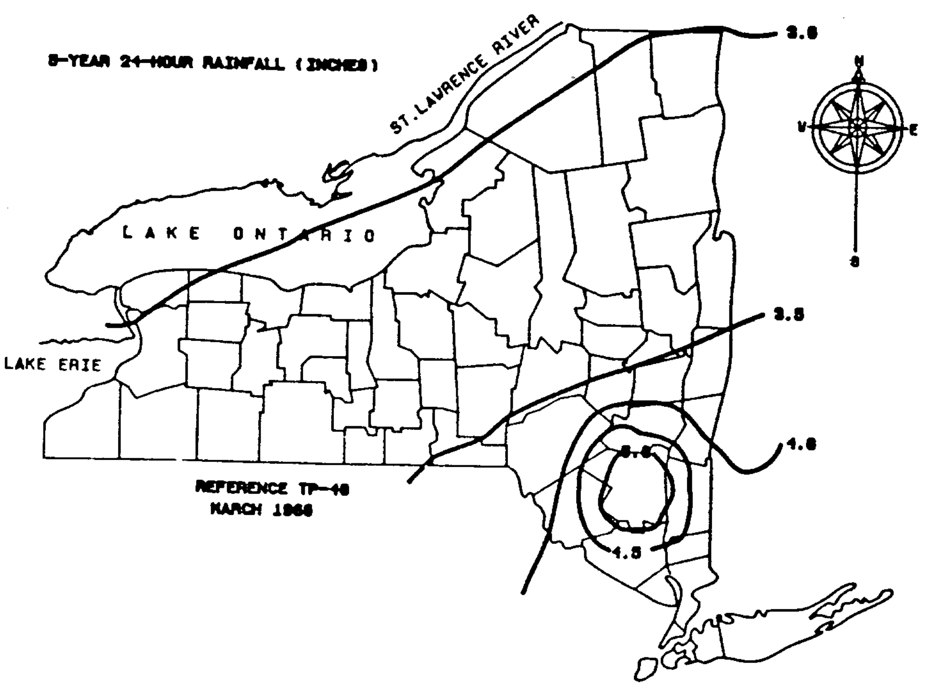


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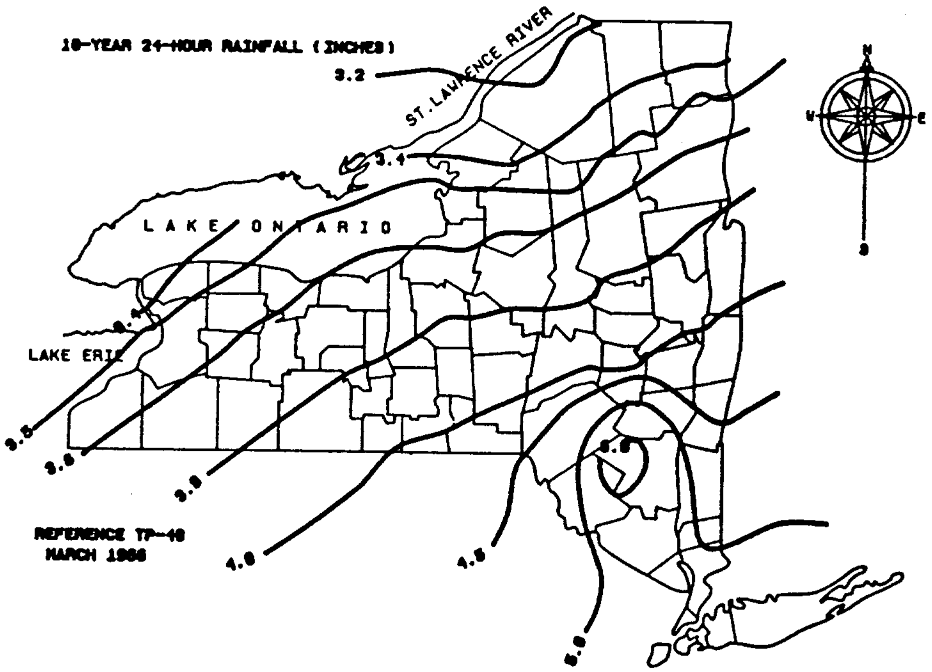
Exhibit 10.1 (cont'd)

New York Rainfall Maps for Different Rainfall Frequencies



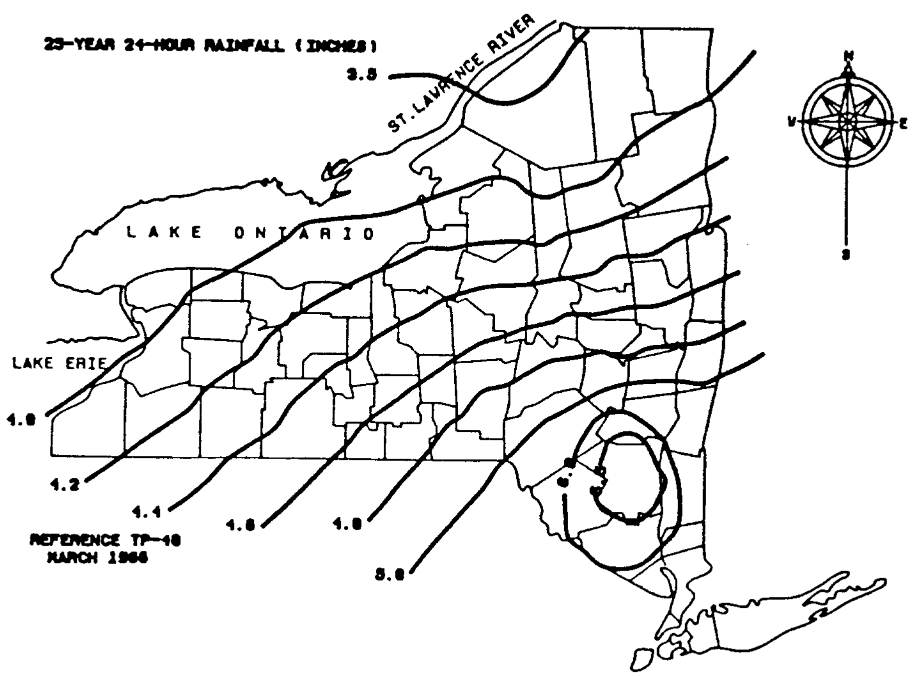
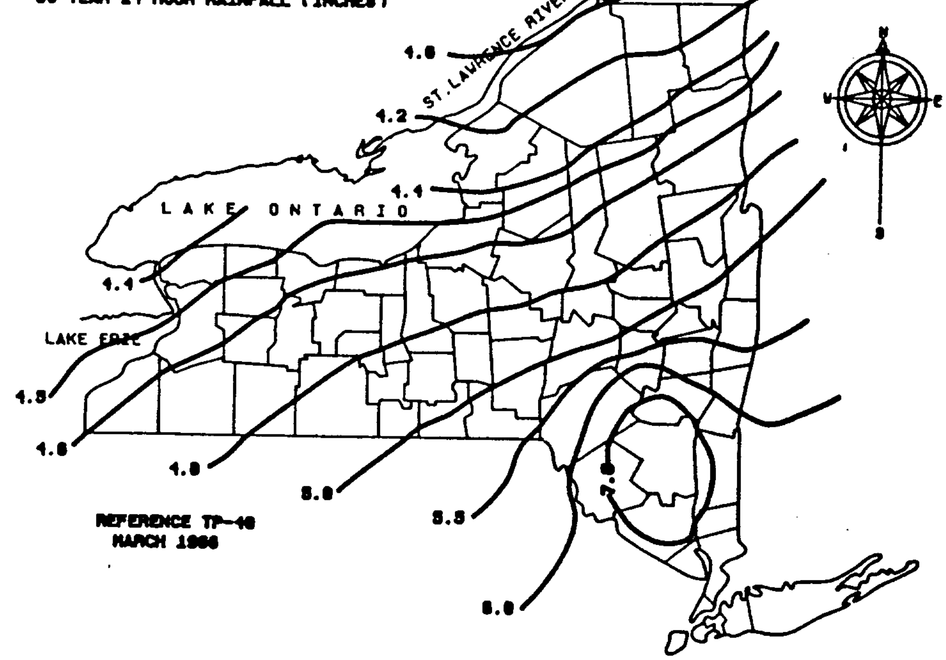


Exhibit 10.1 (cont'd)

New York Rainfall Maps for Different Rainfall Frequencies

50-YEAR 24-HOUR RAINFALL (INCHES)



100-YEAR 24-HOUR RAINFALL (INCHES)

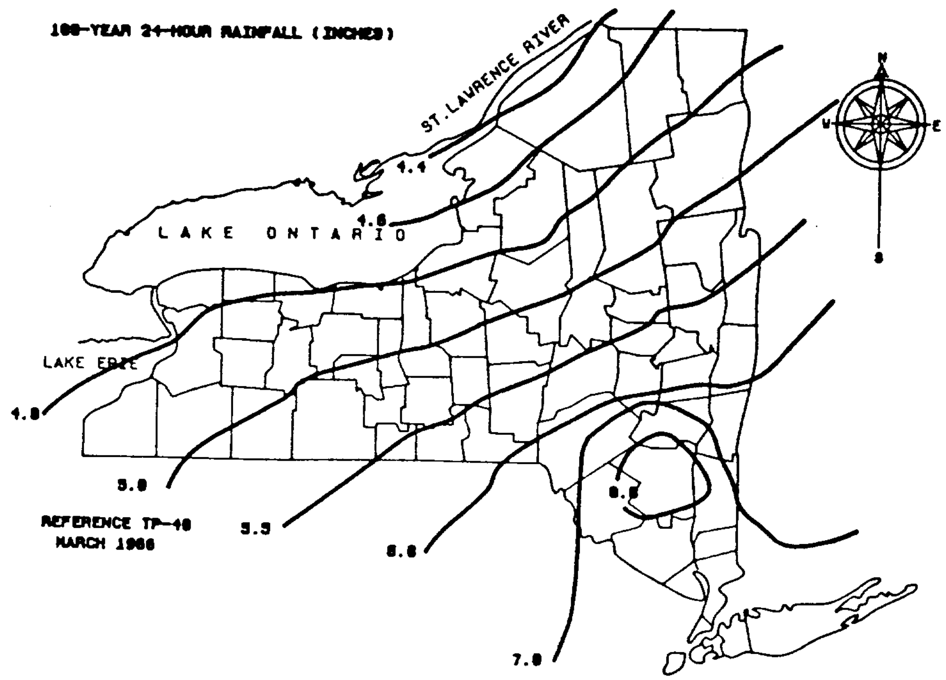


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Exhibit 10.2

SCS Hydrologic Soil Groups - New York

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's; which are A, B, C, and D; are one element used in determining runoff curve numbers.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate-the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave. The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a high permanent water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.5 in/hr).

Disturbed Soil Profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred[10]:

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and Group D Soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Adrian soil is classified as A/D. This indicates that the drained Adrian soil is in group A and the undrained soil is in group D.

SOIL SERIES USED IN NEW YORK AND THEIR HYDROLOGIC GROUPS

Soil Series	Hydrologic Group
ADAMS	A
ADJIDAUMO	D
ADRIAN	A/D
AGWAM	B
ALBRIGHTS	C
ALDEN	D
ALLAGASH	B
ALLARD	B
ALLIS	D
ALTMAR	B
ALTON	A
AMBOY	C
AMENIA	B
ANGOLA	C
APPLETON	C
AQUENTS	D
AQUEPTS	--
AQUOLLS	--
ARKPORT	B
ARNOT	C/D
ASHVILLE	D
ATHERTON	B/D
ATKINS	D
ATSION	C/D
AU GRES	B
AURELIE	D
AURORA	C
BARBOUR	B
BARCELONA	C
BARRE	D
BASH	C
BASHER	B
BATH	C
BECKET	C
BECRAFT	B
BELGRADE	B
BENSON	D
BERKSHIRE	B
BERNARDSTON	C
BERRYLAND	B/D
BESEMAN	A/D
BICE	B
BIDDEFORD	D
BIRDSALL	D
BLASDELL	A
BOMBAY	B
BONAPARTE	A
BONO	D
BOOTS	A/D
BRACEVILLE	C
BRAYTON	C
BRIDGEHAMTON	B
BRIGGS	A
BRINKERTON	D
BROADLABIN	C
BROCKPORT	D
BUCKLAND	D
BURDETT	C
BURNHAM	D
BUSTI	C
BUXTON	C
CAMBRIDGE	C
CAMILLUS	B
CAMRODEN	C
CANAAN	C
CANADICE	D
CANANDAIGUA	D
CANASERAGA	C
CANEADEA	D
CANFIELD	C
CANTON	B
CARBONDALE	A/D
CARLISLE	A/D
CARROLLTON	C
CARVER	A
CASTILE	B
CATHRO	A/D
CAVODE	C
CAYUGA	C
CAZENOVIA	B
CHADAKOIN	B
CHAGRIN	B
CHARLTON	B
CHATFIELD	B
CHAUMONT	D
CHAUTAUQUA	C
CHEEKTOWAGA	D
CHENANGO	A
CHESHIRE	B
CHIPPENY	D
CHIPPEWA	D
CHOCORUA	D
CHURCHVILLE	D
CLAVERACK	C
CLYMER	B
COHOCTAH	B/D
COLLAMER	C
COLONIE	A
COLOSSE	A
COLTON	A
CONESUS	B
CONSTABLE	A
COOK	D
COSAD	C
COVEYTOWN	C
COVINGTON	D
CRARY	C
CROGHAN	B
DALTON	C
DANLE	C
DANNEMORA	D
DARIEN	C
DAWSON	A/D
DEERFIELD	B
DEFORD	C
DEKALB	C
DEPEYSTER	C
DERB	C
DIXMONT	C
DORA	B/D
DOVER	B
DUANE	B
DUNKIRK	B
DUTCHESS	B
EDWARDS	B/D
EELWEIR	C
ELKA	C
ELMRIDGE	C
ELMWOOD	C
ELNORA	B
EMPEYVILLE	C
ENFIELD	B
ENSLEY	B/D
ERIE	C
ERNEST	C
ESSEX	C
FAHEY	B
FARMINGTON	C
FARNHAM	B
FLACKVILLE	C
FLUVAQUENTS	--
FONDA	D
FREDON	C
FREETOWN	D
FREMONT	C
FREWSBURG	C
GALEN	B
GALOO	C/D
GALWAY	B
GEORGIA	C
GETZVILLE	D
GILPIN	C
GLOUCESTER	A
GLOVER	C/D
GRANBY	A/D
GREENE	B
GREENWOOD	A/D
GRENVILLE	B
GROTON	A

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SOIL SERIES USED IN NEW YORK AND THEIR HYDROLOGIC GROUPS

Soil Series	Group
GUFF	D
GUFFIN	D
GULF	B/D
HAIGHTS	B
HALCOTT	C/D
HALSEY	C/D
HAMLIN	B
HANNAWA	D
HARTLAND	B
HAVEN	B
HAWKSNEST	C/D
HEMPSTEAD	B
HENRIETTA	B/D
HERKIMER	B
HERMON	A
HEUVELTON	C
HILTON	B
HINCKLEY	A
HINESBURG	C
HOGANSBURG	B
HOLDERTON	B
HOLLIS	C/D
HOLYOKE	C/D
HOMER	B
HONEOYE	B
HOOSIC	A
HORNELL	D
HOWARD	A
HUDSON	C
HUNAQUEPTS	
HYDRAQUENTS	
ILION	D
INSULA	D
IPSWICH	D
IRA	C
IVORY	C
JOLIET	D
JUNIUS	C
KALURAH	B
KANONA	D
KARS	A
KEARSARGE	B
KENDAIA	C
KINGSBURY	D
KINSMAN	C
KINZUA	B
KINCKERBOCKER	A
LACKAWANNA	C
LAGROSS	A
LAIRDSVILLE	D
LAKEMONT	D
LAMSON	B/D
LANESBORO	C
LANGFORD	C
LANSING	B
LEICESTER	C
LEWBEACH	C
LIMA	B
LIMERICK	C
LINLITHGO	B
LIVINGSTON	D
LOBDELL	B
LOCKPORT	D
LONDONBERRY	C/D
LORSTOWN	C
LOWVILLE	B
LOXELY	A/D
LUPTON	A/D
LYMAN	C/D
LYME	C
LYONS	D
MACOMB	B
MACOMBER	C
MADAMLIN	D
MADRID	B
MALONE	C
MANAHAWKIN	D
MANHEIM	C
MANLIUS	C
MAPLECREST	B
MARCY	D
MARDIN	C
MARILLA	C
MARLOW	C
MARTISCO	B/D
MASSENA	C
MATOON	D
MATUNUCK	D
MEDIFIBRISTS	
MEDIHEMISTS	
MEDISAPRISTS	
MELROSE	C
MENLO	D
MERRIMAC	A
MIDDLEBURY	B
MILLSITE	B
MINELOA	A
MINO	C
MINOA	C
MOHAWK	B
MANARDA	D
MANGAUP	C
MANTAUK	C
MORRIS	C
MOSHERVILLE	C
MUCK	D
MUNSON	D
MUNUSCONG	B/D
MUSKELLUNGE	D
MUSKINGUM	C
NASSAU	C
NAUMBURG	C
NEHASNE	B
NELLIS	B
NEVERSINK	D
NEWSTEAD	C
NIAGARA	C
NICHOLVILLE	C
NORWICH	D
NUNDA	C
OAKVILLE	A
OCCUM	B
OCHREPTS	
ODESSA	D
ONDAWA	B
ONOVILLE	C
ONTARIO	B
ONTEORA	C
OQUAGA	C
ORPARK	C
ORTHENTS	
OSSIPEE	D
OTISVILLE	A
OVID	C
PALATINE	B
PALMS	A/D
PALMYRA	B
PANTON	D
PATCHIN	D
PAWCATUCK	D
PAWLING	B
PAXTON	C
PERU	C
PHELPS	B
PHILO	B
PINCKNEY	C
PITS	
PITTSFIELD	B
PITTSTOWN	C
PLAINFIELD	A
PLYMOUTH	A
PODUNK	B
POMTON	B
POOTATUCK	B
POPE	B
POTSDAM	C
PSAMMENTS	
PUNSIT	C
PYRITIES	B

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SOIL SERIES USED IN NEW YORK AND THEIR HYDROLOGIC GROUPS

QUETICO ....D
RAQUETTE ....B
RAYNE ....B
RAYNHAM C
RAYPOL C
RED HOOK C
RED WATER C
REMSEN ....D
RHINEBECK ....D
RICKER ....A
RIDGEBURY C
RIFLE ....A/D
RIGA ....D
RINGLING ....D
RIPPOWAM C
RIVERHEAD ....B
ROCK OUTCROP .....D
ROMULUS ....D
RUMNEY C
RUSE ....D
SACO ....D
SALMON ....B
SAPRISTS ....A/D
SAUGATUCK C
SCANTIC ....D
SCABORO ....D
SCHOHARIE C
SCHROON ....B
SCHUYLER ....B
SCIO ....B
SCITUATE C
SCRIBA C
SEARSPORT ....D
SEBAGO ....D
SHAKER C
SKERRY C
SLOAN ....B/D
SODUS C
ST. ALBENS ....B
STAFFORD C
STISSING C
STOCKBRIDGE C
STOCKHOLM C
STOWE C
SUCCESS ....A
SUDBURY ....B
SUN ....D
SUNAPEE ....B
SUNCOOL ....A
SUNY ....D
SURPLUS C
SUTTON ....B
SWANTON ....C/D
SWARTSWOOD C
SWORMVILLE C
TACONIC ....C/D
TAWAS ....A/D
TEEL ....B
TIOGA ....B
TOQUERVILLE .....D
TOR ....D
TORULL ....D
TOERVILLE ....B
TRESTLE ....B
TROUT RIVER ......A
TUGHILL ....D
TULLER ....D
TUNBRIDGE C
TUNKHANNOCK ....A
UDIFLUVENTS ......B
UDIPSAMMENTS
UDORTHENTS ......A
UNADILLA ....B
URBAN LAND
VALOIS ....B
VARICK ....D
VARYSBURG ....B
VENANGO C
VERGENNES C
VLY C
VOLUSIA C
WADDINGTON ......A
WAKELAND C
WAKEVILLE ....B
WALLACE ....B
WALLINGTON C
WALLKILL...........C/D
WAPOLE C
WAMPSVILLE ....B
WAPPINGER ....B
WAREHAM C
WARNERS C
WASSAIC ....B
WATCHAUG ....B
WAUBEK ....B
WAYLAND ....C/D
WEAVER C
WEGATCHIE ....D
WELLSBORO C
WESTBURY C
WESTLAND ....B/D
WETHERSFIELD C
WHARTON C
WHATELY ....D
WHITMAN ....D
WILLETTE ....A/D
WILLIAMSON C
WILLOWEMOC C
WILPOINT ....D
WINDSOR ....A
WINOOSKI ....B
WOODBRIDGE C
WOODLAWN ....B
WOODSTOCK ....D
WOOSTER'C
WORDEN C
WORTH C
WURTSBORO C
WYALUSING ....D
YALESVILLE C

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Appendix A
NYS DEC Erosion and Sediment Control Guidelines for New Development

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Thomas C. Jorling
Commissioner

VOL 12

April 1991

MEMORANDUM

TO: **Regional Water Engineers, Bureau Directors, Section Chiefs**
FROM: **Salvatore Pagano - Director, Division of Water**
SUBJECT: **Division of Water Technical and Operational Guidance Series (5.1.10)**

EROSION AND SEDIMENT CONTROL GUIDELINES FOR NEW DEVELOPMENT
(Originator: Philip M. DeGaetano)

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I. PURPOSE

To provide soil erosion and sediment control guidelines to regional water staff involved in the review of land development projects. These guidelines are to be used in conjunction with the **Stormwater Management Guidelines** (TOGS 5.1.8) in reviewing proposed development projects.

II. DISCUSSION

Sediment in runoff from construction sites can have a significant effect on the quality of downstream waters. It is of such concern that it has been highlighted as a source category to be addressed by the EPA regulations on stormwater management. It is also identified as a significant source category in the State Nonpoint Source Assessment Report.

The potential effects of increased sediment are varied:

> "Sediment may destroy fish habitat through blanketing of fish spawning and feeding areas and elimination of certain food organisms, directly impact fish through gill abrasion and fin rot, and reduce sunlight penetration, thereby impairing photosynthesis of aquatic plants. Suspended sediment decreases recreational values, reduces fishery habitat, adds to the mechanical wear of water supply pumps and distribution systems, and adds to treatment costs for water supplies. Nutrients and toxic substances attached to sediment particles are transported to waterbodies and may

enter aquatic food chains, cause fish toxicity problems, contribute to algal blooms, impair recreational uses, and degrade the water as a drinking water source."[1]

The following guidelines are designed for consideration by both government officials and project sponsors in the preparation and review of erosion and sediment control plans for a land development project. If implemented properly, the guidelines herein will assist in achieving the following water and natural resource management objectives.

- reduce the erosion potential from a development or construction project;
- decrease nonpoint source pollution and water quality degradation;
- maintain stream channels for their biological functions, as well as for drainage, through reduced sediment deposition.

The U.S. Environmental Protection Agency has recently adopted stormwater management regulations which will be implemented through the National Pollutant Discharge Elimination System (NPDES). Consequently, the N.Y. State Pollutant Discharge Elimination System (SPDES) program may be used in this state to implement the new federal regulations. The regulations contain provisions which require control of erosion from certain land development projects. However, the federal stormwater management program is not fully operational at this time.

Until the stormwater permit system is operational, it would be appropriate to use the authority of the State Environmental Quality Review Act (SEQRA) to apply the erosion and sediment control guidelines which make up this TOGS for all land development projects and construction activities when it is determined that soil erosion and sedimentation is a relevant area of environmental concern or when it is determined that soil erosion and sedimentation, if not controlled, may have a significant effect on the environment. Upon such determination, an erosion and sediment control plan should be prepared. The following are examples of projects where soil erosion and sedimentation are common relevant areas of environmental concern.

1. land clearing or land grading projects involving five or more acres;
2. residential development consisting of five or more dwelling units, unless each dwelling unit is on a lot of two or more acres;
3. industrial and/or commercial projects which result in an impervious surface of one or more acres;
4. site preparation on slopes which exceed 1½ ft. of vertical rise to 10 ft. of horizontal distance (or site preparation in areas of severe erosion potential where such areas have been mapped);
5. site preparation within 100 ft. of a wetland;
6. site preparation within 100 ft. of any watercourse;
7. excavating or filing which exceeds a total of 100 cu. yds. of material within any parcel or any contiguous parcels.

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1 Nonpoint Source Management Program. January, 1990.

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Pursuant to the consistency requirements of the New York State Nonpoint Source Management Program as authorized under Section 319 of the Federal Clean Water Act of 1987, and pursuant to Presidential Executive Order 12372 requiring intergovernmental review of federal programs, the erosion and sediment control guidelines herein should be applied to all eligible federal agencies which either undertake development projects in the State or assist development projects through funding.

III. GUIDANCE

It is the policy of the Division of Water that an erosion and sediment control plan be prepared for all projects for which soil erosion and sedimentation has been identified as a relevant area of environmental concern, or, for which if it is not controlled, it may have a significant effect on the environment. The plan should be prepared and submitted as part of the SEQR process.

The attached guidelines were developed to aid persons in preparing and reviewing erosion and sediment control plans. They provide guidance on sound management practices, but are not fixed and inflexible rules to be applied in reviewing erosion control plans without considering the particular facts and circumstances of a particular project.

It should be noted that some communities may have duly adopted erosion control requirements, and that they should be consulted and complied with. In the absence of such requirements, Regional Water staff are encouraged to consult the management practices described in this guidance where appropriate to encourage their use by county and local agencies and by developers and consultants involved in preparing and reviewing development plans and proposed projects. To the fullest extent practicable, Regional Water staff should seek the assistance of County Soil and Water Conservation District sta'f during the review of erosion and sediment control plans.

Salvatore Pagano
Director, Division of Water

Attachment

cc: Dr. Banks
Mr. Campbell
Ms. Chrimes
Mr. Bruening
Regional Engineers for Envir. Quality

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EROSION AND SEDIMENT CONTROL GUIDELINES FOR NEW DEVELOPMENT

A. Existing vegetation on a project site should be retained and protected as much as possible to minimize soil loss on a project site and to minimize erosion control costs.

B. Sediment control practices/measures, where necessary, should be designed to protect the natural character of rivers, streams, lakes, coastal waters or other waterbodies on-site and minimize erosion and sedimentation off-site from the start of land disturbance activities to establishment of permanent stabilization.

1. The off-site impacts of erosion and sedimentation related to land clearing, grading and construction activities should not be any greater during and following land disturbance activities than under pre-development conditions.

2. Pursuant to Part 700 et seq. of Title 6, Chapter X of NYCRR:

   a. toxic and other deleterious substances shall not be discharged in amounts that will adversely affect the taste, color or odor thereof, or impair the waters of the state for their best (classified) usages,

   b. suspended, colloidal and settleable solids shall not be discharged in amounts that causes substantial visible contrast to natural conditions, or causes deposition or impairs the waters for their best (classified) usages.

This means that stream reaches on-site and downstream of construction areas should not have substantial visible contrast relative to color, taste, odor, turbidity and sediment deposition from the reaches upstream of the construction area. Impacts such as these which result from construction or developmental activities are a violation of Part 700 water quality standards and may be subject to enforcement actions.

C. Erosion and sediment control measures should be constructed in accordance with an erosion and sediment control plan. The plan should:

1. describe the temporary and permanent structural and vegetative measures that will be used to control erosion and sedimentation for each stage of the project from land clearing to the finished stage.

2. provide a map showing the location of erosion and sediment control measures.

3. provide dimensional details of proposed erosion and sediment control facilities as well as calculations used in the siting and sizing sediment basins. (Guidance for performing calculations can be obtained in the reference cited in Section E.8.)

4. identify temporary erosion and sediment control facilities which will be converted to permanent stormwater management facilities.

5. provide an implementation schedule for staging temporary and permanent erosion and sediment control facilities.

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6. provide a maintenance schedule for soil erosion and sediment control facilities and describe maintenance activities to be performed.

D. Erosion and sediment control measures should be constructed prior to beginning any other land disturbances. The devices should not be removed until the disturbed land areas are stabilized.

E. Specify guidance.

1. Exposure Restrictions: No more than 5 acres of unprotected soil should be exposed at any one time. Previous earthwork should be stabilized in accord with approved design standards and specifications referenced in Section E.8 before additional area is exposed. (Site factors including topography, soil erosion potential, proximity to wetlands and water courses may require limiting the amount of raw earth that can be exposed at any one time to less than 5 acres.)

2. Grading: Perimeter grading should blend with adjoining properties.

3. Vegetative Protection: Where protection of trees and/or other vegetation is required, the location of the site to be protected should be shown on the erosion control plan. The method of protecting vegetation during construction should conform to the design criteria referenced in Section E.8.

4. Drainage control.

a. Surface runoff that is relatively clean and sediment free should be diverted or otherwise prevented from flowing through areas of construction activity on the project site. This will greatly reduce sediment loading in surface runoff.

b. A fill associated with an approved temporary sediment control structure or permanent stormwater management structure, should not be created which causes water to pond off-site on adjacent property, without first having obtained ownership or permanent easement for such use from the owner of the off-site or adjacent property.

c. Natural drainage channels should not be altered or relocated without the proper approvals. Pursuant to Article 15 of the Environmental Conservation Law, a protected stream and the bed and banks thereof should not be altered or relocated without the approval of the Department of Environmental Conservation.[2]

d. Runoff from any land disturbing activity should not be discharged or have the potential to be discharged off-site or into storm drains or into watercourses unless such discharge is directed through a properly designed, installed and maintained structure, such as a sediment trap, to retain sediment on-site. Accumulated sediment should be removed when 60% of the storage capacity of the sediment retention structure is filled with sediment.

e. For finished grading, adequate gradients should be provided so as to prevent water from standing on the surface of lawns for more than 24 hours after the end of a rainfall, except in a swale flow area which may drain as long as 48 hours after the end of rainfall.

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2 A natural drainage channel refers to a swale, water course in a gully, or a protected or unprotectd stream. Natural drainage channels should not be altered or relocated on adjacent properties without first having obtained ownership or a permanent easement for the altered or relocated drainage channel from the owner of the off-site or adjacent property.

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f. Permanent swales or other points of concentrated water flow should be stabilized with sod, rip-rap, paving, or covered with a approved erosion control matting as provided for in the design criteria referenced in Section E.8.

g. Surface flows over cut and fill slopes should be controlled as provided for in the design criteria for vegetating waterways referenced in Section E.8.

5. Timing.

a. Except as noted below, all sites should be seeded and stabilized with erosion control materials, such as straw mulch, jute mesh, or excelsior within 15 days of final grading. If construction has been suspended, or sections completed, areas should be seeded immediately and stabilized with erosion control materials. Maintenance should be performed as necessary to ensure continued stabilization.

i. For active construction areas such as borrow or stockpile areas, roadway improvements, and areas within 50 ft. of a building under construction, a perimeter sediment control system consisting, for example, of silt fencing or hay bales, should be installed and maintained to contain soil.

ii. On cut side of roads, ditches should be stabilized immediately with rock rip-rap or other non-erodible liners, or where appropriate, vegetative measures such as sod. When seeding is approved, an anchor mulch should be used and soil should be limed and fertilized in accord with recommendations referenced in Section E.8.

iii. Permanent seeding should optimally be undertaken in the spring from March 21 through May 20, and in late summer and early fall from August 25 to October 15. During the peak summer months and in the fall after October 15 when seeding is found to be impracticable, an appropriate mulch should be applied. Permanent seeding may be undertaken during summer if plans provide for adequate watering of the seedbed.

iv. All slopes steeper than 3:1 (h:v), as well as basin or trap embankments, and perimeter dikes should, upon completion, be immediately stabilized with sod, seed and anchored straw mulch, or other approved stabilization measures. Areas outside of the perimeter sediment control system should not be disturbed. Maintenance should be performed as necessary to ensure continued stabilization.

b. Temporary sediment trapping devices should be removed within thirty (30) calendar days following establishment of permanent stabilization in all contributory drainage araes. Stormwater management structures used temporarily for sediment control should be converted to the permanent configuration within this time period as well.

6. Stream protection.

a. The bed and banks of all on-site and off-site streams that may be impacted by land clearing, grading, and construction activities should be protected to prevent stream, river, lake or coastal sedimentation, streambank erosion, stream enlargement and degradation or loss of

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fisheries habitat. Measures for protecting the bed and/or banks of a stream may include, for example, gabion baskets, rip-rap, log cribbing, and vegetative measures. [3]

b. Where temporary work roads or haul roads cross stream channels, adequate waterway openings must be constructed using spans, culverts, washed rock backfill or other acceptable, clean methods that will ensure that road construction and use do not result in turbidity and sediment downstream. All stream crossing activities and appurtenances shall be in compliance with a permit issued pursuant to Article 15 of the Environmental Conservation Law, where applicable, and should be carried out in conformance with guidelines in DEC'S Stream Corridor Management manual. [4]

7. Maintenance.

a. An erosion control plan for a project site should identify maintenance requirements for erosion and sediment control practices utilized, and it should provide a maintenance schedule. All erosion and sediment control measures should be inspected periodically and maintained in conformance with the schedule so as to ensure they remain in effective operating condition until such times as they are removed.

b. All points of construction ingress and egress should be protected to prevent the deposition of materials onto traversed public thoroughfare(s) either by installing and maintaining a stabilized construction entrance, or by washing all vehicle wheels in a safe disposal area. All materials deposited onto public thoroughfare(s) should be removed immediately. Proper precautions should be taken to ensure that materials deposited onto public thoroughfares are removed so that they do not enter catch basins, storm sewers, or combined sewers.

c. Accumulated sediment should be removed when 60% of the storage capacity of the retention structure is filled with sediment.

8. Design specifications.

Designs, standards and specifications for controlling erosion and sedimentation are found in the following publication and should be identified and shown in the erosion control plan:

> Empire State Chapter, Soil & Water Conservation Society, New York Guidelines for Urban Erosion and Sediment Control, Syracuse. March 1988.

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3 Whenever possible, vegetative streambank stabilization practices are recommended over structural practices such as rip-rap and gabion linings which may unnecessarily alter the existing stream ecosystem.

4 New York State Department of Environmental Conservation, "Stream Corridor Management: A Basic Reference Manual," Albany, 1986.

APPENDIX B
HOW TO USE THE UNIVERSAL SOIL LOSS EQUATION IN URBANIZING AREAS

To predict soil losses on construction sites, the equation used is:

A = R or (EI) x KLS

Where:

A is the computed soil loss per acre in tons. This quantity may be converted to cubic yards by using conversion factors shown in Table B.1.

R is the rainfall intensity factor which is a measure of the erosive force of rainfall. EI is also used as a designation of rainfall intensity. R refers to the average annual rainfall erosion index. The EI factor is the rainfall erosion index for a part of a year, "probability" storm or for the magnitude of a single storm. The R value for urban areas is the same as that assigned to work units for agricultural lands. This value should be used in predicting annual soil losses on construction sites.

Table B.2 contains EI values of key cities in the New York area for soil loss probabilities other than the average annual losses. These may be used to further characterize soil loss hazards. For example, in Syracuse, New York, the annual average R value is 100. Table B.2 shows that the value of R will equal or exceed 129 in 20% of the years. This is 129 x 100 or 1.29 times the average value.

Soil losses from individual storms may also be computed. For example, Table B.2 shows that a 10 year rain in Syracuse has an erosion index of 61 or more. This means that the soil losses from this one storm may be 61% of the soil losses occurring during an entire average year.

K is the soil erodibility factor. In construction work, B and C soil horizons are mostly involved. Lists of K factors for A, B, and C horizons are shown in Table B.3. (This table includes only representative soils and their K values. For more complete listings of soils, contact the local SCS office.)

Limited research data show that infiltration rates and erosion losses from compacted[1] fills do not differ greatly from those on "cuts," when slopes and surface materials are the same. Loose fills may lose less soil and water than compacted fills. Since research has not yet determined the rates of soil loss on loose fills, the same K values that are used for B and C horizons on cuts or compacted fills may be used for loose fills.

L is the slope length factor

S is the slope gradient factor

These two factors are closely interrelated and have been computed into one combined value known as the LS value. These combined values are shown in Table B.4. Two other factors in the Universal Equation, namely P and C, are not used on urbanized lands though they are used on agricultural lands. These factors are concerned mostly with contouring, contour strip-cropping, crop rotations, stages of crop growth, tillage and harvesting methods which have little or no relation to urbanized lands.

The Universal Soil Loss Equation is designed to estimate soil losses by sheet erosion only. Construction sites are also subject to rill and gully erosion. The losses from rilling and gullying are in addition to losses from sheet erosion and, therefore, must be taken into account for determining total losses on a given site.

One method of measuring rill erosion is by using the Alutin Rill Erosion Method. This procedure is fairly accurate up to losses of 100 tons per acre. Greater losses than this generally fall into the category of gullying and these are computed by measuring the cut area in cubic yards. (See Appendix C for estimating soil losses by rilling.)

A major difference between the above mentioned methods of computing soil losses is that the Universal Soil Loss Equation can be used for estimating soil losses before and after they occur, while losses from rilling and gullying can be computed only after the erosion occurs.

The following are examples showing how the Universal Soil Loss Equation is used for estimating soil losses:

Assume Syracuse, New York, as the locale of a construction site. The disturbed site is 50 acres in size, with an average gradient of 8% and an average slope length of 500 feet. The soil is a Schoharie silt loam with a K value of 0.28 in both the B and C horizons. (The K value is obtained from Table B.3.) The LS value is 2.2 and is obtained from Table B.4.

1. Compute soil losses from this unprotected surface for a 12 month period. The average annual rainfall erosion index (R) is 100.

[1] Compaction in this section of the guidelines refers to that which occurs from normal grading and hauling operations.

A = RKLS = 100 x 0.28 x 2.2 x 50 acres = 3,080 tons or 2,679 cubic yards. (Latter computation obtained by using conversion factor of 0.87 shown in Table B.1.)

2. Compute soil losses from this unprotected surface for a 3 month period (June, July, August). The EI value for this period is 59. This value is obtained as follows:

   Refer to the erosion index distribution curve applicable to Syracuse, New York, Figure B.1. The EI reading for June 1 is 17% and for September 1 is 76%. The percent of average annual index for this period is 76% - 17% or 59%. Since the annual erosion index for this location is 100, the EI value for the 3 month period is 59% of 100 or 59.

   A = (EI) KLS = 59 x 0.28 x 2.2 x 50 acres = approximately 1,817 tons or 1,581 cubic yards.

3. Compute soil losses for the 1 year out of 5 when the rainfall intensity (R) will increase from the average annual R of 100 to an R of 129. (Latter value from Table B.2.)

   A = RKLS or 129 x 0.28 x 2.2 x 50 acres = approximately 3,973 tons or 3,456 cubic yards.

4. Compute soil losses for the 1 year out of 20 when the rainfall intensity (R) will increase from the normal average annual value of 100 to an annual value of 197. (Latter value from Table B.2.)

   A = RKLS = 197 x 0.28 x 2.2 x 50 acres = approximately 6,068 tons or about 5,279 cubic yards.

5. Compute soil losses from the expected magnitude of a single storm that may occur once in 5 years. The EI value of this storm is 38. (Obtained from Table B2.2.)

   A = EI x KLS = 38 x 0.28 x 2.2 x 50 acres = approximately 1,166 tons or about 1,014 cubic yards.

6. Compute soil losses from the expected magnitude of a single storm that may occur once in 10 years. The EI value of this storm is 61. (Obtained from Table B.2.)

   A = EI x KLS = 61 x 0.28 x 2.2 x 50 acres = approximately 1,879 tons or about 1,635 cubic yards.

7. Compute soil losses from the expected magnitude of a single storm that may occur once in 20 years. The EI value of this storm is 65. (Obtained from Table B.2.)

   A = EI x KLS = 65 x 0.28 x 2.2 x 50 acres = approximately 2,002 tons or about 1,742 cubic yards.

<u>Slope Length (L) and Gradient (S)</u>

Slope length is defined as the distance from the point of origin of overland flow to either of the following: (1) the point where the slope decreases to the extent that significant deposition begins or (2) the point where runoff enters a well defined channel. Field slopes are often either convex (steepening substantially toward the lower end) or concave (flattening toward the lower end). When the lower end of the slope is steeper than the upper end, the gradient of the steeper segment should be used with the overall slope length to enter the slope effect chart (Table B.4). On a concave slope, deposition may occur on the lower end of the field such as in a deep depression or channel. In such cases, the appropriate length and gradient are those of that segment of the slope that is above the channel or point of deposition.

NOTE: Sediment yields are difficult to relate quantitatively to soil losses from a given construction site. Sediment yield is commonly expressed by $D_r = (S + /S_e) \times 100$. S + is total sediment passing a measuring station, S_e is loss estimated by the Universal Soil Loss Equation or other means and D_r is the sediment yield ratio in percentage. Research is sparse on this problem, but sediment yield rates range mostly from 10 to 70 percent, depending upon topographic characteristics and size of drainage areas.

Refer to Sections 5 and 8 for procedures in computing sediment storage capacities of debris basins.

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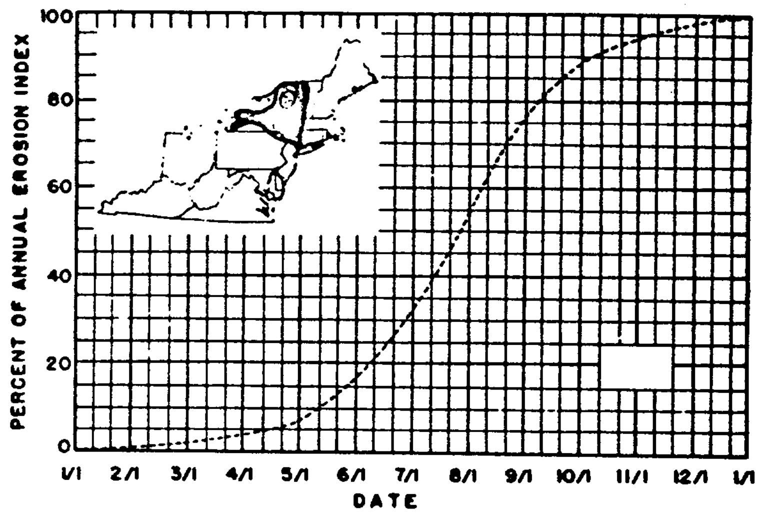
Figure B.1
Monthly Percent of Annual Erosion Index - New York



New York State except Long Island

Figure B.2
Monthly Percent of Annual Erosion Index - Long Island

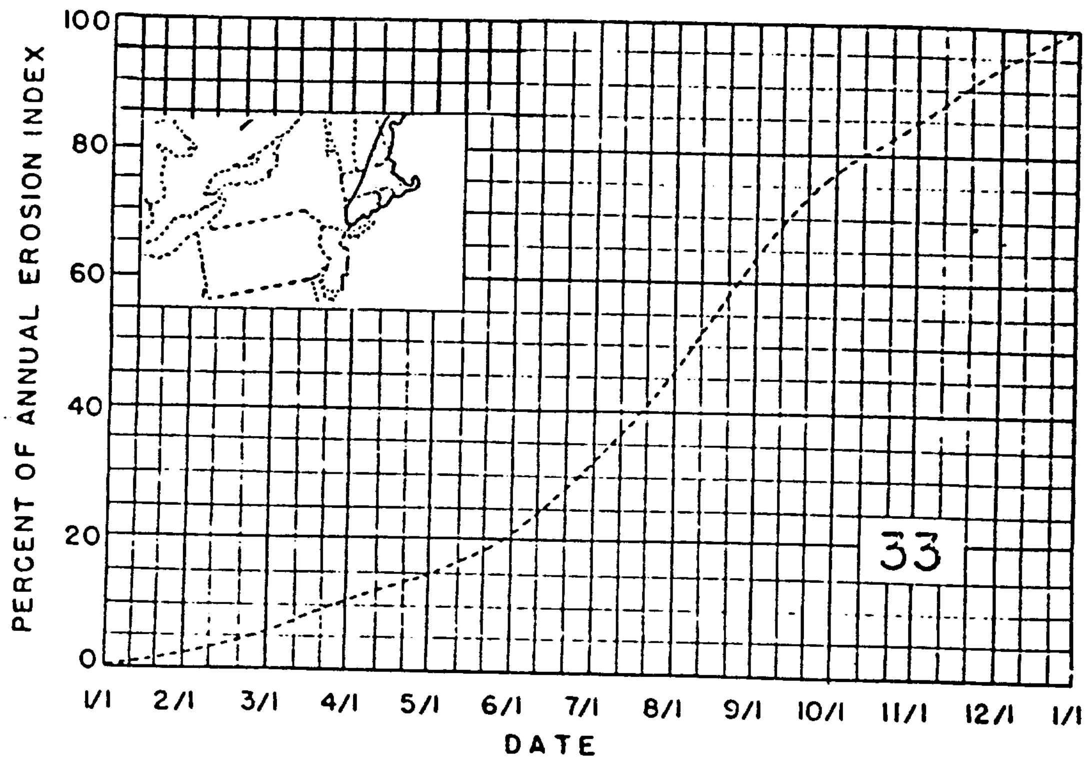


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Table B.1
Factors for Converting Soil Losses (Air-Dry) from Tons (T) to Cubic Yards (Cu. Yds.)

Soil	Conversion
Sands, loamy sands	Multiply soil losses in T by 0.70 (105)[1]
Sandy loam	
Fine sandy loam	
Loams, sandy clay loams	Multiply soil losses in T by 0.87 (85)
Sandy clay	
Silt loam	
Silty clay loam, silty clay	
Clay loam	Multiply soil losses in T by 1.06 (70)
Clay	

[1] The number in parentheses is the air-dry weight of the soil per cubic foot. The conversion factors were calculated from these air-dry weights.

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Table B.2
EI Values of Certain Key Cities in the New York Area[1]

	EI Values at 20% and 5% Probability Levels Probability (EI)		Expected Magnitude of a Single Storm EI Value Normally Exceeded Once in -		
Location	20%*	5%**	5 Years	10 Years	15 Years
New York					
Albany	114	159	38	47	56
Binghamton	106	146	36	47	58
Buffalo	96	139	36	49	61
Geneva	106	152	--	--	--
Marcellus	112	167	38	49	62
Rochester	101	151	38	54	75
Salamanca	106	157	32	40	49
Syracuse	129	197	38	61	65
Pennsylvania					
Erie	181	331			
Scranton	140	188	44	53	63
Vermont					
Burlington	114	178	35	47	58
Connecticut[2]					
New Haven	222	310	73	96	122
New Jersey					
Atlantic City	229	311	--	--	--
Marlboro	354	343	--	--	--
Trenton	216	308	--	--	--

* Once each five years

** Once each twenty years

[1] From Agricultural Handbook No. 537.

[2] For additional cities, refer to Agricultural Handbook 537.

Table B.3
Approximated K Values for Some Representative Soils on Construction Sites in New York

Depositional Unit, Family Textural Class and Representative Series	Horizon[1]	Texture[2]	Erodibility Class & K Values Class	K Values[3,4] Range	Norm
I. Glacial Till					
SANDY SKELETAL					
Glouster	A	sl	Low	0.10-0.20	0.17
	B & C	vglcs	Low	0.10-0.20	0.17
SANDY w/PAN					
Essex	A	sl	Low	0.10-0.20	0.17
	B	gls	Low	0.10-0.20	0.17
	Cx	glcs	Low	0.10-0.20	0.17
COARSE LOAMY w/PAN					
Empeyville	A	stl	Medium	0.24-0.32	0.28
	B	stsl	Medium	0.24-0.32	0.28
	Bx	vstsl	Low	0.10-0.20	0.17
	C	vstsl	Low	0.10-0.20	0.17
Mardin	A	ch sil	Low	0.10-0.20	0.17
	B	ch sil-1	Medium	0.24-0.32	0.28
	Bx & C	v ch l	Medium	0.24-0.32	0.28
Paxton	A	fsl	Medium	0.24-0.32	0.28
	B	gfsl	Medium	0.24-0.32	0.28
	Cx	gfsl	High	0.37-0.49	0.43
Crary	A	sil	Medium	0.24-0.32	0.28
	B	vfsl	High	0.37-0.49	0.43
	IIBx, Cx, C	st fsl	Medium	0.24-0.32	0.28
COARSE LOAMY w/Bt					
Madrid	A	fsl	Medium	0.24-0.32	0.28
	Bt	gfsl	Medium	0.24-0.32	0.28
	C	gfsl	Medium	0.24-0.32	0.28
COARSE LOAM, 20 to 40" over BEDROCK					
Lordstown	A	ch sil	Low	0.10-0.20	0.17
	B	ch sil	High	0.37-0.49	0.43
	C	v ch l	Low	0.10-0.20	0.17
	R		Siltstone or sandstone bedrock 20 to 40" below surface.		
FINE LOAMY w/Bt					
Ontario	A	l	Medium	0.24-0.32	0.28
	Bt	gl	Medium	0.24-0.32	0.28
	C	gl	Medium	0.24-0.32	0.28

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Table B.3 (cont'd)
Approximated K Values for Some Representative Soils on Construction Sites in New York

Depositional Unit, Family Textural Class and Representative Series	Horizon[1]	Texture[2]	Erodibility Class & K Values: Class	K Values[3,4]: Range	Norm
I. Glacial Till (cond't)					
Cazenovia	A	sil	High	0.37-0.49	0.43
	Bt	sicl	High	0.37-0.49	0.43
	C	gsil	Medium	0.24-0.32	0.28
Nunda	Ap	ch sil	High	0.37-0.49	0.43
	B2	ch sil	High	0.37-0.49	0.49
	IIB2t	gcl	Medium	0.24-0.32	0.28
	IIC	gl	Medium	0.24-0.32	0.28
FINE					
Hornell	A	sil	Medium	0.24-0.32	0.28
	B	sic	High	0.37-0.49	0.43
	C	sh sic	Medium	0.24-0.32	0.28
	R		Shale bedrock 20 to 40" below surface.		
Remsen	A	sicl	High	0.37-0.49	0.43
	Bt	c	Medium	0.24-0.32	0.28
	C	c	High	0.37-0.49	0.43
Churchville	A	sil	High	0.37-0.49	0.43
	Bt	sic	Medium	0.24-0.32	0.28
	IIC	gl	Medium	0.24-0.32	0.28
COARSE LOAMY, NO PAN					
Charlton	A	fsl	Low	0.10-0.20	0.17
	B	fsl	High	0.37-0.49	0.43
	C	gfsl	Medium	0.24-0.32	0.28
Nellis	A	l	Medium	0.24-0.32	0.28
	B	l	High	0.37-0.49	0.43
	C	gl	Medium	0.24-0.32	0.28
Pittsfield	A	l	Medium	0.24-0.32	0.28
	B	gfsl	Low	0.10-0.20	0.17
	C	gfsl	High	0.37-0.49	0.43
COARSE LOAMY/SANDY or SANDY SKELETAL					
Canton	A	fsl	Medium	0.24-0.32	0.28
	B	fsl	Very High	0.55-0.78	0.64
	IIC	vgls	Low	0.10-0.20	0.17
COARSE SILTY w/PAN					
Canaseraga	A	sil	High	0.37-0.49	0.43
	B	sil	Very High	0.55-0.78	0.46
	IIBx & C	ch	High	037-0.49	0.43

Table B.3 (cont'd)
Approximated K Values for Some Representative Soils on Construction Sites in New York

Depositional Unit, Family Textural Class and Representative Series	Horizon[1]	Texture[2]	Class	Erodibility Class & K Values K Values[3,4] Range	Norm.
I. Glacial Till (cond't)					
LOAMY SKELETAL					
Manlius	A	sh	Medium	0.24-0.32	0.28
	B	vsh sil	Low	0.10-0.20	0.17
	C	fract'd shales w/ silty fines	Low	0.10-0.20	0.17
	R		Shale bedrock 20 to 40" below surface.		
FINE LOAMY w/PAN					
Volusia	A	ch sil	Low	0.10-0.20	0.17
	Bx	ch sil	High	0.37-0.49	0.43
	C	vch l	Medium	0.24-0.32	0.28
FINE LOAMY, NO PAN					
Kendaia	A	sil	Medium	0.24-0.32	0.28
	B	gsil	Medium	0.24-0.32	0.28
	C	gl	Medium	0.24-0.32	0.28
II. Glacial Outwash and Water Worked Morainic Deposits					
SANDY SKELETAL					
Hinckley	A	ls	Low	0.10-0.20	0.17
	B	gls	Low	0.10-0.20	0.17
	C	vgs	Low	0.10-0.20	0.17
SANDY					
Colonie	A	lfs	Medium	0.24-0.32	0.28
	B	fs	Low	0.10-0.20	0.17
	C	fs	Low	0.10-0.20	0.17
LOAMY SKELETAL					
Chenango	A	gl	Low	0.10-0.20	0.17
	B	vgl	Low	0.10-0.20	0.17
	C	gls	Low	0.10-0.20	0.17
FINE LOAMY/SANDY or SANDY SKELETAL					
Palmyra	A	gl	Low	0.10-0.20	0.17
	B	gl	Medium	0.24-0.32	0.28
	IIC	g & s	Low	0.10-0.20	0.17
LOAMY SKELETAL/CLAYEY					
Varysburg	A	gl	Low	0.10-0.20	0.17
	B2t	vgl	Low	0.10-0.20	0.17
	IIB2t	sic	Medum	0.24-0.32	0.28
	IIC	layered sic,sil sicl	High	0.37-0.49	0.43

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Table B.3 (cont'd)
Approximated K Values for Some Representative Soils on Construction Sites in New York

Depositional Unit, Family Textural Class and Representative Series	Horizon[1]	Texture[2]	Class	Erodibility Class & K Values K Values[3,4] Range	Norm
II. Glacial Outwash and Water Worked Morainic Deposits (cond't)					
COARSE LOAMY					
Riverhead	A	sl	Low	0.10-0.20	0.17
	B	sl	Low	0.10-0.20	0.17
	C	s w/ thin layers of g	Low	0.10-0.20	0.17
COARSE LOAMY/SANDY or SANDY SKELETAL					
Haven	A	l	High	0.37-0.49	0.43
	B	l	High	0.37-0.49	0.43
	IIC	gs	Low	0.10-0.20	0.17
III. Lacustrine or Stream Terrace Deposits					
COARSE SILTY					
Unadilla	A	sil	High	0.37-0.49	0.43
	B	sil	Very High	0.55-0.78	0.64
	C	sil	Very High	0.55-0.78	0.64
COARSE SILTY w/FRAGIPAN					
Williamson	A	sil	High	0.37-0.49	0.43
	Bx	sil	Very High	0.55-0.78	0.64
	C	sil	Very High	0.55-0.78	0.64
COARSE SILTY/SANDY or SANDY SKELETAL					
Allard	A	sil	High	0.37-0.49	0.43
	B	sil	Very High	0.55-0.78	0.64
	IIC	vgls	Low	0.10-0.20	0.17
FINE SILTY w/Bt					
Collamer	A	sil	High	0.37-0.49	0.43
	Bt	sil	High	0.37-0.49	0.43
	C	Layers of sl, vfs	Very High	0.55-0.78	0.64
FINE					
Schoharie	A	sicl	High	0.37-0.49	0.43
	Bt	sic	Medum	0.24-0.32	0.28
	C	sic	High	0.37-0.49	0.43
VERY FINE					
Vergennes	A	c	High	0.37-0.49	0.43
	Bt	c	Low	0.10-0.20	0.17
	C	c	Low	0.10-0.20	0.17

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Table B.3 (cont'd)
Approximated K Values for Some Representative Soils on Construction Sites in New York

Depositional Unit, Family Textural Class and Representative Series	Horizon[1]	Texture[2]	Class	Erodibility Class & K Values K Values[3,4] Range	Norm.
III. Lacustrine or Stream Terrace Deposits (cond't)					
SANDY o/CLAYEY					
Claverack	A	lfs	Medium	0.24-0.32	0.28
	B	lfs	Low	0.10-0.20	0.17
	IIC	sic	High	0.37-0.49	0.43
COARSE LOAMY o/CLAYEY					
Elmwood	A	fsl	Medium	0.24-0.32	0.28
	B	sl	Low	0.10-0.20	0.17
	C	sicl	HIgh	0.37-0.49	0.43

[1] The thickest B and C horizons in the official series descriptions were used in making the K value determinations.
[2] Soil texture abbreviations:

gravel	g	fine sandy loam	fsl	sandy clay loam	scl
very coarse sand	vcos	very fine sandy loam	vfsl	stony clay loam	stcl
coarse sand	cos	gravelly sandy loam	gs	silty clay	sic
sand	s	loam	l	clay	c
fine sand	fs	gravelly loam	gl	channery	ch
very fine sand	vfs	stony loam	stl	shaly	sh
loamy coarse sand	lcos	silt	si	very channery	vch
loamy sand	ls	silt loam	sil	very shaly	vsh
loamy fine sand	lfs	clay loam	cl	sandy loam	sl
silty clay loam	sicl				

[3] K values of the A horizons were taken from "K and T Factors of Soil Series Mapped in the Northeast Region", January 1970, USDA, SCS.

[4] K values of the fine earth fraction of the B and C horizons were determined by using the "Soil Erodibility Nomograph", W.H. Wishmeier, ARS-SWC, Purdue University, 2-1-71. (See Figure B.3.) The K values for the fine earth fraction were then adjusted for coarse fragment content and bulk density based on the following criteria: 15 to 35 percent coarse fragments; decrease K value 1/3. Greater than 35 percent coarse fragments; decrease K value 1/2. Bulk density greater than 2g/cc or 125 lbs./cu. ft.; decrease K value 1/10.

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Figure B.3
Soil Erobility Nomograph

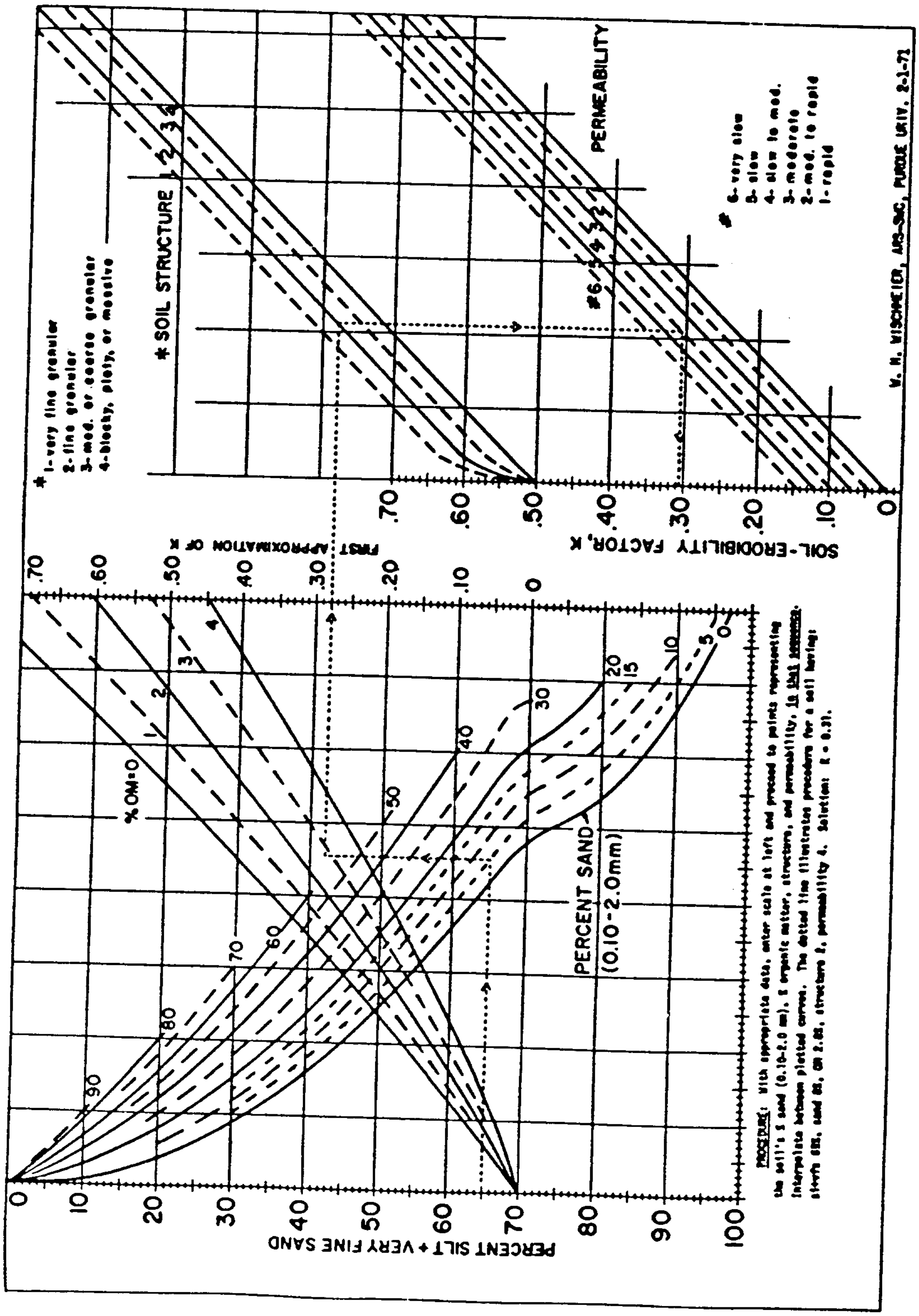

Table B.4
Slope-Effect Table

Slope Length in Feet (L)	LS Value % Slope(s)															
	2	4	6	8	10	12	14	16	18	20	25	30	35	40	50	100
10	.1	.1	.2	.3	.4	.6	.7	.9	1.1	1.3	2.0	2.7	3.6	4.6	6.9	25.7
15	.1	.2	.3	.4	.5	.7	.9	1.1	1.4	1.6	2.4	3.3	4.4	5.6	8.4	31.5
20	.1	.2	.3	.4	.6	.8	1.5	1.3	1.6	1.9	2.8	3.8	5.0	6.4	9.7	36.4
25	.1	.2	.3	.5	.7	.9	1.2	1.4	1.7	2.1	3.1	4.3	5.6	7.2	10.9	40.7
30	.1	.2	.4	.5	.8	1.0	1.3	1.6	1.9	2.3	3.4	4.7	6.1	7.9	11.9	44.6
35	.1	.2	.4	.6	.8	1.1	1.4	1.7	2.1	2.5	3.7	5.1	6.7	8.5	12.9	
40	.2	.3	.4	.6	.9	1.2	1.5	1.8	2.2	2.7	3.9	5.4	7.1	9.1	13.8	
50	.2	.3	.5	.7	1.0	1.3	1.7	2.0	2.4	3.0	4.4	6.0	8.0	10.2	15.4	
60	.2	.3	.5	.8	1.1	1.4	1.8	2.2	2.7	3.3	4.8	6.6	8.7	11.2	16.9	
100	.2	.4	.7	1.0	1.4	1.8	2.3	2.8	3.5	4.2	6.2	8.5	11.3	14.4	21.8	
200	.3	.6	1.0	1.4	2.0	2.6	3.3	4.0	5.0	5.9	8.7	12.1	15.9	20.4		
300	.4	.7	1.2	1.7	2.4	3.2	4.0	5.0	5.9	7.3	10.7	14.8	19.5	24.9		
400	.4	.8	1.4	2.0	2.8	3.6	4.7	5.0	6.0	8.4	12.4	17.1	22.6			
500	.5	.9	1.5	2.2	3.1	4.1	5.2	6.4	7.6	9.4	13.8	19.1	25.2			
600	.5	1.0	1.7	2.4	3.4	4.5	5.7	7.0	8.3	10.3	15.1	20.9				
800	.6	1.2	1.9	2.8	3.9	5.1	6.7	8.1	9.6	11.9	17.5	24.1				
1000	.7	1.3	2.1	3.14	4.4	5.8	7.4	9.1	10.8	13.3	19.5					

$(LS) = \sqrt{L} \times (.76 + .53s + .076s^2)$

Table B.5
Guide to Classification of Vegetal Covers in Waterways and Channels as to Degree of Retardness

Retardance and Cover	Stand	Condition and Height
Retardance A		
Reed canarygrass	Excellent	Tall (Average 36")
Tall fescue	Excellent	Tall (Average 36")
Smooth bromegrass	Excellent	Tall (Average 36")
Switchgrass	Excellent	Tall (Average 36")
Retardance B		
Alfalfa	Good	Uncut (Average 11" tall)
Tall fescue	Good	Average (20" tall)
Smooth bromegrass	Good	Average (20" tall)
Switchgrass	Good	Average (20" tall)
Red fescue	Good	Uncut (Average 16" tall)
Kentucky bluegrass	Good	Uncut (Average 16" tall)
Redtop	Good	Average (22" tall)
Retardance C		
Kentucky bluegrass	Good	Headed (6 to 12")
Grass-legume mixture (orchardgrass, ryegrass and birdsfoot trefoil)	Good	Uncut (6 to 8")
Red fescue	Good	Headed (6 to 12")
Retardance D		
Kentucky bluegrass	Good	Cut to 2.5"
Grass-legume mixture	Good	Uncut, 4"
Red fescue	Good	Cut to 2.5"

Retardance is the degree of resistance to flow by vegetation. Retardance "A" is high, while retardance

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APPENDIX C
FIELD MEASUREMENT OF RILL EROSION IN TONS PER ACRE

The method explained below for measuring rill erosion in tons per acre is known as the Alutin Rill Erosion Method. This procedure accounts for 80 percent of lysimeter measures that involve losses of 5 to 100 tons per acre. Losses greater than 100 tons per acre are usually beyond the realm of rilling

The basic formula used in this calculation is:

Tons Per Acre Soil Loss = sum of cross section of rills in square inches along a measured lineal distance of 14.0 feet across the slope.

The procedure for field measuring rill erosion that is generally accepted is as follows:

Step 1 -- Pace off or measure a lineal distance of 42 or 84 feet across the slope.

Step 2 -- Measure in inches the width and depth of each rill along the chosen distance.

Step 3 -- Multiply each width and depth reading to obtain the area in square inches.

Step 4 -- Add all products of readings along chosen distance.

Step 5 -- Divide this sum by 3 if a 42 foot distance was selected and by 6 if 84 feet was chosen. The result is tons of soil loss per acre.

EXAMPLE:

Width (in.) x	Depth (in.) =	Area in square inches
3	3	9
2	3	6
3	6	18
4	6	24
3	5	15
5	6	30
		102

For a chosen distance of 42 feet, the soil loss in tons per acre = 102/3 = 34.

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APPENDIX D
EXCERPTS FROM EROSION AND SEDIMENT CONTROL ORDINANCES

NEW YORK, ROCKLAND COUNTY: Resolution Concerning Site Drainage Erosion and Sedimentation

RESOLUTION No. 414 - RESOLUTION CONCERNING SITE DRAINAGE EROSION AND SEDIMENTATION

WHEREAS, There have been several inquiries concerning the appropriateness of the further clarification and guidelines in the establishment of grades, contours, drainage and ground cover concerning developments with in the Town of Orangetown; and

WHEREAS, The Rockland County Soil and Water Conservation District has recommended certain standards and guidelines be adopted by the various municipalities within the County of Rockland; and

WHEREAS, Pursuant to Section 21-7 of the Land Development Regulations of the Town of Orangetown and other related sections, the Planning Board has jurisdiction over the review of all plans, plats and control over the plans for the development of subdivisions; and

WHEREAS, It is the desire of the Town Board to provide further guidelines to the Planning Board for the review of subdivisions, now, there fore be it

RESOLVED, That the Planning Board adopt the following guidelines in the review of all subdivisions submitted to it for consideration:

1. Three (3) sets of plans for the control of drainage, erosion and sedimentation shall be submitted to the Planning Board, or its duly authorized representative, at the time the final drawings or construction plans are submitted. These plans shall bear the approval of the Soil and Water Conservation District that the proposed measures to provide drainage and erosion and sedimentation control are adequate.

2. Measures to provide the control of drainage, erosion and sedimentation shall be described and provided for in the construction plans and the estimated cost of accomplishing said measures shall be included in the performance bond. In addition, thereto, the landowner shall be required to provide a cash escrow guarantee to be held by the Town) in an amount determined by the Planning Board or its duly authorized representative, which would insure the Town that emergency measures could be taken by the Town at the landowner's expense due to the nonconformance or negligence of the landowner in his construction program.

3. During the construction phase consultive technical assistance will be furnished, if necessary, by the Planning Board or its duly authorized representative of the Soil and Water Conservation District.

   The Planning Board or its duly authorized representative shall enforce compliance with the approved plans.

4. The Planning Board or its duly authorized representative shall make a continuing review and evaluation of the methods used and the overall effectiveness of the drainage and erosion and sedimentation control program.

   The following control measures should be used for effective control of drainage and erosion and sediment:

   a. The smallest practical area of land should be exposed at any one time during construction.
   b. When land is exposed during construction, the exposure should be kept to the shortest practical period of time.
   c. Where necessary, temporary vegetation and/or mulching should be used to protect areas exposed during construction.
   d. Sediment basins (debris basins, desilting basins, or silt traps) should be installed and maintained to remove sediment from runoff waters and protect land undergoing change.
   e. Provisions should be made to effectively accommodate the increased runoff caused by changed soil and surface conditions during and after construction.
   f. The permanent final vegetation and structures should be installed as soon as practical in the construction.
   g. The development plan should be fitted to the topography and soils so as to create the least erosion potential.
   h. Wherever feasible, natural vegetation should be retained and protected, and be it

RESOLVED Further, That the Office of Building, Zoning and Planning Administration and Enforcement shall be responsible for the inspection and enforcement of any decisions rendered by the Planning Board in connection with these guidelines.

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SECTION 404. Drainage System, Flood Hazards and Erosion Control

A. Drainage Systems

Adequate and comprehensive drainage systems shall be provided to convey the storm water runoff originating within and outside the subdivision in accordance with the natural direction of runoff for the total upland watershed area affecting the subdivision. Such drainage systems shall have sufficient capacity to accommodate the potential future runoff based upon the probable land use and ultimate development of the total watershed area upland of the subdivision.

In general, the preservation of natural watercourses is preferable to the construction of drainage channels, and wherever practicable such natural watercourses should be preserved. Attention is called to the possibilities of using easements for natural watercourses to satisfy the open space requirements of "average density" developments under the Zoning Ordinance. Storm sewers and subdivision drainage facilities shall be based upon a design flow with a minimum return interval of 10 years. The design of natural watercourse channels shall depend upon the drainage are according to the following table.

DESIGN RETURN INTERVALS FOR NATURAL WATERCOURSES

Drainage Area	Recurrence Interval
Above 20 square miles	100 years
Between 4 and 20 square miles	50 years
Less than 4 square miles	25 years

B. Flood Hazard Prevention

Flood hazard prevention shall include the control of soil erosion of land surface and drainage channels and the prevention of inundation and excessive ground water seepage by comprehensive site grading and the establishment of adequate elevations of buildings, building openings and roadways above the observed, anticipated or computed water levels of storm sewers, streams, channels, flood plains, detention basins and swales.

Particular attention shall be paid to development in the vicinity of West Creek and its flood plain; and no alteration of the existing characteristics of this area shall take place without the specific approval of the Town Engineer as to the adequacy of the protective measures taken, if any, and the effects of such development on upstream and downstream reaches of the watercourse and adjacent properties.

C. Erosion Control

In order to ensure that the land can be developed without danger to health or peril from fire, flood or other menace, the Planning Board shall require the developer to follow certain erosion control practices as it deems necessary. Both the Planning Board and the developer shall consult with the Town Engineer, as required, and the Town Engineer shall determine whether or not the required procedures are being put into practice. Such procedures may include:

1. Exposing the smallest practical area of land at any one time during development.
2. Provision of temporary vegetation and/or mulching to protect critical areas
3. Provision of adequate drainage facilities to accommodate effectively the increased runoff caused by changed soil and surface conditions during and after development.
4. Fitting of the development plan to the topography and soils so as to minimize the erosion potential.
5. Retention and protection of natural vegetation wherever possible.
6. Installation of permanent final vegetation and structures as soon as practicable.
7. Provision of adequate protective measures when slopes in excess of 10% are graded; and minimizing such steep grading.

MARYLAND, MONTGOMERY COUNTY: Sediment Control Ordinance

(Amendment to the Subdivision Ordinance, Chapter 104, as Codified in 1965 Montgomery County (Maryland) Code, Adopted April 21, 1957.)

A new subsection is added to Section 104-24 Preliminary Subdivision Plan - Approval Procedure to be known as Section 104-24 (i) as follows:

(i) Sediment Control (adopted 6/27/67). The approval of all preliminary plans and extensions of previously approved plans shall include provisions for erosion and sediment control, in accordance with the Montgomery County Sediment Control Program, adopted by the County Council, June 29, 1965.

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(1) The Board, in its consideration of each preliminary plan or extension of previously approved plan, shall condition its approval upon the execution by the subdivider of erosion and sediment control measures to be specified by the Board after receiving recommendations from the Montgomery Soil Conservation District.

(2) One copy of each approved preliminary plan or extension of previously approved plan shall be referred to the Montgomery Soil Conservation District for review and recommendations as to adequate erosion and sediment control measures to prevent damage to other properties.

(3) The installation and maintenance of the specified erosion and sediment control measures shall be accomplished in accordance with the procedures for Public Works Agreement as specified in Section 104-26(g) and in accordance with standards and specifications on file with the Montgomery Soil Conservation District.

(4) Permits for clearing and grading prior to the recordation of plats shall be obtained from the Department of Public Works subject to the granting of temporary easements and other conditions deemed necessary by the Department in order to inspect and enforce the performance of the specified erosion and sediment control measures provided for in subsection (1) above.

(5) In the event the subdivision proceeds to clear and grade prior to recording of plats, without satisfying the conditions specified under Section 4, the Board may revoke the approval of the preliminary plan or extension of previously approved plan.

Amend Article I, Section 23-2, General Requirements (of subdivision plans), by the addition of a new paragraph to be known as 23-2(1) to read as follows:

(1) Erosion and Sediment Control Measures

Adequate controls of erosion and sediment control methods shall be provided prior to any clearing, grading or construction.

Amend Section 23-8, Preliminary Plats - Preparation, by the addition of a new paragraph to be known as 23-8(g) to read as follows: (Preliminary plats shall include a)

(g) Statement that erosion and sediment control methods shall be provided prior to any clearing, grading or construction.

Amend Article 2 of Chapter 23 by the addition of a new paragraph to Section 23-12, Final Plats - Approval, to be known as 23-12(c) to read as follows: (Plats shall be approved only if)

(c) Plans and specifications for the control of erosion and sedimentation, if such controls are deemed necessary, have been submitted and approved by the Director of Public Works or his agent. This approval shall be concurrent with the approval of the aforesaid plans and specifications and become a part thereof.

MARYLAND - STATE-WIDE HOUSE BILL NO. 1151 (1970): Sediment Control

Section 3. And be it further enacted, the new Sections 105 through 110 inclusive be and they are hereby added to Article 96A of the Annotated Code of Maryland (1957 Edition, 1961 Replacement Volume and 1969 Cumulative Supplement), title "Water Resources," to follow immediately after Section 104 therefore and to be under the new subtitle "Sediment Control" and to read as follows:

105: The General Assembly of the State of Maryland hereby determines and finds that the lands and waters comprising the watersheds of the State are great natural assets and resources; that as a result of erosion and sediment deposition on lands and in waters within the watersheds of the State, said waters are being polluted and despoiled to such a degree that fish, marine life and recreational use of the waters are being adversely affected. In order to protect the natural resources of the State, the Secretary of Natural Resources is directed to adopt criteria and procedures to be used by the counties and the local Soil Conservation Districts to implement soil and shore erosion control programs. Such procedures may provide for the review and approval of major grading, sediment and erosion control plans by the Department of Natural Resources.

106: (A) Before land is cleared, graded, transported or otherwise disturbed for purposes including, but not limited to the construction of buildings, the mining of minerals, the development of golf courses and the construction of roads and streets by any private person, partnership, corporation, municipal corporation, county or state agency within the State of Maryland, the proposed earth change shall first be submitted to and approved by the appropriate Soil Conservation District. Land clearing, soil movement and construction shall be carried out in accordance with the written recommendations of the said Soil Conservation Districts regarding the control of erosion and siltation and the elimination of pollution.

(B) In Prince George's and Montgomery Counties, the Washington Suburban Sanitary Commission shall, after consultation with and advice of the Soil Conservation Districts of the two counties and the Depart-

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ment of Natural Resources, prepare and adopt regulations for erosion and siltation control requirements for utility construction, with the regulations to be adopted and enforced as are other regulations of the Commission pursuant to the authority conferred upon it by other laws. The provisions of this subsection shall not apply until erosion and siltation control requirements for utility construction have been approved by the Soil Conservation Districts in each county.

(C) The Department of Natural Resources shall assist the Soil Conservation Districts in the preparation of a unified sediment control program and in the implementation of said program pursuant to this subtitle. Furthermore, nothing in this subtitle shall affect the responsibilities of the Department of Water Resources under Article 96A of the Annotated Code of Maryland (1964 Replacement Volume and 1969 Supplement).

(D) Notwithstanding the provisions of this section, the Department of Natural Resources shall review and approve all land clearing, soil movement and construction activity undertaken by any agency of the State government.

107: The provisions of this subtitle shall not apply to agricultural land management practices, the construction of agricultural structures or to the construction of single family residences and/or their accessory buildings on lots of two acres or more. Regardless of planning, zoning or subdivision controls, no permits shall be issued by any county or municipality for grading or for the construction of any building, other than those matters exempted above, unless such grading or construction is in accordance with plans approved as provided in this subtitle.

108: (A) The counties and municipalities shall have the power and authority to issue grading and building permits as otherwise provided by law. No grading or building permits shall be issued until the developer submits a grading and sediment control plan designed by a professional engineer registered in the State of Maryland, approved by the appropriate Soil Conservation District and the developer certifies that all land clearing, construction and development will be done pursuant to the said plan. Criteria for sediment control and for referral of an applicant to the appropriate Soil Conservation District and the Department of Natural Resources. The county agency responsible for on-site inspection and enforcement of the provisions of this subheading shall make a final inspection and forward its report to the appropriate Soil Conservation District. Notice of violation of the provisions of this subtitle shall be filed with the Department of Natural Resources as well as with the appropriate county agency.

(B) Each county shall adopt grading and building ordinances, or portion thereof, which are necessary to carry out the provisions of this subtitle. The Department of Natural Resources and the appropriate Soil Conservation District shall assist the several counties in the development of such ordinances or necessary portions thereof. The provisions of this subsection shall be carried out prior to March 1, 1971. Prior to March 1, 1971, established ordinances and procedures shall be used by the counties to carry out the provisions of this subtitle.

109: Any violation of this subheading shall be deemed a misdemeanor, and the person, partnership or corporation who is found guilty of such violation shall be subject to a fine not exceeding five thousand dollars ($5,000) or one year's imprisonment for each and every violation. Any agency whose approval is required under this subheading or any person in interest may seek an injunction against any person, partnership or corporation, whether public or private, violating or threatening violation of any provisions of this subheading.

110: For the purposes of this subheading, the Bureau of Public Works or similar municipal agency is empowered and directed to act in the place of the appropriate Soil Conservation District in municipalities which are not within a Soil Conservation District.

MARYLAND, PRINCE GEORGE'S COUNTY: Procedure for Incorporating Erosion and Sediment Control in Subdivision Plans

Under this sediment control program, the following procedures are provided to assist landowners, developers and engineers in the inclusion of required erosion and sediment control measures in the planning and construction of subdivisions.

Prior to preparation and submission of a preliminary plan, but after completion of the topographic survey, a developer may seek technical assistance from staff members of the Soil Conservation District or the Prince George's County Planning Board regarding erosion and sediment control measures.

Preliminary Subdivision Plan Stage

Under existing procedures, developers submit plans to the Prince George's County Planning Board. The Planning Board staff, then on the basis of size, topography, erosion hazards and other factors relating to sedimentation, determines which plans will be submitted to the Soil Conservation District for review of erosion and sediment control measures. It so indicates on the copies referred to other agencies. Soil Conservation District technical assistance in developing needed erosion and sediment control measures will be furnished on request at this stage.

After all reviews are completed, the planning staff submits the plan to the Prince George's County Planning Board with recommendations, including any sediment control requirements deemed necessary. The Board may give conditional approval of the plan, subject to the requirements being carried out by the developer.

Construction Stage

Consultive technical assistance in establishing the planned erosion and sediment control measures is furnished by the Soil Conservation District on request of the builders, developers and their engineers, consistent with current operating policies and available resources at the time the work is to be done.

Article 22: Grading and Erosion Control to the Building Code

Section 2200.0 Purpose

The purpose of this article is to safeguard life, limb, property and public welfare by establishing minimum requirements for grading, drainage and erosion control of land within Prince George's County, Maryland, and to establish procedures by which these requirements are to be administered and enforced.

Section 2205.0 Application

A written application in form prescribed by the Building Official shall be required for each permit. Plans and specifications shall be submitted with each application for a grading permit, unless specifically not required by the Building Official.

(11) Site development plan showing elevations, dimensions, location, extent and the slope of all proposed grading, load bearing fill, buildings, parking areas, and driveways; all clearly indicated.

(12) The area in square yards of the total site minus that area to remain undisturbed and currently having an effective erosion resistant ground cover or surface.

(13) The planned area of the development, or of each subdivision thereof, the development sequence of such subdivision and the time of exposure of each area prior to completion of effective temporary and/or permanent erosion and sediment control measures.

(14) Adequate plans of all drainage provisions, retaining walls, cribbing, planting, antierosion devices or other protective devices to be constructed in connection with or as part of the proposed work, together with a map showing the drainage area of land tributary to the site and calculated runoff from the area served by all drains.

Section 2207.0 Soils Report

The Building Official shall, if load bearing fill is proposed, and may otherwise require a soils investigation to correlate surface and subsurface conditions with the proposed grading plan. The results of the investigation shall be presented in a report by a Soil Engineer which shall include but need not be limited to: data regarding the nature, distribution and supporting ability of existing soils and rock on the site, conclusions and recommendations for grading requirements and erosion control, including recommendations to insure stable soil conditions and ground water control as applicable. The Building Official may require such supplemental reports and date as he deems necessary. Recommendations included in such reports and approved by the Building Official shall be incorporated in the grading plan or specifications.

Section 2212.0 Conditions of Approval

In granting any permit pursuant to this article, the Building Official may impose such conditions as may be reasonably necessary to prevent creation of nuisance or unreasonable hazard to persons or to public or private property. Such conditions may include but need not be limited to: (1) The granting (or securing from others) and recordation in County Land Records, easements for drainage facilities, including the acceptance of their discharge on the property of others and for the maintenance of slopes or antierosion facilities.

(2) Adequate control of dust by watering or other control methods acceptable to the Building Official and in conformance with applicable air pollution ordinances.

(3) Improvement of any existing grading, ground surface or drainage conditions on the site to meet the standards required under this article for new grading, drainage and erosion control.

Section 2214.0 Responsibility of Permittee

Notwithstanding, other conditions or provisions of the permit, or the minimum standards set forth in this article, the Permittee is responsible for the prevention of damage to the adjacent property. No person shall grade on land in any manner, or so close to the property line as to endanger or damage any adjoining public street, sidewalk, alley or any other public or private property without supporting and protecting such property from settling, cracking, erosion, sediment or other damage or personal injury which might result.

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Section 2220.2 Inspection

After commencing initial grading operation, the Permittee shall request inspections at the following stages in the development of the site, or of each subdivision thereof:

(1) Upon completion of stripping, the stockpiling of topsoil and disposal of all unsuitable material; but prior to beginning any other preparation of the ground.

(2) Upon completion of preparation of ground to receive fill, but prior to beginning any placement.

(3) Upon completion of rough grading, but prior to placing top soil, permanent drainage or other site development improvements and ground covers.

(4) Upon completion of final grading; permanent drainage and erosion control facilities, including established ground covers and planting; and all other work of the permit.

Section 2225.0 Maintenance

In implementation of the Sediment Control Program for Prince George's County, as adopted by the Board of County Commissioners on June 20, 1967, all grading plans and specifications accompanying grading and/or combined grading and building permits shall include provisions for both interim (temporary) and ultimate (permanent) erosion and sediment control.

2228.1 - The design, installation and maintenance of erosion and sediment control measures shall be accomplished in accordance with guide standards adopted by Prince George's County Soil Conservation District on file with the Prince George's County Department of Inspections and Permits.

2228.2 - All graded surfaces, with particular emphasis on the face of all cut and fill slopes, shall be seeded, sodded and/or planted or otherwise protected from erosion as soon as practicable; and shall be watered, tended and maintained until growth is well established at time of completion and final inspection.

Section 2229.0 Preparation of Ground

2229.3 - Natural and/or existing slopes exceeding five (5) horizontal to one (1) vertical shall be benched or continuously stepped into competent materials prior to placing all classes of fill.

2229.4 - Fills toeing out on natural slopes steeper than four (4) horizontal to one (1) vertical shall not be made unless approved by the Building Official after receipt of a report by a Soil Engineer certifying that he has investigated the property, made soil tests and that in his opinion such steeper slopes will safely support the proposed fill.

2229.5 - All trees in areas of grade change shall be removed unless protected with suitable tree wells.

Section 2237.0 Drainage

The following provisions apply to a conveyance and disposal of stormwater runoff.

2237.1 - All drainage facilities shall be designed to convey surface water in such a manner to prevent detrimental erosion, overflow or ponding to the nearest practical street, storm drain or other watercourse in accordance with such applicable design criteria, standards and procedures as contained herein or otherwise required by the Prince George's County Public Works Department and by the Washington Suburban Sanitary Commission.

2237.2 - The ponding of water shall not be permitted above cut or fill slopes or on drainage terraces, nor shall water be impounded on adjacent property. Adequate drainage facilities shall be provided to prevent such ponding.

2237.3 - Erosion Control - The Permittee and the Owner shall make adequate provisions to prevent any surface waters from materially damaging the face of any excavation or fill. All slopes shall be temporarily and/or permanently protected from surface water runoff from above by interceptor and diversion berms, swales, brow or berm ditches and shall be sodded, seeded and/or planted; unless upon the recommendation of the Prince George's Soil Conservation District, the Building Official determines such treatment is unnecessary and specifically waives this requirement.

2237.5 Facilities and Improvements - All drainage terraces, interceptor and diversion berms, swales and brow or berm ditches shall be designed and constructed and, when required, shall be piped or paved or otherwise improved to the satisfaction of the Building Official. Drainage discharging into natural watercourses may require that such natural ground be protected from erosion by an adequate amount of riprap or other measures.

2237.6 Drainage Terraces - Cut and fill slopes in excess of thirty (30) feet but not more than sixty (60) feet in vertical heights shall be terraced at approximate mid-height. Terraces in slopes with a vertical height greater than sixty (60) feet shall be made at equal vertical intervals not more than thirty (30) feet apart. Drainage terraces shall be a minimum of five (5) feet wide with a minimum invert gradient of one percent (1%) if sodded or one half percent (1/2%) if paved; and must convey water to a safe disposal area.

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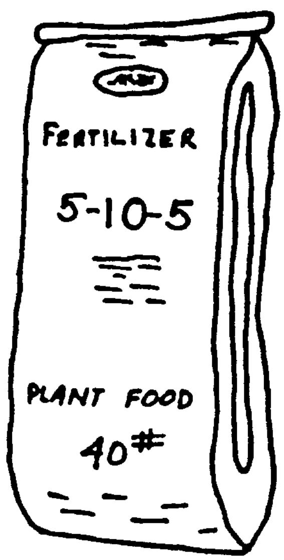
APPENDIX E
HOW TO READ FERTILIZER LABELS

FERTILIZER GRADE

5-10-5

MEANS

5%	-	**10%**	-	**5%**
NITROGEN	-	**PHOSPHORUS**	-	**POTASH**
(N)	-	**(P_2O_5)**	-	**(K_2O)**



OR

2 lbs.	-	**4 lbs.**	-	**2 lbs.**
N/40 lb. bag	-	**P_2O_5/40 lb. bag**	-	**K_2O/40 lb. bag**

R0039654

Nassau County Soil and Water Conservation District
1425 Old Country Road, Building J - Plainview, NY 11803 - Phone (516) 454-0900

EROSION AND SEDIMENT CONTROL PLAN REVIEW CHECKLIST

LEGEND FOR REVIEW CHECKLIST

AS = ALTERNATIVES SUGGESTED	A = ADEQUATE	INC = INCOMPLETE
R = REQUESTED, NOT SUBMITTED	NA = NOT APPLICABL	NC = NOT CHECKED

PROJECT NAME:______________________ SITE LOCATION:______________________

APPLICANT'S NAME & ADDRESS:______________________ ______________________

THE DISTRICT HAS REVIEWED THE SUBJECT PROPOSAL AND SUGGESTS THE FOLLOWING ITEMS BE REVISED TO PROVIDE THE PROPER SOIL EROSION, SEDIMENT, AND STORMWATER CONTROLS CONSISTENT WITH THE SUBJECT TOPOGRAPHY. TECHNICAL REVIEW SUPPLIED BY THE SOIL CONSERVATION SERVICE

PLANS - GENERAL

______1. Scope of plan clearly delineated and noted in title block

______2. Vicinity map with scale and north arrow.

______3. Legend, scales, north arrow for plan view.

______4. Existing and proposed topography shown, contours labeled and spot elevations at critical areas.

______5. Typical designs on plan review drawings shown for necessary diversion berms, interceptor drains and outlets, level spreaders, storm drain inlet protectors, grassed waterways, etc.

______6. Limit of 100 year floodplain delineated on plan.

______7. Existing and proposed improvements and utilities.

______8. The total disturbed area delineated on site plan:

______ a. Indicate the total acreage to be paved, roofed, sodded, seeded, etc.

______ b. Delineate all areas to be stabilized vegetatively by seeding, sodding, or ground covers.

______ c. Greenbelt areas are clearly delineated.

______9. Standard General Notes.

_____10. Scale.

_____11. Sequence of operations.

_____12. Stock pile area designated or referenced.

_____13. Property boundaries indicated, and easements as needed.

_____14. Street profiles.

_____15. Composite drainage area map for plans requiring more than one sheet, with sediment control measures shown in their approximate locations.

SOILS INFORMATION

_____16. Detailed soils Map attached or overlaid on plan map with interpretations.

_____17. Deep soil pit logs attached and exact location shown on plan map for all proposed dry and diffusion wells, and septic systems.

EROSION AND SEDIMENT CONTROL PLAN REVIEW CHECKLIST - Page 2

SOIL EROSION AND SEDIMENT CONTROL

_____18. Permanent Dikes (perimeter, diversion, interceptor)

- _____a. Practice meets purpose and design criteria.
- _____b. Positive drainage is maintained, and contributing drainage area shown
- _____c. Outlet to sediment trapping device or onto stable outlet
- _____d. Points of vehicular crossings shown and stabilized (mountable berm).
- _____e. Standard detail and construction specifications

_____19. Temporary Swales (interceptor, perimeter).

- _____a. Practice meets purpose and design criteria.
- _____b. Contributing drainage area shown.
- _____c. Channel grade exceeding ____% slope properly stabilized.
- _____d. Adequate outlet or discharge condition.
- _____e. Provisions for traffic crossing shown on plan.
- _____f. Standard detail and construction specifications

_____20. Traps (Rip-rap, earth, pipe, and storm inlet).

- _____a. Practice meets purpose and design criteria
- _____b. Contributing drainage area delineated on plan.
- _____c. Trap sized by largest drainage area (existing or developed) to trap.
- _____d. Type and size of outlet structure.
- _____e. Outlet conditions.
- _____f. Plan view of trap and storage area (drawn to scale with bottom dimensioned
- _____g. Volume calculations.
- _____h. Bottom, crest and clean-out (at 50% trap efficiency) elevations.
- _____i. Standard detail and construction specifications

_____21. Straw Bale Dike and Silt Fence

- _____a. Meets purpose and design criteria
- _____b. Controlled slope less than 100 feet
- _____c. Drainage area less than 1 acre per 100 feet of dike or fence. (for sheet erosion only)
- _____d. Standard detail and construction specifications

_____22. Grade Stabilization Structure (flume, pipe, slope drain, etc.)

- _____a. Meets purpose and design criteria
- _____b. Pipe drain size noted
- _____c. Contributing drainage area shown
- _____d. Standard detail and construction specifications

_____23. Permanent Structural Practices or Sediment Control Measures Exceeding the Design Criteria of the Standard detail.

- _____a. Practice meets purpose and design
- _____b. Drainage area map
- _____c. Runoff calculations
- _____d. Calculations for size, velocity, and Q
- _____e. Standard detail with dimensions and construction specifications

_____24. Provisions for protecting cut and fill slopes from surface runoff

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_____25. Site Grading

- _____a. Maximum created slope of 2 foot horiz. to 1 foot vert.
- _____b. Slopes requiring regular maintenance will be no steeper than 3 foot deep.
- _____c. Details of cut and fill slopes shown

_____26. Seeding Specification and Notes

- _____a. Seedbed Preparation
- _____b. Permanent seeding (mix and rate) - includes method of application.
- _____c. Temporary seeding (mix and rates) - includes method of application
- _____d. Mulching (includes anchoring method)
- _____e. Sod (type and installation)
- _____f. Fertilizer (amount and type)
- _____g. Lime (amount and type)
- _____h. Seeding dates (temporary and Permanent - to cover entire year).

_____27. Storm inlets adequately protected (detail required)

_____28. Stabilized construction entrances shown on plan (detail required)

_____29. Provisions for sediment and erosion control of areas disturbed for storm drain and utility construction.

_____30. Storm Drainage

- _____a. Drainage area map and computations
- _____b. Plan and profile indicating pipe size, type, slope, Q, structures, and inlet (type), top and invert elevations
- _____c. Proposed outlet protection dimensions and computations.
- _____d. Constructed outfall ditch or swale cross-section and flow computations for depth and velocity
- _____e. Profile of outfall sufficient to show natural gradient of accepting channel or conduit.
- _____f. Outlet protection of 0% slope for minimum required distance

_____31. Riprap and Gabions

- _____a. Median stone size and minimum depth of treated section shown on plan.
- _____b. Riprap placed upon approved filter cloth
- _____c. Cross-section detail of treated areas

_____32. Permit notification from other agencies

_____33. Storm Water Management referred to:________________ Date:

Nassau County DPW __________ ________

Town of __________ ________

City of __________ ________

Village __________ ________

______34. Sediment Basin or Recharge Basin

- ______a. Seedbed preparation, seeding rate and method of application, and mulch details included.

ADDITIONAL COMMENTS

Plans reviewed by: ________________ Date Reviewed: ______________________

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GLOSSARY

SECTION 12
GLOSSARY

The list of terms that follows is representative of those used by soil conservationists, soil scientists, engineers, developers, contractors, planners, etc. The terms are in common use in conservation matters.

ACCESS ROAD - A road or vehicular travel way constructed to provide needed access.

ACRE-FOOT - The volume of water that will cover 1 acre to a depth of 1 foot.

AESTHETIC VALUE - The increase in value of a property derived from such intangible factors as its inherent attractiveness, its access to attractive views, or its general appeal to the sense of beauty of the owner or purchaser.

A-HORIZON - The organic material and leached minerals in the uppermost layer of soil.

AMORTIZATION - To repay a debt in a sequence of equal payments. Part of each payment is used to pay the interest due at the time it is made, and the balance is applied to the reduction of the principal.

ANGLE OF REPOSE - Angle between the horizontal and the maximum slope that a soil assumes through natural processes.

ANTECEDENT MOISTURE CONDITION (AMC) - The degree of wetness of a watershed at the beginning of a storm.

APRON - A floor or lining to protect a surface from erosion; for example, the pavement below chutes, spillways, or at the toes of dams.

ASSESSED VALUE - The value placed on property for taxation purposes.

ASSOCIATED COSTS - A term commonly used in water resource development projects. These costs include the value of goods and services needed over and above project costs to make the immediate products or services of a project available for use or sale.

BASE FLOW - The stream discharge from groundwater runoff.

BEDDING - The process of laying a drain or other conduit in its trench and tamping earth around the conduit to form its bed. The manner of bedding may be specified to conform to the earth load and conduit strength.

BEDLOAD - The sediment that moves by sliding, rolling, or bounding on or very near the streambed; sediment moved mainly by tractive or gravitational forces or both, but at velocities less than the surrounding flow.

B-HORIZON - The intermediate layer of clays and oxides in a soil below the A-horizon; also called the zone of accumulation.

BENCH MARK (economics) - Data for a specific time period that is used as a base for comparative purposes with comparable data.

(engineering) - A point of reference in elevation surveys.

BERM - A shelf that breaks the continuity of a slope.

BLIND - Placement of loose soil around a tile or conduit to prevent damage or misalignment when the trench is backfilled. Allows water to flow more freely to the tile.

BLIND DRAIN - A type of drain consisting of an excavated trench refilled with pervious materials, such as coarse sand, gravel or crushed stone, where water percolates through the voids and flows toward an outlet. Often referred to as a French drain because of its initial development and widespread use in France.

BLIND INLET - Inlet to a drain in which entrance of water is by percolation rather than open flow channels.

BRUSH LAYERING - The embedment of green branches of shrub or tree species, perpendicular to the slope, on successive horizontal rows or contours.

BRUSH-MATTING - A mulch of hardwood brush fastened down with stakes and wire.

cfs. - Abbreviation for cubic feet per second. A unit of water flow.

CAPITAL RECOVERY PERIOD - The period of time required for the net returns from an outlay of capital to equal the investment.

CAPITALIZED COST - The first cost of an asset plus the present value of all renewals expected within the planning horizon.

CHANNEL - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

CHANNEL IMPROVEMENT - The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

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CHANNEL STABILIZATION - Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

COMPACTION - To unite firmly; the act or process of becoming compact, usually applied in geology to the changing of loose sediments into hard, firm rock. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per cubic foot.

CONDUIT - Any channel intended for the conveyance of water, whether open or closed.

CONIFER - A tree belonging to the order Coniferae, usually evergreen, with cones and needle-shaped or scale-like leaves and producing wood known commercially as "soft wood."

CONSERVATION - The protection, improvement, and use of natural resources according to principles that will assure their highest economic or social benefits.

CONSERVATION DISTRICT - A public organization created under state enabling law as a special purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body and always with limited authorities. Often called a soil conservation district or a soil and water conservation district.

CONTOUR - 1. An imaginary line on the surface of the earth connecting points of the same elevation.

2. A line drawn on a map connecting points of the same elevation.

CONTOUR INTERVAL - The vertical distance between contour lines.

CONTOUR MAP - A map that shows the shape of the surface features of the ground by the use of contours.

CONTOUR WATTLING - The packing of lengths of bundles of twigs or whips into a continuous length partially buried across a slope at regular contour intervals and supported on the downhill slide by stakes.

CREST - 1. The top of a dam, dike, spillway, or weir, frequently restricted to the overflow portion.

2. The summit of a wave or peak of a flood.

CRITICAL SITE - A sediment producing, highly erodible, or severely eroded area or site.

CRITICAL VELOCITY - Velocity at which a given discharge changes from tranquil to rapid flow; that velocity in open channels for which the specific energy (sum of the depth and velocity head) is a minimum for a given discharge.

CROSS-SECTION - A drawing that shows the features that would be exposed by a vertical cut through a man-made or natural structure.

CROWN (forestry) - The upper part of a tree, including the branches and foliage.

CUBIC FOOT PER SECOND - Rate of fluid flow at which 1 cubic foot of fluid passes a measuring point in 1 second. (Abbr. cfs.) (Syn. Second-foot; CUSEC.) See cfs.

CUT - Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

CUT-AND-FILL - Process of earth moving by excavating part of an area and using the excavated material for adjacent embankment or fill areas.

CUTOFF - 1. Wall, collar, or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

2. In river hydraulics, the new and shorter channel formed either naturally or artificially when a stream cuts through the neck of a band.

DEBRIS DAM - A barrier built across a stream channel to retain rock, sand, gravel, silt, or other material.

DEBRIS GUARD - Screen or grate at the intake of a channel, drainage, or pump structure for the purpose of stopping debris.

DECIDUOUS PLANT - A plant that sheds all its leaves every year at a certain season.

DEGRADATION - To wear down by erosion, especially through stream action.

DEPOSIT - Material left in a new position by a natural transporting agent, such as water, wind, ice, or gravity, or by the activity of man.

DESIGN STANDARDS - Standards of construction governing the size, shape, and relationship of spaces in any structure which will control soil erosion and sedimentation.

DESIGN STORM - A given rainfall amount, areal distribution, and time distribution, used to estimate runoff. The rainfall amount is for a given frequency (25-year, 50-year, etc.).

DESILTING AREA - An area of grass, shrubs, or other vegetation used for inducing deposition of silt and other debris from flowing water, located above a stock tank, pond, field, or other area needing protection from sediment accumulation. See Filter Strip.

DETENTION DAM - A dam constructed for the purpose of temporary storage of streamflow or surface runoff and for releasing the stored water at controlled rates.

DIKE - An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee.

DISCHARGE - Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minutes, or cubic meters per second.

DISCHARGE FORMULA (hydraulics) - A formula to calculate rate of flow of fluid in a conduit or through an opening. For steady flow discharge, $Q = AV$, wherein Q is rate of flow, A is cross sectional area, and V is mean velocity. Common units are cubic feet per second, square feet, and feet per second, respectively. To calculate the mean velocity, V, for uniform flow in pipes or open channels, see Manning's formula.

DIVERSION - Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream. See Terrace.

DIVERSION TERRACE - Diversions, which differ from terraces in that they consist of individually designed channels across a hillside, may be used to protect bottomland from hillside runoff or may be needed above a terrace system for protection against runoff from an un-terraced area. They may also divert water out of active gullies, protect farm buildings from runoff, reduce the number of waterways, and are sometimes used in connection with strip cropping to shorten the length of slope so that the strips can effectively control erosion. See Terrace.

DRAINAGE - The removal of excess surface water or groundwater from land by means of surface or subsurface drains.

DRAINAGE AREA - The area draining into a stream at a given point. The area may be of different sizes for surface runoff, subsurface flow and base flow, but generally the surface runoff area is used as the drainage area. See watershed.

DRAINAGE DISTRICT - A cooperative, self-governing public corporation created under state law to finance, construct, operate, and maintain a drainage system involving a group of land holding.

DROP-INLET SPILLWAY - Overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

DROP SPILLWAY - Overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

DROP STRUCTURE - A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

EFFLUENT - 1. The discharge or outflow of water from ground or subsurface storage.

2. The fluids discharged from domestic, industrial, and municipal waste collection systems or treatment facilities.

EROSION - 1. The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

2. Detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

a. **GULLY EROSION** - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

b. **RILL EROSION** - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils. See Rill.

c. **SHEET EROSION** - The removal of a fairly uniform layer of soil from the land surface by runoff water.

EUTROPHICATION - A means of aging of lakes whereby aquatic plants are abundant and waters are deficient in oxygen. The process is usually accelerated by enrichment of waters with surface runoff containing nitrogen and phosphorus.

EVAPOTRANSPIRATION (ET) - Plant transpiration plus evaporation from the soil. Difficult to determine separately, therefore used as a unit for study.

FALLOW - Cropland kept free of vegetation during the growing season. May be a normal part of the cropping system for weed control, water conservation, soil conditioning, etc.

FILTER STRIP - Strip of permanent vegetation above ponds, diversion terraces,and other structures to retard flow of runoff water, causing deposition of transported material, thereby reducing sediment flow. See Desilting Area.

FINISHED GRADE - The final grade or elevation of the ground surface conforming to the approved grading plan.

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FLOOD FRINGE - That portion of the floodplain subject only to shallow inundation and low velocity flow of floodwater.

FLOODPLAIN - A level surface of stratified alluvium on either side of a stream which is built up by silt and sand carried out of the main channel and submerged during times of flood.

FLOODPLAIN MANAGEMENT - The wise use of floodplains so as to reduce human suffering and property damage resulting from floods and to lessen the need for expensive flood control structures, such as dams and reservoirs.

FLOODWAY - That portion of the floodplain required to store and discharge floodwaters without causing significant damaging or potentially damaging increases in flood heights and velocities.

FREEBOARD (hydraulics) - Vertical distance between the maximum water surface elevation anticipated in design and the top of restraining banks or structures provided to prevent overtopping because of unforeseen conditions.

FREQUENCY - An expression or measure of how often a hydrologic event of given size or magnitude should, on the average, be equaled or exceeded. For example, a 50-year frequency flood should be equaled or exceeded in size, on the average, only once in 50 years. In drought or deficiency studies it usually defines how many years will, on the average, be equal to or less than a given size or magnitude.

FUNCTIONAL PLAN - A plan for one element or closely related elements of a comprehensive plan, for example, transportation, recreation, and open spaces. Such plans, of necessity, should be closely related to the land use plan. Plans that fall short of considering all elements of a comprehensive plan may be considered as functional plans. Thus, resource conservation and development plans and watershed project plans should be considered as functional plans.

GABION - A galvanized wire basket filled with stone used for structural purposes. When fastened together used as retaining walls, revetments, slope protection and similar structures.

GRADE STABILIZATION STRUCTURE - A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel grade.

GRASSED WATERWAY - A natural or constructed waterway, usually broad and shallow, covered with erosion resistant grasses, used to conduct surface water from cropland.

GRAVEL ENVELOPE - Selected aggregate placed around the screened pipe section of well casing or a subsurface drain to facilitate the entry of water into the well or drain.

GRAVEL FILTER - Graded sand and gravel aggregate placed around a drain or well screen to prevent the movement of fine materials from the aquifer into the drain or well.

GULLY - A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow. A gully may be dendritic or branching or it may be linear, rather long, narrow, and of uniform width. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage.

HARDPAN - A hardened soil layer in the lower A or in the B horizon caused by cementation of soil particles with organic matter or with materials such as silica, sesquioxides, or calcium carbonate. The hardness does not change appreciably with changes in moisture content, and pieces of the hard layer do not slake in water.

HIGHWAY EROSION CONTROL - The prevention and control of erosion in ditches, at cross drains, and on fills and road banks within a highway right-of-way. Includes vegetative practices and structural practices.

HOOD INLET - Entrance to a closed conduit that has been shaped to induce full flow at minimum water surface elevation.

HORIZONS, MINERAL SOIL -

A horizons are surface layers.

B horizons are subsoil horizons [1]; They are designated as follows:

B alone indicates some residual transformation or change in place, such as color.

Bt indicates accumulations of translocated clay. Bx indicates a B horizon with fragipan characteristics such as firmness, brittleness and high density.

C horizons are substrata layer [1]; they consist of mineral material like or unlike the material from which the A & B horizons have formed and have been little affected by soil forming process. They are designated as follows:

C alone indicates material like the material from which the A & B horizons have formed.

Cx indicates a C horizon of material like that of the A & B horizons but has the firm, brittle and dense characteristics of a fragipan.

[1] Roman numerals are prefixed to the appropriate horizon designations such as IIB, IIbt, IIBx, and IIC or IICS when it is necessary to number a series of layers of unlike or contrasting material from the sur-

face downward. Claverack is an example in which the A & B horizons have formed in sand and the underlying material is contrasting silty clay that is indicated as a IIC horizon.

HYDRAULIC GRADE LINE - In a closed conduit, a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the hydraulic grade line is the free water surface.

HYDROGRAPH - A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

HYDROLOGIC SOIL COVER COMPLEX - A combination of a hydrologic soil group and a type of cover.

HYDROLOGIC SOIL GROUP - A group of soils having the same runoff potential under similar storm and cover conditions.

HYDROLOGY - The science that deals with the occurrence and behavior of water in the atmosphere, on the ground and under the ground. Rainfall intensities, rainfall interception by trees, effects of crop rotation on runoff, floods, droughts and the flow of springs and wells, are some of the topics studied by a hydrologist.

HYDROSEEDING - The dissemination of seed hydraulically in a water medium; mulch, lime, and fertilizer can be incorporated into the sprayed mixture.

IMPERVIOUS SOIL - A soil through which water, air, or roots cannot penetrate. No soil is impervious to water and air all the time.

IMPOUNDMENT - Generally, an artificial collection or storage of water, as a reservoir, pit, dugout, sump, etc. See Reservoir.

INDUSTRIAL PARK - A tract of land, the control and administration of which are vested in a single body, suitable for industrial use because of location, topography, proper zoning, availability of utilities, and accessibility to transportation.

INFILTRATION - Rainfall minus interception, evaporation, and surface runoff. The part of rainfall that enters the soil.

INFILTRATION RATE - A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions, including the presence of an excess of water. See Infiltration Velocity.

INITIAL ABSTRACTION (I_a) - When considering surface runoff, I_a is all the rainfall before runoff begins. When considering direct runoff, I_a consists of interception, evaporation and the soil-water storage that must be exhausted before direct runoff may begin.

INOCULATION (OF SEEDS) - The addition of nitrogen fixing bacteria (inoculant) to legume seeds or to the soil in which the seeds are to be planted; the bacteria take free nitrogen from the air and make it available to the seeds.

INTERCEPTION - Precipitation retained on plant or plant residue surfaces and finally absorbed, evaporated, or sublimated. That which flows down the plant to the ground is called "steamflow" and not counted as true interception.

INTERMITTENT STREAM - A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long term continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than 3 months.

ISO-ERODENT VALUE - A term used to correlate areas of equally erosive average annual rainfall.

LANDSCAPE - All the natural features, such as fields, hills, forests, water, etc., that distinguish one part of the earth's surface from another part, usually that portion of land or territory which the eye can comprehend in a single view, including all of its natural characteristics.

LIME, AGRICULTURAL - A soil amendment consisting principally of calcium carbonate but including magnesium carbonate and perhaps other materials, used to furnish calcium and magnesium as essential elements for the growth of plants and to neutralize soil acidity.

LINING - A protective covering over all or part of the perimeter of a reservoir or a conduit to prevent seepage losses, withstand pressure, resist erosion, and reduce friction or otherwise improve conditions of flow.

LIVE STAKING - Securing vegetative cover for control of erosion and shallow sliding by means of willow or poplar cuttings that root easily and grow rapidly under certain conditions.

MANNING'S FORMULA (hydraulics) - A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = ((1.486)(r^{2/3})(s^{1/2}))/n$$

where:

V = the mean velocity of flow in feet per second; r = the hydraulic radius;

s = the slope of the energy gradient or for assumed uniform flow the slope of the channel in feet per foot; and

n = the roughness coefficient or retardance factor of the channel lining.

MUCK SOIL - 1. An organic soil in which the organic matter is well decomposed (USA usage).

2. A soil containing 20 to 50 percent organic matter.

MULCH - A natural or artificial layer of plant residue or other materials, such as sand or paper, on the soil surface.

NETTING - Plastic, paper, or cotton material used to hold mulch on the soil surface.

OUTLET - Point of water disposal from a stream, river, lake, tidewater, or artificial drain.

PARTICLE SIZE CLASSES FOR FAMILY GROUPINGS (as used in the Soil Classification System of the National Cooperative Soil Survey in the United States) - Various particle size classes are applied to arbitrary control sections that vary according to the depth of the soil, presence or absence of argillic horizons, depth to paralithic or lithic contacts, fragipans, horizons. No single set of particle size classes is appropriate as a family grouping for all kinds of soil. The classification tabulated below provides a choice of several particle size classes.

1. Sandy-Skeletal - More than 35 percent, by volume, coarser than 2 millimeters, with enough fines to fill interstices larger than 1 millimeter; fraction less than 2 millimeters is as defined for the sandy class.

2. Loamy-Skeletal - More than 35 percent, by volume, coarser than 2 millimeters, with enough fines to fill interstices larger than 1 millimeter; fraction less than 2 millimeters is as defined for loamy classes.

3. Sandy - Sands, except very fine sand, and loamy sands, except loamy very fine sand.

4a. Coarse-Loamy - With less than 18 percent clay and more than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 centimeters).

b. Fine-Loamy - With more than 18 percent clay but less than 35 percent clay and more than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 centimeters).

c. Coarse-Silty - With less than 18 percent clay and less than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 centimeters).

d. Fine-Silty - With more than 18 percent clay and less than 35 percent clay and less than 15 percent coarser than very fine sand (including coarse fragments up to 7.5 centimeters).

5a. Fine - With more than 35 percent clay but less than 60 percent clay.

b. Very-Fine - With more than 60 percent clay.

PEAK FLOW - The maximum instantaneous flow of water from a given storm condition at a specific location.

PEAT - Dark brown residual material produced by the partial decomposition and disintegration of plants that grow in wet places.

PERMEABILITY - The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.

pH - A numerical measure of the acidity or alkalinity of a soil; neutral soil has a pH of 7; all pH values below 7 are acid, and all above 7 are alkaline.

PLANNED UNIT DEVELOPMENT - A zoning classification permitting flexibility of site design by combining building types and uses in ways that would be prohibited by traditional zoning standards.

PLAT OF SURVEY - A scaled drawing identifying a parcel of real estate, prepared by a registered surveyor, including a legal description of the property and the dimensions of the physical improvements.

RAINFALL INTENSITY - The rate at which rain is falling at any given instant, usually expressed in inches per hour.

RETARDANCE (vegetation) - The characteristic of the vegetative lining of a channel that tends to restrict and impede flow relative to a perfectly smooth channel.

RETENTION - The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

RETURN FLOW - That portion of the water diverted from a stream which finds its way back to the stream channel either as surface or underground flow.

REVETMENT - Facing of stone or other material, either permanent or temporary, placed along the edge of a stream to stabilize the bank and to protect it from the erosive action of the stream.

RIPARIAN RIGHTS - The rights of an owner whose land abuts water. They differ from state to state and often depend on whether the water is a river, lake, or ocean. See Water Rights.

RIPRAP - Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves); also applied to brush or pole mattresses, or brush and stone, or other similar materials used for soil erosion control.

RUNOFF - That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, groundwater runoff, or seepage.

RUNOFF CURVE NUMBER (CN) - A parameter combining the effects of soils, watershed characteristics and land use. This parameter represents the hydrologic soil cover complex of the watershed.

SCALPING - Removal of sod or other vegetation in spots or strips.

SCARIFY - To abrade, scratch, or modify the surface; for example, to scratch the impervious seed coat of hard seed or to break the surface of the soil with a narrow-bladed implement.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENT BASIN - A basin or pond designed to store a calculated amount of sediment being transported on the site.

SEDIMENT DISCHARGE - The quantity of sediment, measured in dry weight or by volume, transported through a stream cross-section in a given time. Sediment discharge consists of both suspended load and bedload.

SEEDBED - The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

SEEPAGE - 1. Water escaping through or emerging from the ground along an extensive line or surface as contrasted with a spring where the water emerges from a localized spot.

2. The process by which water percolates through the soil.

3. (percolation) The slow movement of gravitational water through the soil.

SETTLING BASIN - An enlargement in the channel of a stream to permit the settling of debris carried in suspension.

SHRINK-SWELL POTENTIAL - The susceptibility of soil to volume change due to loss or gain in moisture content.

SHRUB - A woody perennial plant differing from a perennial herb by its more woody stems and from a tree by its low stature and habit of branching from the base. There is no definite line between herbs and shrubs or between shrubs and trees; all possible intergradations occur.

SIDE SLOPES (engineering) - The slope of the sides of a canal, dam, or embankment. It is customary to name the horizontal distance first, as 0.5 to 1, or frequently, 1-1/2:1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.

SITE ANALYSIS - Evaluation of the qualities and drawbacks of a site by comparison with those aspects of other comparable sites.

SOIL EROSION AND SEDIMENTATION CONTROL PLAN - A plan which fully indicates the necessary land protection and structural measures, including a schedule of the timing of their installation, which will effectively minimize soil erosion and sediment yields.

SOIL STRUCTURE - The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated soil particles. The principal forms of soil structure are: platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are: (1) single grain (each grain by itself, as in dune sand), or (2) massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

SOIL SURVEY - Survey showing soil type and composition.

SOIL TEXTURE - The relative proportions of the various soil separates in a soil as described by the classes of soil texture shown in Figure 1. The textural classes may be modified by the addition of suitable adjectives when coarse fragments are present in substantial amounts; for example, gravelly silt loam. (For other modifications, see coarse fragments.) Sand, loamy sand, and sandy loam are further subdivided on the basis of the proportions of the various sand separates present.

SPILLWAY - An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

SPOIL - Soil or rock material excavated from a canal, basin, or similar construction.

STAGE (hydraulics) - The variable water surface or the water surface elevation above any chosen datum. See Gage Height; Gaging Station.

STATE SOIL AND WATER CONSERVATION COMMITTEE, COMMISSION, OR BOARD - The state agency established by state soil conservation district enabling legislation to assist with the administration of the provisions of the state soil conservation districts law. The official title may vary from the above as new or amended state laws are made.

STILLING BASIN - An open structure or excavation at the foot of an overfall, chute, drop, or spillway to reduce the energy of the descending stream.

STREAMBANKS - The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

STRATA CAPACITY - The maximum amount of material a stream is able to transport.

STREAM LOAD - Quantity of solid and dissolved material carried by a stream. See Sediment Load.

STORMWATER MANAGEMENT - Runoff water safely conveyed or temporarily stored and released at an allowable rate to minimize erosion and flooding.

STRIPPING - Denuding vacant or untouched land of its present vegetative cover and topsoil.

SUBGRADE - The soil prepared and compacted to support a structure or a pavement system.

SUBSOIL - The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately.

SUMP - Pit, tank, or reservoir in which water is collected for withdrawal or stored.

SUSPENDED LOAD - The fine sediment kept in suspension in a stream because the settling velocity is lower than the upward velocity of the current.

SWALE - A linear, but flattish depression in the ground surface which conveys drainage water but offers no impediment to traffic, as do ditches or gutters.

TERRACE - An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Terraces or terrace systems may be classified by their alignment, gradient, outlet, and cross-section. Alignment is parallel or non-parallel. Gradient may be level, uniformly graded, or variably graded. Grade is often incorporated to permit paralleling the terraces. Outlets may be soil infiltration only, vegetated waterways, tile outlets, or combinations of these. Cross-sections may be narrow base, broad base, bench, steep backslope, flat channel, or channel.

TIME OF CONCENTRATION - Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to the outlet.

TIMING SCHEDULE - A construction progress schedule showing the proposed dates of commencement and completion of each of the various subdivisions of work as shown and called for in the approved plans and specifications.

TOPOGRAPHIC MAP - A schematic drawing of prominent landforms indicated by conventional symbols such as hachures or contour lines.

TOPSOIL - The uppermost layers of soil containing organic material and suited for plant survival and growth.

TRAP EFFICIENCY - The capability of a reservoir to trap sediment.

TRAVEL TIME - The time for water to travel from one location to another in a watershed. A travel time is part of a component of time of concentration (T_c).

TRIBUTARY - Secondary or branch of a stream, drain, or other channel that contributes flow to the primary or main channel.

UNIFIED SOIL CLASSIFICATION SYSTEM (engineering) - A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.

UNIT HYDROGRAPH - A discharge hydrograph coming from one inch of direct runoff distributed uniformly over the watershed, with the direct runoff generated at a uniform rate during the given storm duration. A watershed may have 1-hour, 2-hour, etc. unit hydrographs.

WATER QUALITY STANDARDS - Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonates, pH, total dissolved salts, etc.

WATER RIGHTS - The legal rights to the use of water. They consist of riparian rights and those acquired by appropriation and prescription. Riparian rights are those rights to use and control water by virtue of ownership of the bank or banks. Appropriated rights are those acquired by an individual to the exclusive use of water, based strictly on priority of appropriation and application of the water to beneficial use and without limitation of the place of use to riparian land. Prescribed rights are those to which legal title is acquired by long possession and use without protest of other parties.

WATERSHED - The area contributing direct runoff to a stream. Usually it is assumed that base flow in the stream also comes from the same area. However, the ground water watershed may be larger or smaller.

WATER TABLE - The upper surface of groundwater or that level below which the soil is saturated with water; locus of points in soil water at which the hydraulic pressure is equal to atmospheric pressure.

WATERWAY - A natural course or constructed channel for the flow of water.

WATTLE - A group or bundle of twigs, whips or withes.

WEEP-HOLES (engineering) - Openings left in retaining walls, aprons, linings, or foundations to permit drainage and reduce pressure.

ZONING (rural) - A means by which governmental authority is used to promote the proper use of land under certain circumstances. This power traditionally resides in the state, and the power to regulate land uses by zoning is usually delegated to minor units of government, such as towns, municipalities, and counties, through an enabling act that specifies powers granted and the conditions under which these are to be exercised.

ZONING ORDINANCE - The exercise of police power for the purpose of carrying out the land use plan of an area. It may also include regulations to effect control of the size and height of buildings, population density, and use of buildings; for example, residential, commercial, industrial, etc.

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SECTION 13
DIRECTORIES

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New York Soil Conservation Service Field Office Listing

COUNTY	OFFICE LOCATION	PHONE
Albany	RD #2, Martin Road, Voorheesville, 12186	518-765-3560
Allegany	Ag Service Center, RD #2, Belmont St., Belmont, 14813	716-268-7831
Broome	4-H Center, 840 Front Street, Binghamton, 13905	607-773-2691
Cattaraugus	RR #2, Box 16B, Parkside Drive, Ellicottville, 14731	716-699-2326
Cayuga	248 Grant Avenue, Auburn, 13021	315-252-5832
Chautauqua	Frank W. Bratt Ag Center, RD #2, Turner Road, Jamestown, 14701	716-664-2351
Chemung	209 North Main Street, Horseheads, 14845	607-739-2009
Chenango	99 North Broad Street, Norwich, 13815	607-334-4632
Clinton	RFD#6, Box 16A, Rt. 22, Plattsburg, 12901	518-561-7373
Columbia	337 Fairview Avenue, Hudson, 12534	518-828-4386
Cortland	100 Grange Place, Room 205, Cortland, 13045	607-756-5991
Delaware	129 North Street, Walton, 13856	607-865-7161
Dutchess/Putnam/ Westchester	Farm & Home Center, Rt. 44, P.O. Box 37, Millbrook, 12545	914-677-3194
Erie	21 S. Grove Street, East Aurora, 14052	716-652-8480
Essex	125 Pleasant Street, Box 1139 J, Westport, 12993	518-962-8225
Franklin	Agricultural Service Center, RFD 3, Box 7B, Malone, 12953	518-483-4061
Fulton	Hales Mills Road, Box 239, Johnstown, 12095	518-762-0079
Genesee	USDA Center, 166 Washington Avenue, Batavia, 14020	716-343-2362
Greene	HC #3, Box 907, Cairo, 12413-9502	518-622-3620
Hamilton	Hamilton Co. Courthouse, Lake Pleasant, 12108	518-548-3991
Herkimer	113 George Street, Herkimer, 13350	315-866-2651
Jefferson	RD #6, Box 376B, Rices Road, Watertown, 13601	315-782-2671
Lewis	P.O. Box 113, Lowville, 13367	315-376-6122
Livingston	129 Main Street, Leicester, 14481	716-382-3214
Madison	Farm & Home Center, Eaton St., Box 189, Morrisville, 13408	315-684-3181
Monroe	249 Highland Avenue, Rochester, 14620	716-473-2120
Montgomery	567 Route 5S, Fultonville, 12072	518-853-4015
Nassau	1425 Old Country Rd., Bldg. J, Plainview, 11803	516-454-1579
Niagara	4487 Lake Avenue, Lockport, 14094	716-434-4949
Oneida	RR #1, Box 126-C, Second St., Oriskany, 13424	315-736-3334
Onondaga	4876 Onondaga Road, Syracuse, 13215	315-469-5034
Ontario	Farm & Home Center, 482 N. Main Street, Canandaigua, 14424	716-394-1341
Orange/ Rockland	33 Fulton Street, Middletown, 10940	914-343-1873
Orleans	446 West Avenue, Albion, 14411	716-589-5959
Oswego	2 Erie Street, Oswego, 13126	315-343-0040
Otsego	Library Building, 22 Main Street, Cooperstown, 13326	607-547-8337
Rensselaer	1701 Seventh Avenue, Old Health Bldg., Troy, 12180-3496	518-270-2797
St. Lawrence	3 Commerce Lane, Canton, 13617	315-386-2975
Saratoga	50 West High Street, Municipal Center, Ballston Spa, 12020	518-885-6900
Schenectady	192 Hetcheltown Road, Scotia, 12302	518-399-6980
Schoharie	Ag Headquarters, 41 South Grand Street, Cobleskill, 12043	518-234-4092
Schuyler	Rural Urban Center, 208 Broadway, Box 326, Montour Falls, 14865	607-535-9650
Seneca	Academy Square, 12 North Park Street, Seneca Falls, 13148	315-568-4366
Steuben	Steuben Co. Office Bldg., 3 Pulteney Square East, Bath, 14810	607-776-9631

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Suffolk	Riverhead Co. Center, 300 Center Drive, Room E16, Riverhead, 11901-3398	516-727-2315
Sullivan	69 Ferndale-Loomis Road, Liberty, 12754	914-292-6552
Tioga	56 Main Street, Room 313, Owego, 13827	607-687-2240
Tompkins	Corners Community Center, 903 Hanshaw Road, Ithaca, 14850	607-257-3820
Ulster	380 Washington Avenue, Kingston, 12401	914-338-4764
Warren	122 Main Street, Warrensburg, 12885	518-623-3119
Washington	Moss Street, RD #1, Box 15-C, Hudson Falls, 12839	518-747-2154
Wayne	8340 Ridge Road, RR #2, Sodus, 14551	315-483-6958
Wyoming	31 Duncan St., Warsaw, 14569	716-786-5070
Yates	110 Court St., Room 105, Penn Yan, 14527	315-536-6233

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Otsego	Library Building, 22 Main Street, Cooperstown, 13326	607-547-8337
Putnam	Putnam County Offices, Myrtle Avenue, P.O. Box 212, Mahopac Falls, 10542	914-628-1630
Rensselaer	1701 Seventh Avenue, Old Health Bldg., Troy, 12180-3496	518-270-2797
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Westchester	214 Central Avenue, White Plains, 10606	914-682-3080
Wyoming	31 Duncan St., Warsaw, 14569	716-786-5070
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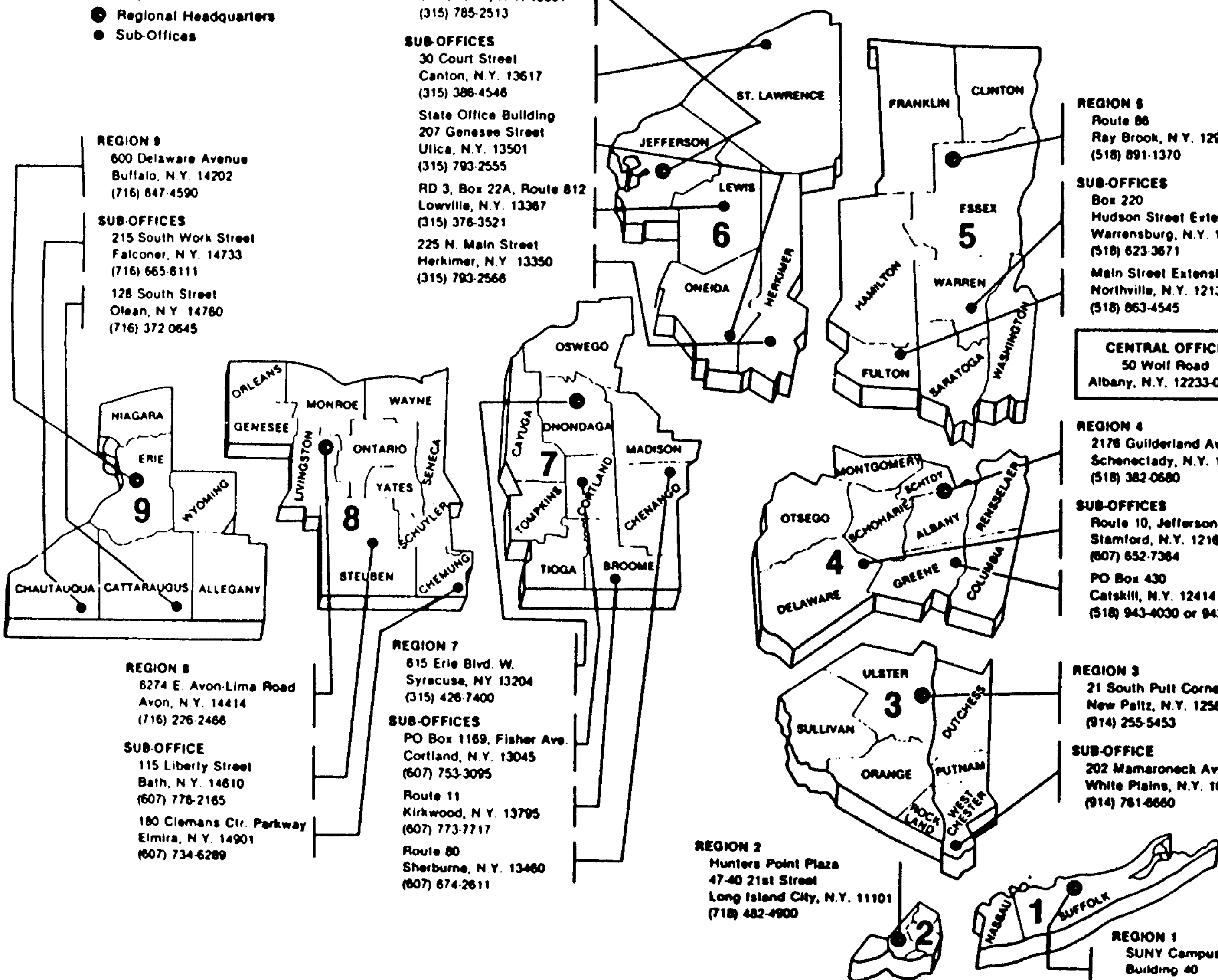
New York State Department of Environmental Conservation
Regional Offices

LEGEND
- ◉ Regional Headquarters
- ● Sub-Offices



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600 Delaware Avenue
Buffalo, N.Y. 14202
(716) 847-4590

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215 South Work Street
Falconer, N.Y. 14733
(716) 665-6111

128 South Street
Olean, N.Y. 14760
(716) 372-0645

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State Office Building
317 Washington Street
Watertown, N.Y. 13601
(315) 785-2513

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State Office Building
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Utica, N.Y. 13501
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Herkimer, N.Y. 13350
(315) 793-2566

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(518) 891-1370

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Warrensburg, N.Y. 12885
(518) 623-3671

Main Street Extension
Northville, N.Y. 12134
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50 Wolf Road
Albany, N.Y. 12233-0001

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2176 Guilderland Ave.
Schenectady, N.Y. 12306
(518) 382-0680

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Catskill, N.Y. 12414
(518) 943-4030 or 943-4384

REGION 8
6274 E. Avon-Lima Road
Avon, N.Y. 14414
(716) 226-2466

SUB-OFFICE
115 Liberty Street
Bath, N.Y. 14810
(607) 776-2165

180 Clemans Ctr. Parkway
Elmira, N.Y. 14901
(607) 734-6289

REGION 7
615 Erie Blvd. W.
Syracuse, NY 13204
(315) 426-7400

SUB-OFFICES
PO Box 1169, Fisher Ave.
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(607) 753-3095

Route 11
Kirkwood, N.Y. 13795
(607) 773-7717

Route 80
Sherburne, N.Y. 13460
(607) 674-2611

REGION 3
21 South Putt Corners Road
New Paltz, N.Y. 12561
(914) 255-5453

SUB-OFFICE
202 Mamaroneck Ave.
White Plains, N.Y. 10601
(914) 761-6660

REGION 2
Hunters Point Plaza
47-40 21st Street
Long Island City, N.Y. 11101
(718) 482-4900

REGION 1
SUNY Campus
Building 40
Stony Brook, N.Y. 11794
(516) 751-7900

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U.S. Department of Agriculture

Soil Conservation Service

Syracuse, New York

A GUIDE TO: CONSERVATION PLANTINGS ON CRITICAL AREAS FOR NEW YORK

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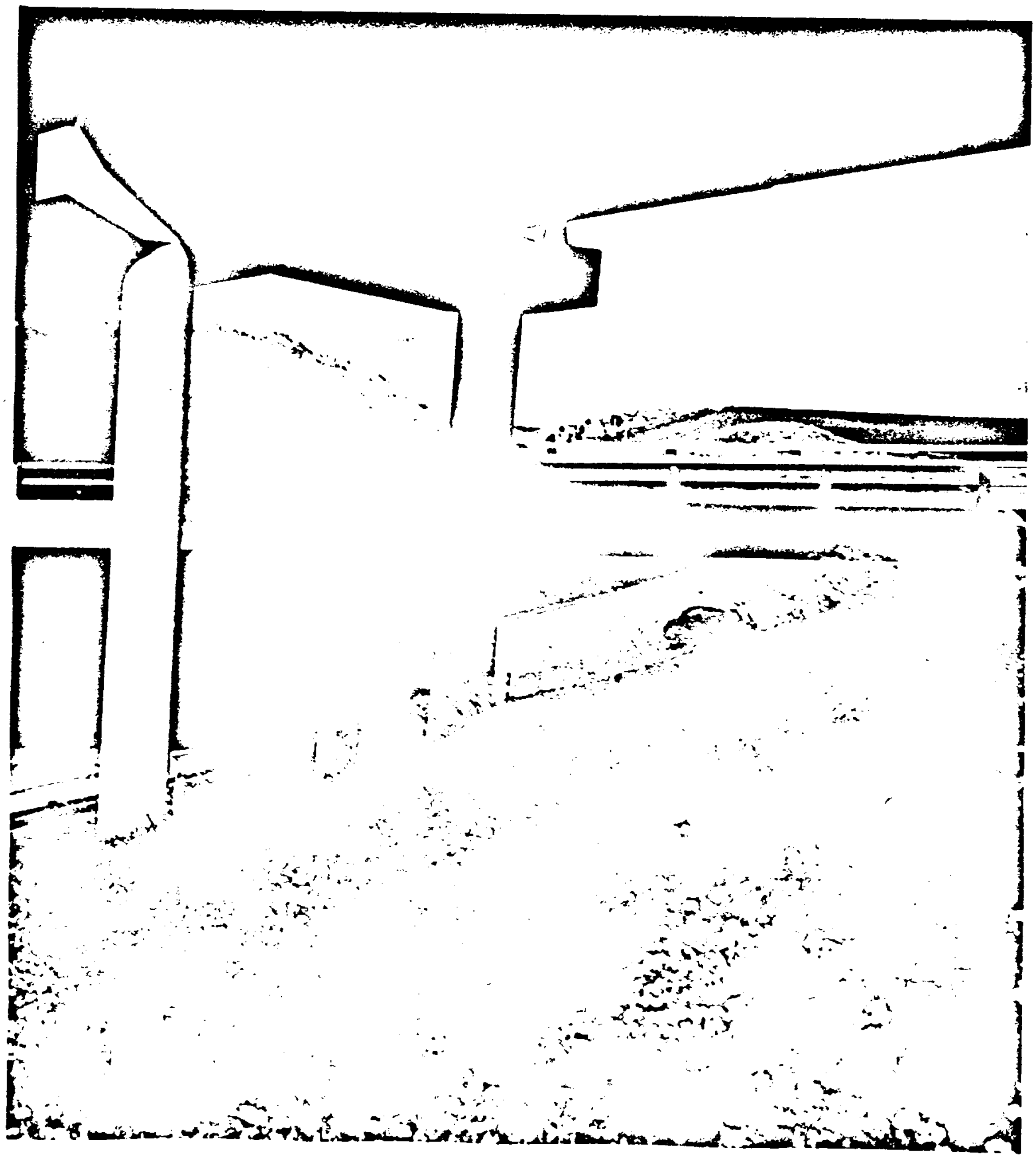

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INTRODUCTION

Erosion is the wearing away of the land surface through the forces of wind and water. Sedimentation is the transport and delivery of eroded soil particles. Erosion represents a major conservation problem in New York. The combined efforts of the Soil Conservation Service and New York's 57 Soil and Water Conservation Districts over the past half century have produced great accomplishments toward the reduction of erosion and sedimentation. These efforts must continue and even intensify if we are to continue to protect and conserve our valuable soil resource. Increased public awareness has resulted in thousands of New York landowners establishing conservation plans and applying practices to protect their land from erosion and enhance water quality by reducing the amount of nutrients, pesticides and sediment moving from eroding areas.

This publication is focused specifically on one type of erosion, namely critical erosion. A critical erosion area is one which is eroding at an accelerated rate and producing large quantities of sediment. The critical erosion area frequently creates a hazard to life and limb, or threatens private property or a public utility. Examples of critical erosion areas include rapidly eroding cropland, construction sites, streambanks, roadbanks, logging roads, skid trails, ditch and channel banks, surface mined land, sandblows and dunes, denuded and gullied areas, and landfills.

The most cost-effective way to control erosion is to establish appropriate vegetative cover. The type of cover depends upon the needs and characteristics of each individual site. This guide provides specific data for treating critical erosion areas. Topics covered include planning considerations, the techniques of seeding and planting, a description of various plant materials, recommendations for selected areas, special site considerations, tabular data for grasses and legumes, trees and shrubs, mulches, fish and wildlife benefits from stabilizing vegetation and additional suggested reference material.

Chapter 1: PLANNING CONSIDERATIONS

Factors to Consider

Each critical erosion area is a unique site requiring the consideration of many factors toward resolving the erosion problem. The various factors to be considered in planning a solution for each area include soil types and condition, water management, land use, geology, existing vegetation, present and proposed use of the site, climate, shade tolerance, and the overall environment of the area.

Soils

Soil is the medium in which seeds germinate and roots grow. The condition of the soil may well determine the success or failure of seedings or plantings. Often, removal of topsoil leaves a subsoil layer remaining as the material to be seeded or planted. This material is typically infertile, poor in structure and aggregation, low in organic matter, and may be very acid. In many cases, the subsoil is highly susceptible to erosion due to slow water intake and rapid runoff. Applications of organic matter, manure, lime, and appropriate commercial fertilizers are usually necessary to assist in overcoming these limiting conditions.

Where topsoil has been removed, four inches or more of loamy topsoil applied to the site before seeding enhances establishment of ground cover and minimizes maintenance.

For detailed information about soil characteristics, a recent soil map prepared as part of the National Cooperative Soil Survey will be helpful. Soil properties relating to plant growth and engineering are outlined in the soil survey reports. Copies of maps and reports are available from Soil and Water Conservation District offices, the Soil Conservation Service, and Cornell Cooperative Extension.

Water Management

In many instances a critical erosion area exists due to the action of water, either from surface runoff as a result of rainfall or snow melt, or surface flow in the form

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of seeps, or poor drainage, which keeps the soil saturated for a long duration. Proper water management is necessary in all three instances.

Where surface runoff is a problem, water can be directed away from the area by means of a shallow ditch known as a diversion. The diversion is constructed at a point on site where it will intercept runoff water and carry it to a safe outlet that will not adversely impact the area or the environment.

Seeps and poor drainage can keep soil saturated, create slumping, and make it difficult to establish adequate vegetation. These can be alleviated through surface and/or subsurface drainage measures. In most instances, this consists of installing perforated tile which intercepts and collects this subsurface water and directs it away from the problem area.

Land Use

The land use of the area surrounding the critical erosion site must be taken into consideration when planning the critical area treatment. Conservation plantings should be considered based on their size and appearance at maximum growth and development to determine whether or not they are appropriate for the particular site and its planned use.

Conservation plantings which enhance and blend with the surroundings are preferred. As an example, plantings which would be ideal for a rural or forested environment may not fit in an urban setting. Likewise, plantings which provide habitat enhancement for various species of fish and wildlife may not be applicable to an urban area. However the primary objective is effective erosion control, while in some cases aesthetics may be secondary.

Geology

When planning a solution for any critical erosion area, site geology, which includes both the overburden soil and underlying bedrock should be taken into consideration. Of primary importance is the existence of unstructured bedrock at a shallow depth which can have considerable impact on the establishment of vegetation. In most instances, a detailed review of the soil survey will provide sufficient information on site geology and any geologic limitations.

Existing Vegetation

Existing vegetation can provide a dual role in planning a solution for a critical erosion area. The vegetation currently on the site can provide clues as to the types of plantings that can be expected to grow and flourish.

Second, the existing vegetation may be both desirable and aesthetically pleasing. Planning considerations may involve incorporating this vegetation into the overall site design.

Present and Proposed Use

In determining the suitable plant species for any critical erosion area, consideration must be given to the current use of the site and in particular the future use, especially if the use will change. If recreation will be involved or the site is adjacent to an urban area, species which will tolerate human or vehicular traffic without suffering substantial damage should be chosen. If fish or wildlife habitat is desired, plant species should be selected which will be of benefit for food and/or cover.

Climate

Climatological variations should be considered in selecting plant species for a site. Factors such as amount of rainfall, and particularly in New York, wide fluctuations in temperature are of prime importance in determining which species of vegetation will flourish. Tolerance of species to substantial snow cover is also an important consideration in certain areas of the state. Refer to *Figure 1 Plant Hardiness Zones*, from USDA Plant Hardiness Zone Map, Misc. Publication No. 1475, 1990.

Shade Tolerance

If the critical erosion area to be seeded is in woodland, shade tolerance becomes critical to the success of the planting. The tolerance of each species to be used should be verified.

Overall Environment

The overall environment of a critical erosion area brings together all of the factors discussed up to this point. Planning for a critical erosion area should attempt to identify, and as much as possible, utilize the environment of the area. A site, when properly planned and established, should blend with the overall surroundings. It should not stand out as something unusual or visually displeasing.

Site Preparation

Where equipment will travel over the site during planting or for maintenance after establishment, slopes should be no steeper than 3:1. They should be benched to allow for maintenance. Leave existing trees and shrubs where desirable, and protect from injury and soil compaction to a distance of two times the canopy radius.

Install any necessary water control measures such as:

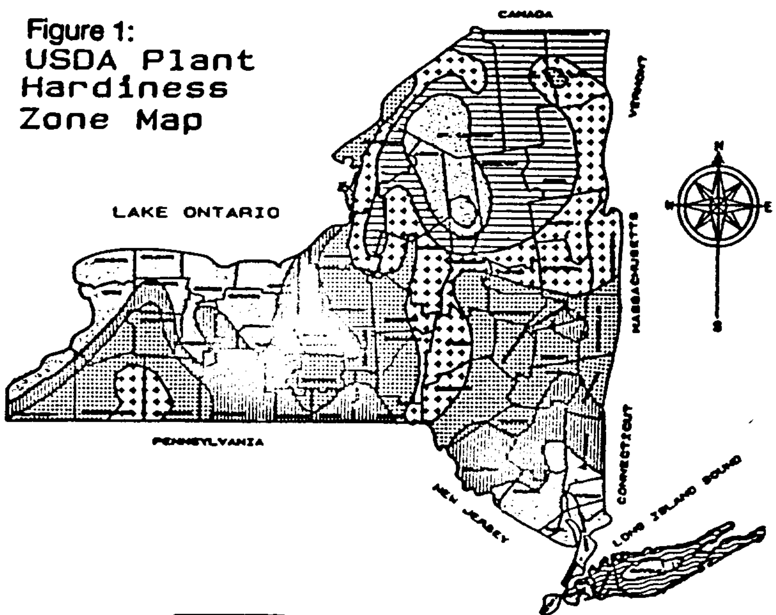
- diversions
- waterways or outlets
- surface drains
- subsurface (tile) drains
- bench terraces

Respread topsoil over the area when construction is completed if topsoil has been stripped off and stockpiled.

Test the soil to determine need for lime and/or fertilizer. If sandy or gravelly, determine percent of fines.

Remove all surface debris such as stones (greater than 2"), tree stumps, etc. depending on maintenance requirements of the area.

Figure 1:
USDA Plant Hardiness Zone Map



Temperature (C)	Zone	Temperature (F)
-45.6 and Below	1	Below -50
-42.6 to -45.5	2a	-45 to -50
-40.0 to -42.7	2b	-40 to -45
-37.3 to-40.0	3a	-35 to -40
-34.5 to -37.2	3b	-30 to -35
-31.7 to -34.4	4a	-25 to -30
-28.9 to -31.6	4b	-20 to -25
-26.2 to -28.8	5a	-15 to -20
-23.4 to -26.1	5b	-10 to -15
-20.6 to 23.3	6a	-5 to -10
-17.6 to -20.5	6b	0 to -5
-15.0 to -17.7	7a	5 to 0
-12.3 to -15.0	7b	10 to 5

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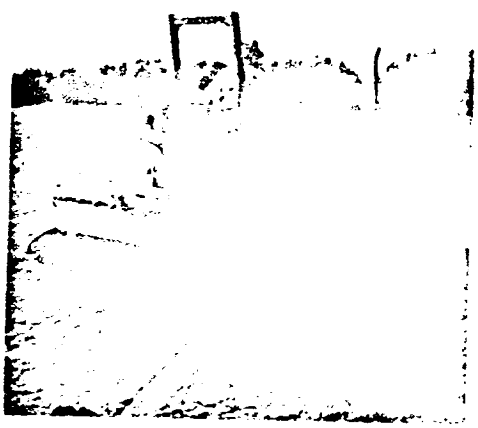
SYRACUSE, NEW YORK 1990

Chapter 2: TECHNIQUES OF SEEDING AND PLANTING



Drill - Seeding using offset packer wheels to cover seed and firm seedbed.

Seedbed Preparation

The surface should be scarified to a depth of at least two inches with a disk or other suitable implement. In some situations, such as drainage ditch banks, scarification can be excluded if lime, fertilizer and seed are applied to the roughened surface within 24 hours after digging. Sandy and gravelly sites seldom require scarification. On some small areas, direct seeding is possible without scarifying the slope. This is primarily on cool, moist slopes as in the Adirondack Mountains.

Apply lime, fertilizer, or manure. Mix them into the surface soil to a depth of at least two inches. If lime and fertilizer are applied by hydroseeder, incorporation into the soil is not practical. Both manure and soils should be analyzed for nutrient content. When results are available, nutrients should be applied according to nutrient needs of the erosion control cover. *Note:* Scarification and lime/fertilizer applications may be combined steps.

Application Rates

The following are suggested application rates for permanent seedings:

- Apply the amount of lime needed to attain a pH of at least 6.0 if legumes are included in the seeding mixture. If only grasses are to be seeded, a pH of 5.5 is acceptable.

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- Apply at least 30 pounds of nitrogen and 60 pounds each of phosphorus and potassium (600 pounds of 5-10-10 or equivalent) per acre.[1] Nitrogen application can be eliminated if 10 tons of manure per acre are applied.

Note: Lime, fertilizer and manure are most effective when worked into the soil surface.

Manure applications to sites should be recommended only after an evaluation of any potential water quality hazards. When available, manure may be applied to critical areas before seeding.[2] Work it into the soil if practical, especially on waterways and spillways. Manure helps to improve soil structure by adding organic matter.

Seed Specifications

Certified seed or sod of proven cultivars provides best results. Legumes should be scarified if necessary, and inoculated with the proper strain of nitrogen-fixing bacteria immediately before seeding. Use only plant cultivars adapted to local climatic conditions. *Note:* Quantity of seed does not compensate for poor quality.

Refer to *Descriptions of Grass and Legume Species* and *Tables 1A* and *1B* which contain information on plant characteristics, adaptation, use, suitability and level of maintenance required. Suggested seeding rates and seed mixtures for specified uses are shown in *Tables 2* and *3* for permanent seedings, and in *Table 4* for temporary seedings.

Time Of Seeding

Cool season plants are those which begin growth in cool seasons (spring/fall) and normally set seed in June/July. Frequently, cool season plants become dormant when temperatures persist above 85° Fahrenheit and moisture is limited. Kentucky bluegrass, red fescue and reed canarygrass are examples.

Warm season plants are those which begin growth slowly in the spring, produce a rapid flush of growth during the heat of the summer and set seed in the fall. Many warm season plants are sensitive to frost. In the fall frost may kill top growth. In the spring growth initiates from the base of the plant. Examples of warm season plants are switchgrass, lovegrass, and bluestems.

Timeliness of plantings may also be crucial. For example, a fall seeding of cool season grasses on a warm, droughty, sandy site may be successful. However, a spring seeding may fail.

1 Pounds of nutrients based on elemental N, P_2O_5 and K_2O.

2 Do not use manure when birdsfoot trefoil is planned for use.

Cool Season Mixtures

Good results are usually attained from seedings or plantings that are established in the spring before May 20 or in late summer after August 15. Spring seeding of legumes is recommended, however, late summer seedings prior to September 1 can also be made. When crownvetch is seeded in late summer at least 35 percent of the seed should be hard seed (un-scarified) to provide additional germination in the spring.

Temporary seedings of annual ryegrass, spring oats, or a combination of them may be made any time during the early or mid-spring season. Sudangrass or annual ryegrass may be used for late spring and summer seedings. Annual ryegrass or winter grains may be used for late summer and fall temporary seedings.

Temporary seedings of spring grains and annual ryegrass may be made in August. Permanent seedings of perennial grasses and/or legumes may then be overseeded in the spring. For other temporary seedings, where regrowth is desired in the spring, winter hardy grains or perennial ryegrass may be seeded in August or early September.

If seedings or plantings are made during dry periods (May 15-August 10), irrigation may be necessary to insure a successful seeding. Irrigation generally is not recommended on steep slopes.

Warm Season Mixtures

Seed should be planted on droughty, sandy or gravelly sites as early in the spring as possible and prior to May 1. On sites where soils have a high percentage of fines (greater than 15% silt and clay) plant by June 1. April or early May seedings are frequently more successful than late May seedings.

Seeding Or Planting

Proper seeding and planting techniques are important to insure successful plantings on critical areas. The slope of the land, soil texture, moisture regime and plant species all need to be evaluated before selecting the most appropriate system and equipment.

Drill

A grass drill (not a grain drill) or a cultipacker-seeder are the best methods of seeding. But the preferred method will depend on slope and conditions of the planting site. Grasses must be planted no more than 1/4 to 1/2 inch deep. If the drill does not have a packer attachment, a packer/roller should be trailed behind the drill.

Tracking

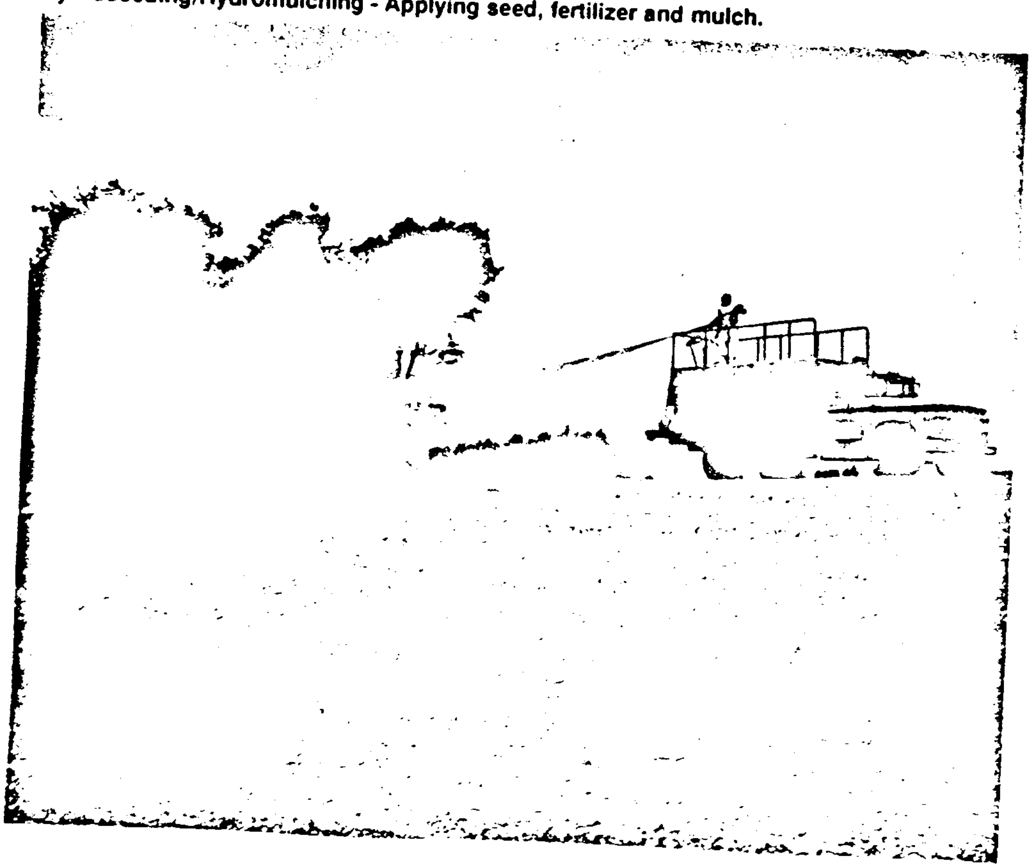
On steep slopes or where drilling is not feasible, broadcasting and tracking with a bulldozer is an alternative method. Tracking is performed by running a dozer up and down the slope, offsetting each pass so that the entire area is covered with tracks. This technique is especially valuable on droughty sites and wherever flatpea or warm season grasses are used.

Hydroseeder

This method is best for steep, inaccessible areas where a drill or other mechanized equipment is difficult or impossible to use. When applying seed, lime, fertilizer or mulch materials with the hydroseeder, do not use more than 100-150 pounds of solids per 100 gallons of water.

When legume seed is to be included in a slurry mixture containing fertilizer, the amount of inoculant added to the tank should be four times the rate prescribed by the inoculant manufacturer. A low solution pH is detrimental to the legume inoculant. If inoculant is in a seed, fertilizer, and lime slurry, it should be used within 3-4 hours, or a fresh supply of inoculant should be added. If there are

Hydroseeding/Hydromulching - Applying seed, fertilizer and mulch.



no legumes in the seed mixture, the seed may be mixed in a slurry with the lime and fertilizer. Hydrated lime should not be used if seed is to be mixed into the slurry.

Broadcast

Seed may be broadcast by using a whirlwind or cyclone seeder, or by hand. If spread by hand, seed may be mixed with sawdust to help achieve an even distribution. This is helpful for seeding small quantities of very small or light seeded species such as redtop, lovegrass, or little bluestem.

One half of the seed should be applied by walking in one direction, the other one half by walking at 90 degrees to the first direction. This yields a much more uniform seeding with fewer "missed" areas. Incorporate seed by cultipacking or raking, or tracking with a bulldozer.

Frost seeding is a technique which promotes seed incorporation by the frost action of daily freezing and thawing. This takes advantage of the frost cracks in the soil by broadcasting seed from February through April when snow is not present. Some of the seed will move into the frost cracks as the ground repeatedly freezes and thaws. Success depends greatly on timing. Round seeds work better than light fluffy seeds when using this technique.

Sprigging

This is done by planting a shoot, root, or sprout of a plant. It is a costly method, but may be necessary to establish some plants on critical erosion areas.

Sprigging should be done in the early spring, just before the time that normal plant growth begins. Lime and fertilizer should be applied in accordance with the needs of the species to be planted.

Sodding

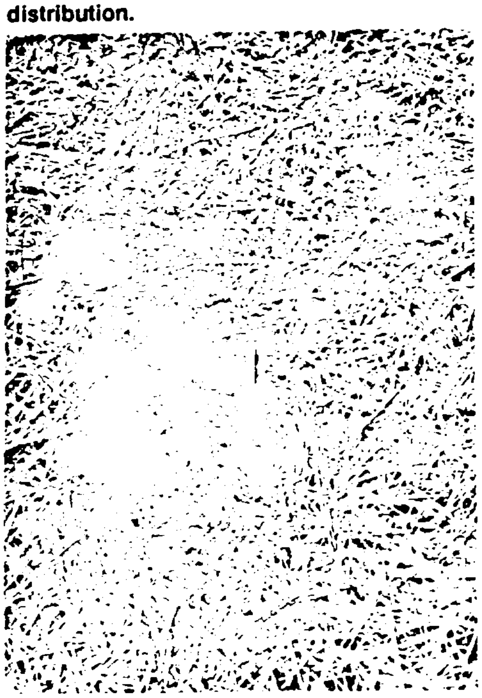
This consists of covering an area with sections of sod in order to provide quick soil protection. Select a dense sod containing suitable varieties for the site to be sodded. Sod must be free of problem weeds. Use "certified" varieties of grasses. Additionally, sod should be at least one year old, but not older than 3 years. The sod should be placed within 12 hours of cutting.

Lay strips of sod across the slope, beginning at the bottom. Strips may be anchored using 6-12 inch wire staples that are spaced 2 feet apart along the up-hill edge of the sod strip. Stagger joints and make sure the ends are butted up tightly. Roll the sod after placement to improve contact with the soil surface. Irrigate after rolling and during dry periods.

Maintenance

In spring of the second year of new seedings apply 300 - 400 lbs/ac of 5-10-10 of fertilizer or equivalent. When seedings or plantings consist of only grasses, an application of nitrogen fertilizer should be applied annually at the rate of 40 pounds per acre, or approximately 1 pound per 1000 square feet. Where legumes are included in the planting, nitrogen applications are usually not necessary nor recommended. If nitrogen applications are made they can be injurious to the legume. Obtain a soil test and apply phosphorus and potassium as tests indicate.

Mulching - Proper mulch rate and uniform distribution.



Mulching

Mulching is a very important step in establishing vegetation on critical areas. A mulch cover will help hold moisture, protect soil from erosion, hold seed in place, and keep soil temperatures more constant. Mulch reduces the "frost heaving" of small plants during the early spring freeze/thaw periods. It should be applied uniformly by mechanical means or by hand. Some bare soil should still be visible through the mulch.

Hay, straw or other fibrous mulches are the best for newly seeded areas. Some mulches are subject to blowing and must be kept moist or "tied" down. Mulch materials may also be used alone as a temporary ground cover measure for reducing soil erosion.

Hydromulching

Hydromulching is a process by which water and various combinations of seed, fertilizer, ground limestone, inoculants, wood cellulose and even compatible insecticides and fungicides are mixed in a tank to form a slurry. The slurry is maintained by continuous agitation until used. The material is sprayed over the area to be seeded, under high pressure. Wood cellulose mulch is suitable for use only in a slurry. It cannot be used for dry applications.

Dry straw or hay materials may be applied using a straw chopper or bedding chopper. Rotating blades chop the hay or straw and a blower propels the mulch

Strawmulching machine.

out a spout directed towards the area being mulched. Hay or straw frequently requires anchoring to prevent the mulch from being blown away. See *Table 5* for guide to mulching materials, rates and uses, and *Table 6* for mulch anchoring.

Planning Considerations

1. Consider mulching equipment availability, i.e.: hydromulchers, straw mulchers, etc. Some mulch materials require specialized equipment to apply a product properly.

2. Prior to mulching, install the necessary temporary or permanent water erosion control (structural) practices and drainage systems within or adjacent to the area to be mulched.

3. Slope, grade and smooth the site if conventional equipment is to be used in applying and anchoring the mulch.

4. Remove all undesirable stones and other debris depending on anticipated land use.

5. Compacted or crusted soil surface should be loosened to at least two inches by disking or other suitable methods.

6. When mulching new seedings, apply mulch immediately after seeding, the same day as seeding or within 48 hours. Do not mulch if germination is occurring.

Mulching Materials

1. Select from *Table 5*, the type of mulch and application rate that will best meet the need and availability of material.

2. If required, select the anchoring method from *Table 6* that will work best.

3. The best combination of mulching material for critical areas is straw (small grain) mulch applied at 2 tons/acre (90 lbs/1,000 sq. ft.). Anchor the straw mulch with wood fiber mulch (hydromulch) at 750 lbs/acre (17-20 lbs/1,000 sq. ft.). The wood fiber mulch must be applied through a hydroseeder immediately after straw mulching.

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Chapter 3: SELECTION AND DESCRIPTION OF PLANT MATERIALS

Trees and Shrubs

Many trees and shrubs (woody and herbaceous) are useful in protecting soil surfaces against wind and water erosion. Some trees and shrubs can also be used as soil stabilizers. Furthermore, they serve a number of environmental and engineering functions such as acoustical control, atmospheric purification, traffic control, glare reduction and reflection control. They also serve as climatological controls and provide aesthetic values through screening and space articulation.

Species Selection

The first, and most important step is proper selection of plant materials. Each site must be evaluated for soil and water conditions, climatic adaptability of the plant, and expected plant growth rate. It is advisable to consult with extension horticulturists, arborists, nursery people, or foresters in selecting plants that are suited for local conditions.

Important considerations when selecting trees or shrubs:

- Select only short species of shrubs when planting under utility wires.
- Avoid planting directly over or near water, gas, oil and sewer lines or buried telephone and power cables.
- Plant trees away from buildings to avoid contact at maturity.
- The form, beauty, color, ultimate size, hardiness, shade tolerance, water needs and soil preference of trees and shrubs must be considered.

When erosion or sediment control is not of primary concern, critical areas may be stabilized with rugged, fast growing trees and shrubs. Once established, they have a good record of taking care of themselves. In some cases, it may be desirable to use trees and shrubs as screening plants to shield sites such as gravel pits from public view. These plants should be given the best attention at planting by providing them with good soil, water and mulch. It is particularly necessary that the plants be checked and watered as needed during the first two growing seasons to promote rapid growth.

Quality planting stock should be used. Normally one or two year old deciduous seedlings and three or four year old coniferous transplants, when properly produced and handled, will meet the requirements. Larger specimen plants may be used if immediate landscape values are a consideration, but the costs will be considerably higher. Stock should be kept cool and moist until planted. Competing vegetation, if significant, should be destroyed or suppressed prior to planting by scalping (clearing) a small area where the plant is to be placed.

Dormant stock should be planted in the spring by May 15 or in the fall from August 15 through October 15.

Of the plants suggested in *Table 7*, the fastest growing trees are the poplars, willows, elms and pines, in that order. Of the shrubs, the fastest growing are forsythia, tall hedge buckthorn, and mock-orange. Shrub and tree recommendations for various soil conditions are also listed in *Table 7*.

Planting

Some erosion control shrubs are planted as bare-root seedlings, or in the case of willows and dogwood, hardwood cuttings or rooted cuttings can be used.

Hardwood cuttings should be a minimum of 3/8 inch diameter and 8-12 inches long. Cuttings are planted so that only the upper most bud is exposed. Along streams, plant on 2 foot centers beginning at the normal water level and plant two or three rows. Normally the area is overseeded with a grass mix immediately after planting. Refer to *Table 3* for selecting an appropriate seed mixture.

Nursery grown trees and shrubs have a much better chance of survival than plants dug from wild stands. Nursery stock has a root ball wrapped with burlap, plastic or wire or has been grown in a container. Deciduous trees with trunk diameters less than three inches may be planted anytime the soil is workable, but must be mulched and watered. Roots must be kept moist until planting by watering or heeling in.

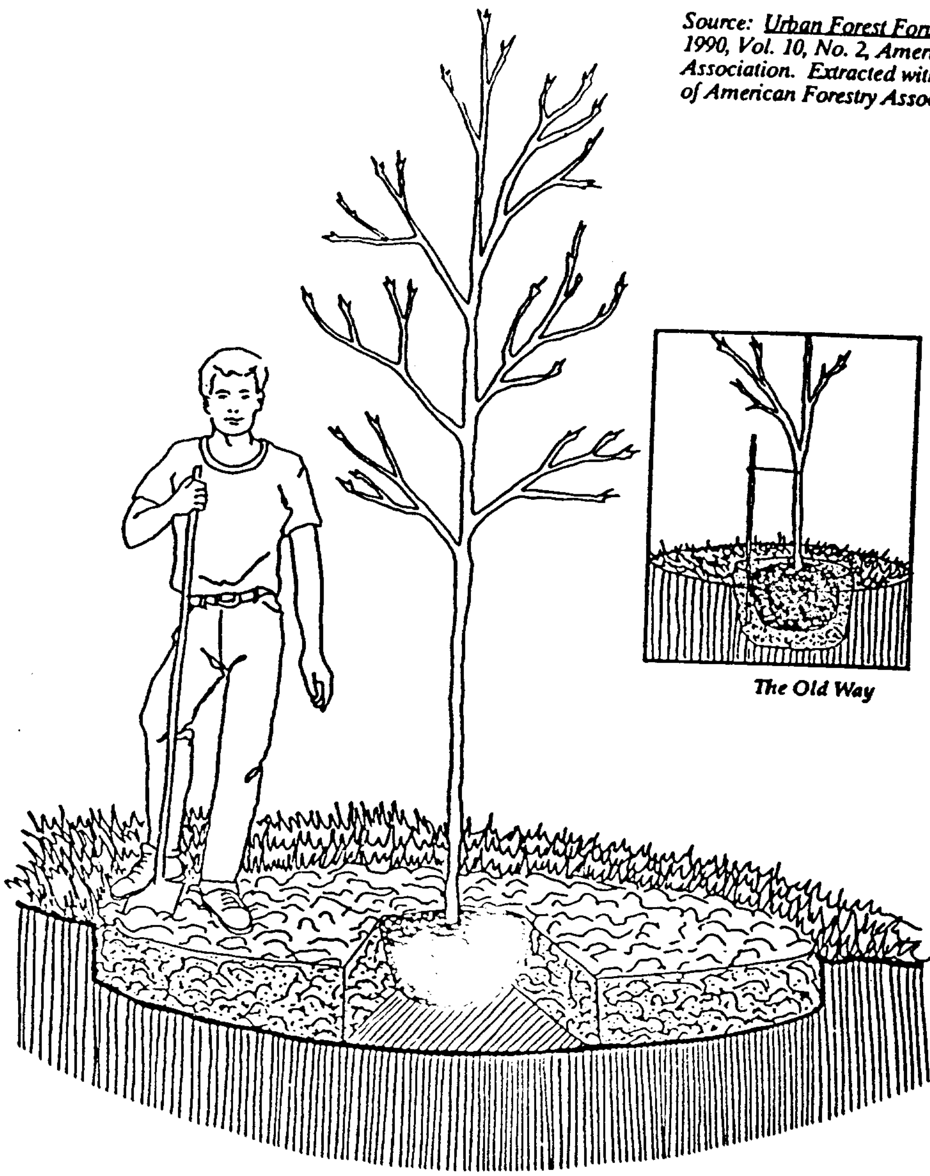
Proper spacing, planting depth and soil mixtures are also important considerations. New planting procedures are recommended by the American Forestry Association. See *Figure 2 - New Tree Planting Procedures* on the next page for details.

Fertilizing and Watering

Erosion control shrubs which are planted as bare-root seedlings or cuttings should not be fertilized during the planting year. They are not usually watered except at time of planting or during drought.

Figure 2: New Tree Planting Procedure

Source: Urban Forest Forum, April/May 1990, Vol. 10, No. 2, American Forestry Association. Extracted with permission of American Forestry Association.



The new method of tree planting will result in better survival and growth than the old method. Grass competition and soil compaction are two of the most common factors in poor performance. The New Method: Prepare a planting area five times the diameter of the root ball or container. Use a rototiller and/or spades to loosen and mix the soil to a depth of about 12 inches. Organic matter (well decomposed) can be added. Dig a hole in the center to set the tree, so that the root ball will rest on solid ground. Backfill around the root area, pressing the soil but not packing it. Mulch the entire prepared area with 2 to 4 inches of bark, wood chips, decomposed sawdust, or leaves. Reference the article for a full explanation.

The amount of fertilizer applied to other landscape plants will depend upon soil fertility and growth desired. Generally, shrubs should be fertilized in spring before growth starts. If soil temperatures are at least 40 degrees Fahrenheit, roots can absorb nutrients.

Deciduous shrubs should be fertilized the second year with one-quarter pound of a 5-10-5 fertilizer per plant (or 25 lbs. per 1,000 sq. ft. for block planting) or the equivalent. A slow release fertilizer is preferred. Evergreens should be fertilized at half the rate.

Trees are fertilized according to size. Use one pound of 5-10-5 per inch of trunk diameter for trees up to three inches in diameter. Broadcast fertilizer over the soil near the dripline of the tree branches.

Valuable trees and shrubs should be watered for two to three growing seasons after transplanting. A three to four inch mound of soil around the planting hole will provide a reservoir area for water to soak into the rooting zone. During dry periods, trees should receive about two inches of water at two to three week intervals.

Protection

Broken branches and roots should be pruned at planting time. Severe pruning is not needed on nursery-grown plants.

Trees may need to be secured with stakes and guy wires during the establishment period, usually one or two growing seasons. If wire is used, pad it with rubber hose to protect the bark.

Mulching

Mulches conserve soil moisture, insulate the soil and smother weeds. Wood chips and bark mulches are generally the preferred mulch material; straw and hay are attractive to rodents. Several fabric materials are available. Use according to manufacturer's recommendations. See *Mulching* section in *Chapter 2* for more information.

Inspection

The planting should be inspected after the first and second growing seasons. Replanting and repairs should be scheduled as needed.

Descriptions Of Grass And Legume Species

The following narrative describes the important individual characteristics, qualities and tolerances of plants recommended for use in vegetative stabilization of critical erosion areas. It is intended to point out specific traits which can be used to an advantage in revegetative work.

American beachgrass - *Ammophila breviligulata:* Beachgrass is the primary dune building plant for coastal sands. This cool season grass is extensively rhizomatous in sandy soils, and readily grows up through new deposition layers. It is planted vegetatively with dormant culms (stems) that can be obtained from coastal nurseries. Beachgrass and other sand colonizing plants are very intolerant of foot or vehicular traffic.

Big bluestem - *Andropogon gerardi* and little bluestem- *Schizachyrium scoparium:* Warm season bunch grasses have dense deep root systems and grow in large clumps. Under favorable conditions big bluestem grows up to 7 feet tall and little bluestem to 3 feet tall. Both are very drought tolerant even on soils with a very low percentage of silt and clay.

Birdsfoot trefoil - *Lotus corniculatus:* A winter hardy, perennial legume adapted to both well and poorly drained soils. Under favorable conditions trefoil will spread by reseeding. Trefoil is tolerant of medium acid soils, but grows more vigorously if such sites are limed to a pH of 6.0 - 6.5.

Canada bluegrass - *Poa compressa:* This rhizomatous perennial is slow starting and is seldom used alone. It is shade and drought tolerant. It can also be used to an advantage under conditions too dry or not otherwise entirely favorable to Kentucky bluegrass.

Caucasian bluestem - *Bothriochloa caucasicus:* This is an introduced warm season grass from Eurasia. In mixtures with native warm season grasses, Caucasian provides faster cover. It is only marginally hardy in New York and may winter kill, providing room for the native grasses.

Creeping foxtail - *Alopecurus arundinaceus:* This foxtail is a perennial, cool season grass that is not related to the weedy foxtails. Creeping foxtail is tolerant of wet soils and cold temperatures and is very vigorous once established. The small light seed does not flow in planting machinery and must be broadcast.

Creeping red fescue - *Festuca rubra (subsp. commutata):* This fescue is a cool season grass that spreads by underground stems or rhizomes. It is adapted to a wide range of soil types, tolerant of dry sites and valuable for its shade tolerance. It is a short grass used for low maintenance areas or general purpose turf.

Crownvetch - *Coronilla varia:* Crownvetch is a winter hardy, perennial legume that develops dense growth on well or moderately well drained soils. It spreads by underground stems and is self seeding. The seedlings will grow in moderately acid sites, but they will do better if the area is limed to a pH of 5.5 to 6.0.

Deertongue - *Panicum clandestinum:* Deertongue is a native perennial, warm season grass which normally reaches a height of up to 3 feet. It spreads slowly by rhizomes and seed. It is the most acid-tolerant of the grasses described. In droughty and low-fertility areas, deer-tongue can be used also. It does not persist as well as other warm season grasses on some sandy sites.

Flatpea - *Lathyrus sylvestris:* Flatpea is a perennial, deeply tap rooted legume with long vine-like stems capable of climbing to a height of eight feet. It is not adapted to wet sites, but will persist on moderately well drained to droughty soils. Seedlings are slow to develop, however once established, plants are vigorous and form a thick vegetative ground cover which resists encroachment by other plants.

Kentucky bluegrass - *Poa pratensis:* Kentucky bluegrass grows best on well drained, fertile soils. It establishes slowly but spreads by rhizomes to make an excellent, smooth turf. During hot, dry weather the plant goes dormant. It is used both as lawn and pasture grass.

Perennial ryegrass - *Lolium perenne:* This is a bunch grass having very rapid seedling growth. It tolerates fairly wet soils but can stand only short periods of flooding. It's used to provide quick protective cover on exposed soils, but does not withstand hot, dry weather or severe winters. Diploid cultivars are recommended for critical area seedings. New tetraploid cultivars are not as winter hardy.

Redtop - *Agrostis gigantea (A. alba):* This grass tolerates acid soils and droughty to poorly drained conditions. It emerges very quickly to form protective cover. Redtop is low growing and has a creeping growth habit. Although vigorous in the seedling stages, redtop does not seriously compete with slower growing cool season species. The reseeding habit and rhizomatous character of the roots make it a good plant for erosion control.

Reed canarygrass - *Phalaris arundinacea:* It will grow on poorly or well drained soils, and is tolerant of both flooding and drought. It spreads by scaly rhizomes which can also be used for vegetative propagation. The stems are coarse and the leaves are broad. Seed germinates slowly and loses viability after one year of storage. Use only fresh seed grown the previous season. Spring plantings are recommended. Avoid using reed canarygrass on slow moving waterways as the grass will retard water flow and eventually clog the waterway.

Sand lovegrass - *Eragrostis trichodes:* This species is commonly used in the plains area. Sand lovegrass is slower to establish than weeping lovegrass, but persists longer. This species is extremely small seeded.

Smooth bromegrass - *Bromus inermis:* This winter hardy forage grass spreads by rhizomes to form a coarse dense sod. It's tolerant of heat and drought. It grows on diverse types of soil, but is not tolerant of poorly drained areas. It has good seedling vigor, but is slow to establish a sod. The large, light seed is difficult to plant mechanically.

Switchgrass - *Panicum virgatum:* This perennial, warm season grass has short rhizomes and coarse stems. It has good seedling vigor and is widely adapted to soils which are moderately well drained to droughty. It will tolerate extremely acid soils, pH 4.0 to 4.5 and is the most widely used native warm season grass.

Tall fescue - *Festuca arundinacea:* It is a very widely adapted grass. Most seed sources are infected with a non-visible fungus which actually helps the plant compete under adverse conditions, but reduces forage quality. Tall fescue tolerates poor drainage and can survive winter flooding. It will grow on acid, alkaline or saline soils. Although considered a bunch grass, some tall fescue spreads slowly by short rhizomes. It produces a coarse, tough turf that resists traffic when seeded at heavy rates.

Weeping lovegrass - *Eragrostis curvula:* This warm season bunch grass has rapid first year growth. It spreads by tillering so that individual plants may be 12-15 inches in diameter in 2 to 3 years. Excellent growth can be obtained on low-fertility soils. Plants often winter kill in New York and New England but can be used as an annual.

White clover - *Trifolium repens:* Both standard and ladino types are readily adopted to most cool season grass mixtures. Clover adds nitrogen fixing capability which is beneficial to overall grass vigor on critical sites.

Wildflowers - Many species: Many species of wildflowers (forbs) are available for use on critical areas. Wildflowers can have a very positive impact with the public, and also serve to attract birds. Most seed companies which deal in wildflowers have mixes tailored to the Northeast, and some have mixtures for wet or dry soils.

Two cultivars selected for use in the Northeast are 'Golden Jubilee' black-eyed susan and 'Lancer' perennial pea. Both are adapted to most well drained soils. Perennial pea adds color to flatpea and crownvetch seedings.

Chapter 4: RECOMMENDATIONS FOR SELECTED AREAS

Construction Sites, Rights-of-Way, Capped Landfills

There are several important principles to be considered in vegetative control of erosion and sedimentation on construction sites including:

- Soils should not be exposed for more than about 15 days unless construction is to resume within 30 days. If construction is suspended for some reason, areas should be seeded and/or mulched without delay.
- Carefully select plant species adapted to the site and the purpose for which they are to be used.
- Do not burn or otherwise remove the protective vegetative litter from the site. Bare areas are vulnerable to erosion.
- Grade to a slope that allows for ease in planting and maintenance.
- Stockpile topsoil for use on the areas that need it for establishing vegetation.
- Limit removal of vegetation to the smallest possible area to accomplish construction needs.
- If the site is to be broadcast seeded, it should be done while the bulldozers are still on the area to provide tracking services.
- Guidelines for controlling erosion and sedimentation are available from New York State Department of Environmental Conservation.

Droughty Sites, Sand and Gravel Pits

Grade and shape site as needed. The amount and kind of grading required will vary with the planned use. For example, a recreation area development may require grading for access roads, trails, picnic or camp sites, etc. A wildlife area development may need only minor reshaping of steep banks to facilitate vegetation. Proper planning of operations during excavation of material can greatly reduce the amount of reshaping required for satisfactory establishment of vegetation.

Regardless of planned use, all banks should be reshaped to a maximum slope of 2:1. On some types of soil material, the banks should be no steeper than 3:1. If equipment is to travel on the slopes when revegetating, they should not exceed 3:1. Select seed mix based on the percent fines (silt and clay fraction by weight) passing a # 200 mesh sieve. If less than 16%, use warm season grasses only. If 16-20%, use warm season grasses or perennial legume mixes. If 21%, or higher, cool season grass legume mixtures can be used.

Dikes, Levees, Dams, Pond Banks, Terraces, Diversions or Other Earth Works

Select plant species that are adapted to the site. If the site is to be mowed regularly, grasses such as Kentucky bluegrass and creeping red fescue should be seeded.

Roadbanks

Old roadbanks should be scarified or regraded if rilled or gullied. This may be accomplished using a drag chain, disk or chisel, brush rake or a dozer. Lime and fertilizer should be applied after scarification.

New roadbanks should be limed and fertilized, seeded, and mulched as soon as possible after earth work is completed. If not seeded within 24 hours after construction, scarify the surface before seeding.

Rural Homesites

There are usually areas that can be seeded immediately following the completion of clearing and shaping of the site. Cover should be established on all areas that lie outside of those needed for construction activities. This will help reduce erosion and sedimentation. Lime, fertilizer, and seed should be applied as soon as possible after each work site is completed. If this is done, scarification of the seedbed may not be necessary.

Industrial Areas

During the development of industrial areas there are many places that should be protected by vegetative cover. Areas where construction activities will not take place should be vegetated as soon as possible after the earth work is completed. Species requiring little or no maintenance can be used on many of these areas.

Rights-of-Way (ROW)

Woody plant suppression is a secondary goal of many right-of-way plantings. Flatpea and crownvetch are the most successful plants for this purpose. Neither species is tolerant of poorly drained soils. On poorly drained sites reed canarygrass is the best choice. Flatpea and/or crownvetch should be planted as the final grading and smoothing are completed to promote good soil-seed contact. This is most important and will enable the rapid establishment of a stand which can

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suppress woody plants. Shade tolerance might also be a concern through wooded sites. If the canopy creates 50% shade cover or more, crownvetch may not grow vigorously or provide adequate woody plant suppression. Flatpea remains vigorous with a minimum of 3-4 hours of direct sunlight.

Capped Landfills

Landfills are often capped with an impervious layer specified in the closure plan. Then 20"- 24" of coarse sandy material may be applied as a growth media. Even when better material is used, droughty conditions often result due to the limited rooting depth to the impervious layer or high concentrations of methane. Warm season grasses are often the best species for these sites. They have extensive fibrous root systems and better water/nutrient use efficiency than do cool season grasses.

Streambanks

The following discussion and methods are provided as a guide in analyzing the problem, and the measures that can be used in its control. Except for minor site corrections where simple measures can be employed, the complexity of planning and construction require the assistance of an engineer.

Type of Planting

Straight stream sections and the inside of curved sections should be stabilized by seeding, or by planting shrubs on properly sloped banks above the normal water line. Shrubs are best suited to swift, steep-sided gravelly streams, especially those subject to ice-scour. Herbaceous plants are best suited to slower streams having low or gently sloping banks.

The outside bank of curved channel sections should be stabilized by using structural control (riprapping, gabions, cribbing, etc.) at the toe of the slope, and by planting shrubs on properly sloped banks above the installed structural measures.

For critical sections where surface runoff water cannot be diverted, sodding or seeding protected by jute netting or similar erosion control fabric should be used.

Topsoil

When soil conditions are particularly adverse for herbaceous vegetation, topsoil should be spread to a depth of four inches or more and then incorporated into the surface.

Mulching

Seeded side slopes should be mulched. Where streambanks are steeper than 2:1 or higher than ten feet, the mulch should be anchored.

Seeding Mixtures

Refer to the seeding mixture numbers found in *Tables 2* and *3*.

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Shrub Species and Arrangement

Top of Bank: Bayberry, coralberry, 'Streamco' purpleosier willow, or 'Bankers' dwarf willow spaced 4' x 4' to 6' x 6'.

Average Annual High Water Line: 'Streamco' purpleosier willow, or 'Bankers' dwarf willow spaced 3' x 3' to 4' x 4' (approximately 65-120 shrubs per 1,000 sq. ft.).

Normal Water Line: 'Streamco' purpleosier willow or 'Bankers' dwarf willow spaced 2' x 2' (approximately 240 shrubs per 1,000 sq. ft.), single row of 'Ruby' redosier dogwood or silky dogwood - spaced 2' apart in the row, or riprap. On sections where riprapping is not required, the silky dogwood would be planted just above the normal water line.

Preparing Cuttings: Woody cuttings, of the shrubs mentioned above, can be purchased from commercial nurseries or taken from native sources in the area during late winter before the leaves come out. To do this, take the cuttings from the latest growth, which is the new wood that grew during the previous season. The cuttings should be taken from 8-12 inches long, and from 3/8 to 1/2 inch in diameter. Be sure to use a sharp knife or pruning shears to avoid bruising the bark. Each cutting should have at least three healthy buds on it. Since the ends may dry out, make the cuts at least one inch away from the highest and lowest buds. Keep the cuttings cold and moist and plant them as soon as possible. Being careful not to injure the buds, plant the cuttings with the buds pointed up. The top bud should be at ground level or slightly above.

Large Streambanks

The problem of stabilizing the banks of large streams is complex. It does not lend itself to precise design, and the success of a given project is dependent upon the judgement, experience and skill of the designer.

Salt or Other Toxic Sites

When dealing with leachable toxics in sites, it is important to minimize disturbance of the surface. The surface may have been leached out since the last deposition of the toxic substance. Disturbance will bring higher concentrations back to the surface. This may prevent vegetating the site until the surface has leached the toxic material below the root zone.

Biotechnical Slope Stabilization

These critical erosion areas often require a combination of engineering and plant material treatments. Expensive structural engineering can sometimes be reduced by using woody plants which provide improved slope stability. An in-depth discussion of these techniques is found in "*Biotechnical Slope Protection* *and Erosion Control*" by Gray and Leiser, or *Chapter 18* of the *SCS Engineering Field Manual.*

Biotechnical slope stabilization is a series of techniques, all of which use plants in combination with engineering to protect slopes from soil movement and erosion. The principles are not new, and were utilized by the Soil Conservation Service on the Winooski River in Vermont 40 years ago. The resurgence in interest is for two reasons:

- Cost savings is considerable when compared to structural engineering practices used alone to correct critical erosion problems.
- Aesthetic cover provided by plants is often preferred over rock or concrete.

Wattles or Live Fascines

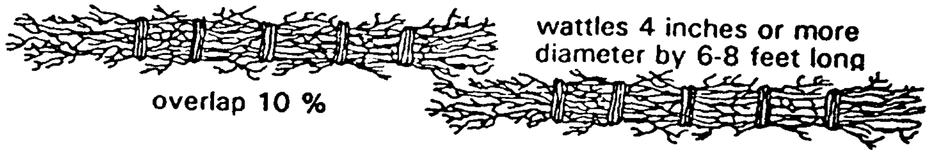
The primary procedure uses bundles of willow or dogwood whips about four inches in diameter and seven feet long. The bundles are referred to as "wattles" or "live fascines." The wattles are placed across the slope on the contours at three to five foot elevation intervals. Shallow trenches are dug and the wattles are placed in them, staked down, and covered with soil. The wattles sprout roots and stems along their length creating a continuous barrier to sloughing, etc. Wattles can be installed with hand labor. Refer to *Figure 3* on next page for details.

Brush Matting

A second technique is called brush matting. This system is used where major

Streambank stabilization - Planting willow wattles to modify flow along the bank.

Figure 3. Wattling or live-fascine installation



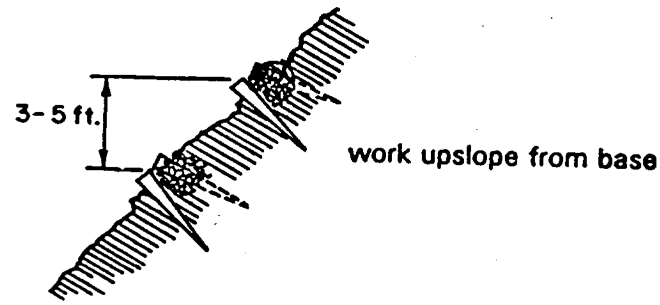
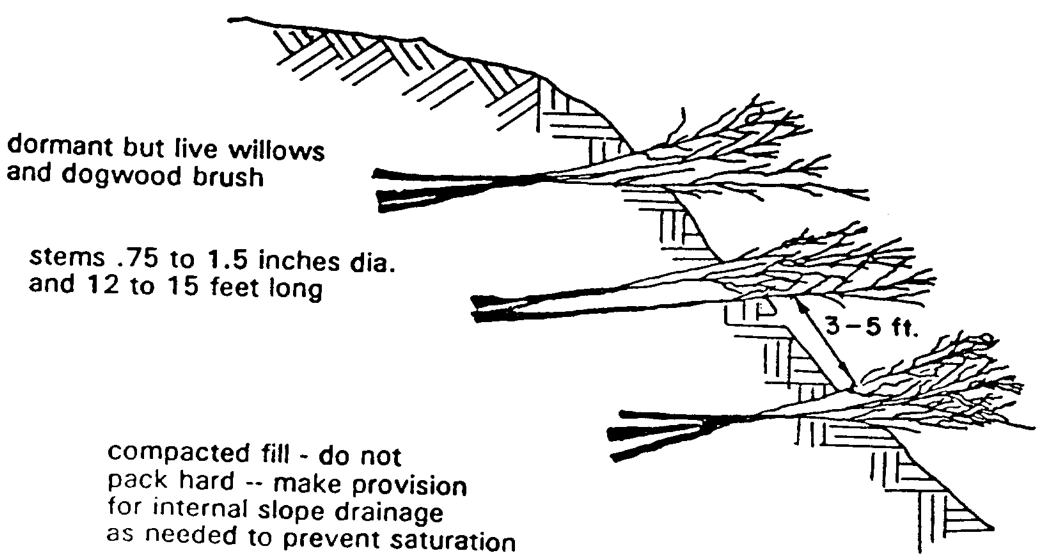


Figure 4. Brush matting installation



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reconstruction of a slope is needed, and it requires a bulldozer and/or a backhoe. It also requires a much greater volume of vegetation than does wattling. Starting at the base of the slope a pad is constructed on the contour. A layer of brush is placed on the pad, with butt ends into the hillside and tops out. A thin layer of soil is spread over the brush, then a second and third brush layer is applied also with soil between. Then a three to five foot layer of soil is placed on top and the process is repeated, working up the slope. About three to five feet of brush tops remains protruding out from the slope at each lift. See *Figure 4.*

For these techniques to be effective, the wattles and brush matting must consist of species which will root rapidly and grow. Non-rooting species (most shrubs) will fail. 'Streamco' and 'Bankers' willows have been tested and work very well for biotechnical slope stabilization. After the slope is stable, many other woody plants will invade and may dominate the site causing it to blend in with local vegetation. It is strongly recommended that the assistance of someone experienced in these techniques should be involved during the planning phase.

Lake Frontage

Erosion control of lake shoreline can be extremely difficult, especially where bluffs occur along the Great Lakes or other large lakes. Before a course of action is selected, consult with specialists from: Sea Grant, Cornell Cooperative Extension, County Soil and Water Conservation District, USDA Soil Conservation Service, or US Army Corp of Engineers.

When vegetative solutions are feasible, 'Cape' American beachgrass is the most commonly used plant on unconsolidated sands or gravels.

Filter Strips

Filter strips are extremely useful in preventing sediment from reaching water courses. Strips of grass or grass/legume should be a minimum of 20 feet wide for sediment trapping. *In table 3,* Seed mixture #2 or #5 is suggested. Mixture #2 should be used on soils of well to moderately well drained. Mixture #5 may be used on soils of poorly to very poorly drained classes.

Insufficient documentation is currently available on nutrient absorption by plants within filter strips. However, actively growing grasses are effective nutrient users. When nutrients are to be filtered, manage the filter strips to keep the plant in a vegetative growth stage. Mowing and removing the forage prior to seed head production will be the best practice to keep the grass vigorously growing.

Sandblows and Dunes

Few plants will stabilize eroding, sandy areas. American beachgrass has been successful in many situations. It is necessary to plant culms of this grass. As the beachgrass begins to stabilize the sand, other plants can be established. Keep people and vehicles off planted areas.

When planting or sprigging beachgrass, the best planting time is in early spring before May 15. Plant sprigs containing 3 stems (culms) about 8" deep at a spacing of 18" apart in rows. Rows should be staggered 18" apart. A 12" x 12" spacing will stabilize an area faster and should be considered when patching blowout areas.

Cape American beachgrass on sand and gravel bank two months after planting.

Fertilize the planted area with 10-10-10 fertilizer or equivalent, at a rate of 400 pounds per acre at planting time. Follow this with 40 pounds per acre of nitrogen after spring growth begins, and repeat annually until an adequate plant cover is established.

Temporary Stabilization of Sandblows and Dunes

Two temporary stabilization techniques may be used. One uses brush placed with butts windward. Start by placing brush on the leeward side and working toward the windward side. Overlap butts with tops to provide a shingling effect. A second approach uses snowfence. Place the fencing material at right angles to the prevailing wind.

Permanent Stabilization of Sandblows and Dunes

Vegetative stabilization is done by planting culms of 'Cape' American beachgrass. A planting unit of beachgrass consists of three healthy culms. Planting should be done between March 1 and April 15. Culms will be planted 8 to 9 inches deep. Culms may be purchased commercially or dug locally during the planting season. The stems should be cut back to 15 inches before or after digging. They may be stored by heeling-in, or storing at 28 to 32 degrees Fahrenheit.

An alternative, less expensive method is to plant the beachgrass in bands. These bands should be spaced 20 to 40 feet

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apart. The bands should consist of at least two parallel rows spaced approximately 18 inches by 18 inches. The closer band spacing should be used on the prevailing wind side of dunes.

On inland windblown areas, use 20 foot spacing between double rows of American beachgrass. Bands should be perpendicular to damaging wind direction. Fertilizer should be applied to the planted bands as discussed above.

Shrub and tree plantings may be combined with beachgrass on coastal and inland sites. Where this is the intent, the woody species are planted 1 to 3 years after the beachgrass is put on the site. Some compatible trees and shrubs are:

Inland Area Species:
- *American holly*
- *Scotch pine*
- *Pitch pine*
- *'Arnot' bristly locust*
- *Bayberry*
- *Rugosa rose*

Coastal Area Species:
- *American holly*
- *Beach plum*
- *Bayberry*
- *Rugosa rose*
- *'Emerald Sea' shore juniper*

WINDBREAKS

An often overlooked possibility for vegetating critical areas is to provide additional benefits of wind, snow, sight, noise, and dust control. Minimal maintenance of the barriers is desirable, so plants must be selected with an eye toward adaptation as well as effectiveness. Guiding principles for windbreaks include:

- Windbreaks are most effective at downwind distances of less than 10 times the height of the trees.
- Two row windbreaks often provide acceptable performance; visual screens can be single row plantings.
- Noise barriers increase in effectiveness as their distance to the noise source is reduced.
- Visual screens are most successful with evergreens providing year-round benefits, but a partial screen can be achieved faster with poplars or other fast growing deciduous species.
- Snow control plantings should be placed on the windward side at least 50 feet from the locations to be protected. Snow will accumulate upwind of, in, and downwind of the windbreak. Care should be exercised to avoid snow accumulation on inappropriate locations.
- Species selection and placement are critical to avoid interfering with septic and drainage systems. Utilities such as water, gas, and electric lines should also be avoided.
- Gaps in the windbreak/screen should be filled with replacement trees as soon as possible.

Wildlife And Fish Benefits

Some species of wildlife will benefit from the stabilization of critically eroding areas regardless of type of plants used. Proper planning of critical area plantings can result in additional wildlife benefits.

Wildlife

Nearly all plants provide some wildlife cover but some are better than others. Wildlife are selective in the plants they use for food. Whenever possible, select plants that provide both food and cover for the wildlife species for which habitat improvement is intended. Refer to *Table 9 "Wildlife and Fish Benefits of Stabilizing Plants"* for food and cover value of various plants.

Most species of wildlife, with the exception of field nesting songbirds, require hardwood shrubs and/or trees for food, escape, roosting or loafing cover. Many species prefer evergreens for winter cover. For a description of the types and amounts of the habitat elements that are needed by the individual wildlife species for minimum and optimum habitat, refer to the *USDA Soil Conservation Service (SCS) Field Office Technical Guide - Standards and Specifications for Wildlife Upland Habitat Management or Wildlife Wetland Habitat Management.*

Steep slopes (over 3:1) are not as desirable for ground nesting birds as are flatter slopes. Level areas are best. If seeding large areas for general wildlife benefits it is best to add 1/4 to 1/2 acre or larger clumps of wildlife shrubs and evergreens totaling not more than 5 acres or 1/4 of the area, whichever is larger.

Exposed soil areas to be planted to trees and/or shrubs should be stabilized by seeding mixture 22 or 23 from *Table 3* before or at the time the shrubs and/or trees are planted. Only the aisles should be seeded to grass. Maintenance mowing should be performed after July 15 to minimize loss of nesting birds.

Fish

Fish benefit from stabilized streambanks. Controlled upland erosion reduces sediment reaching streams that may smother fish eggs. Shade provided by overhanging grasses, shrubs and trees help cool the water. Stems and roots protruding into the water also provide cover for fish. Small shrubs, such as 'Ruby' redosier dogwood, alder, and 'Streamco' purpleosier willow will provide some shade to small streams when planted on the bank, particularly on north or south flowing streams.

On larger streams, and streams flowing east or west, shade trees like boxelder maple, sycamore and red or silver maple are needed to provide shade over the water. These large trees should be planted on top of the streambank 8 to 10 feet from the edge.

Care should be taken in planing woody plant establishment so that fishermen are not excluded from the entire bank.

Appendix

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TABLE 1A

GRASS AND LEGUME PLANTING GUIDE, GROWTH HABIT, SEASON AND SOIL DRAINAGE TOLERANCES

COMMON NAME	BOTANICAL NAME	Growth Habit	Season		Soil Drainage Tolerance				
			Cool	Warm	Dry (not) Droughty	Well Drained	Mod. Well Drained	Somewhat Poorly Drained	Poorly Drained
Bluegrass, Canada	Poa compressa	PlR	X	-	X	X	X	X	X
Bluegrass, Kentucky	Poa pratensis	PlR	X	-	X	X	X	X	-
Bluestem, big	Andropogon gerardi	PlB	-	X	X	X	X	-	-
Bluestem, Caucasian	Bothriochloa caucasicus	PlB	-	X	X	X	-	-	-
Bluestem, little	Schizachyrium scoparium	PlB	-	X	X	X	X	-	-
Bromegrass, smooth	Bromus inermis	PlR	X	-	X	X	X	X	-
Canarygrass, reed	Phalaris arundinacea	PlR	X	-	X	X	X	X	X
Deertongue	Panicum clandestinum	PlR	-	X	X	X	X	X	X
Fescue, creeping red	Festuca rubra subsp. commutata	PlR	X	-	X	X	X	X	-
Fescue, tall	Festuca arundinacea	PlBR	X	-	-	X	X	X	-
Lovegrass, sand	Eragrostis trichodes	PlB	-	X	X	X	-	-	-
Lovegrass, weeping	Eragrostis curvula	PsB	-	X	X	X	X	X	-
Redtop	Agrostis gigantea	PsR	X	-	X	X	X	X	X
Ryegrass, perennial	Lolium perenne	PsB	X	-	-	X	X	X	-
Switchgrass	Panicum virgatum	PlR	-	X	X	X	X	X	-
Crownvetch *	Coronilla varia	PlR	X	-	-	X	X	-	-
Platpea *	Lathyrus sylvestris	PlR	X	-	X	X	X	X	-
Trefoil, birdsfoot *	Lotus corniculatus	PlB	X	-	X	X	X	X	X

Growth Habit: P perennial; l - long lived; s - short lived;
R rhizomatous or spreads by root stock; B - bunch
* - legume requiring inoculation of special inoculum prior to seeding

TABLE 1B

GRASS AND LEGUME PLANTING GUIDE TOLERANCE
USE SUITABILITY AND MAINTENANCE

COMMON NAME	pH Range	Tolerant to		Traffic Resistance	Use Suitability						Maintenance Levels		
		Flooding	Shade		Critical Areas	Waterways & Channels	Lawns	Playgrounds	Athletic Fields	Beautification	High	Medium	Low
Bluegrass, Canada	4.5-9.5	-	X	X	X	-	-	X	-	-	-	X	X
Bluegrass, Kentucky	5.5-7.0	X	-	X	X	X	X	X	X	-	X	X	X
Bluestem, big	5.0-7.5	-	-	-	X	-	-	-	-	X	-	-	X
Bluestem, Caucasian	4.5-7.5	-	-	-	X	-	-	-	-	-	-	-	X
Bluestem, little	5.5-7.5	-	-	-	X	-	-	-	-	X	-	-	X
Bromegrass, smooth	5.5-8.0	X	-	-	X	X	-	-	-	-	X	X	X
Canarygrass, reed	5.0-7.5	X	-	-	X	X	-	-	-	-	X	X	X
Deertongue	3.8-5.0	-	-	-	X	X	-	-	-	-	-	-	X
Fescue, creeping red	4.5-9.5	X	X	X	X	X	X	X	X	X	X	X	X
Fescue tall	5.0-9.0	X	X	X	X	X	X	X	X	X	X	X	X
Lovegrass, sand	4.5-8.0	-	-	-	X	-	-	-	-	X	-	-	X
Lovegrass, weeping	4.5-8.0	-	-	-	X	-	-	-	-	-	-	-	X
Redtop	4.0-7.5	X	-	X	X	X	X	X	X	-	-	-	X
Ryegrass, perennial	5.5-7.5	-	-	-	X	-	X	X	X	-	-	X	X
Switchgrass	4.5-7.5	X	-	-	X	X	-	-	-	X	-	X	X
Crownvetch	5.5-9.0	-	X	-	X	-	-	-	-	X	-	X	X
Flatpea	5.0-9.0	-	X	-	X	-	-	-	-	X	-	X	X
Trefoil, birdsfoot	5.0-9.0	-	-	-	X	-	-	-	-	X	X	X	X

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TABLE 2

PERMANENT SOIL AND WATER CONSERVATION SEEDINGS

PRINCIPAL USE *	MOWED (Mix No.)	NOT MOWED (Mix No.)
Borrow Areas	1,2,3,4	Any mix
Dikes, Levees, Dams & Pond Banks	1,2,3,4,5,8	1,2,3,4,5, 6,7,9,10,11,13
Drainage Ditch & Channel Banks	1,2,3,4,5,8	1,2,3,4,5,6,7,8,9
Diversions	1,2,3,4,8,22,23	1,2,3,4,8,9,10,11 13,22,23
Effluent Disposal Areas and Filter Strips	5,6,8	5,6,8
Gravel Pits (select mix based on % fines)	——	15a,b,13
Gullied & Eroded Areas	——	Any except 1,6,8,16 17,20,21,23
Reclaimed landfills w/liner	——	4,7,12,15a
Minespoil & Wastes & Other Spoil Banks *	——	9,11,12,15a,b,18
Recreation Seedings, General		
Picnic, Playgrounds		
Driving for Archery Ranges,		
Camping, Parking		
Not shaded	1,4,8,17,23	——
Shaded	1,4,8,16,22	——
Roadsides & Other Slopes & Banks	1,2,3,4,7,23	4,7,9,10,11,12,13 14,15a,b
Shorelines, fluctuating water levels	——	5 or 6
Ski Slopes	3,4,7,8,9,11,13,20	4,10,11,13
Sod Waterways & Spillways	1,2,3,4,7,8,13,23	1,2,3,4,7,8,13,23
Streambanks	2,4,7,13,23	3,4,5,6,10,11,13,23
Utility Rights-of-Way	1,2,3,4	1,4,14,15a,b,18,20
Woods, Roads, Skid Trails, Staging Areas		
Not Shaded	——	4,18,19,20,23
Shaded	——	18,19,20
Sand Dunes	——	21

*If suppression of woody growth is desired, and site conditions allow, use mix 18, 19 or 20.

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TABLE 3
PERMANENT SEEDING MIXTURE RECOMMENDATIONS BY RATE AND SITE ADAPTATION

Seed as early as possible in the spring and no later than June 1. Late summer/early fall seedings can also be done between August 15 - September 15. These late season seedings are not recommended for mixes 12, 15a, 15b, 18 and 19.

SEED MIXTURE	Variety	Rate in lbs/ac (lbs/1000 ft2)	SOIL-SITE ADAPTATION		
			Excessively Drained	Well to Mod Well Drained	Poorly To Very Poorly Drained
1.Ky. bluegrass*	Adelphi/Baron	20 (.5)	-	X	-
Creeping red	Ensylva	20 (.5			
fescue, or		5 (.1)			
Redtop or	Common	2 (.1)			
Perennial ryegrass	Pennfine	5 (.1)			
2.Creeping red fescue	Ensylva	20 .5			
Redtop	Common	2 (.1)			
Perennial ryegrass	Pennfine	5 (.1)	-	X	X
or Tall fescue or	KY-31	20 (.5)			
Smooth bromegrass	Saratoga	20 (.5)			
3.Creeping red fescue	Ensylva	20 (.5)			
Tall fescue or	KY-31	20 (.5)	X	X	-
Smooth bromegrass	Saratoga/Baylor	20 (.5)			
& Birdsfoot trefoil	Empire	8 (.2)			
4.Creeping red* fescue or	Ensylva	20 (.5)			
Tall fescue	KY-31				
Redtop or	Common	2 (.1)			
Perennial ryegrass	Pennfine	5 (.1)	-	X	-
& Birdsfoot trefoil	Empire	8 (.2)			
5.Tall fescue**	KY-31	20 (.5)			
Reed canarygrass	Palaton/Venture	10(.25)			
Redtop or	Common	3 (.1)			
Perennial rye-grass	Pennfine	5 (.1)		X	X

TABLE 3 (cont.)

SEED MIXTURE	Variety	Rate in lbs/ac (lbs/1000 ft2)	SOIL-SITE ADAPTATION: Excessively Drained	Well to Mod Well Drained	Poorly To Very Poorly Drained
6.Reed canarygrass** Creeping foxtail Redtop or Perennial ryegrass Birdsfoot trefoil	Palaton/Venture Garrison Common Pennfine Empire	15 (.33) 5 (.1) 5 (.1) 5 (.1) 10 (.25)	-	x	x
7.Smooth bromegrass Perennial ryegrass Birdsfoot trefoil	Saratoga Pennfine Empire	15 (.33) 5 (.1) 10 (.25)	-	x	-
8.Tall fescue*	KY-31/Rebel	30 (.75)	-	x	-
9.Creeping red fescue Tall fescue Smooth bromegrass Crownvetch	Ensylva KY-31 Saratoga/Baylor Penngift/Chemung	10 (.25) 15 (.33) 15 (.33) 15 (.33)	x	x	-
10.Creeping red fescue Perennial Ryegrass Redtop Crownvetch	Ensylva Pennfine Common Penngift/Chemung	20 (.45 5 (.1) 2 (.1) 15 (.33	x	x	-
11.Birdsfoot trefoil Crownvetch & Creeping red fescue or Smooth brome-grass or Tall fescue	Viking Penngift/Chemung Ensylva Saratoga/Baylor KY-31	8 (.2) 15 (.33 20 (.5) 20 (.5) 20 (.5)	x	x	-
12.Switchgrass*** NOTE: This rate is in PLS.***	Shelter/Blackwell	20 (.5)	x	x	-
13.Tall fescue* Redtop Perennial ryegrass Birdsfoot trefoil	KY-31 Common Pennfine Viking	10 (.25) 2 (.1) 5 (.1) 8 (.2)	-	x	-
14.Crownvetch Ryegrass	Penngift/Chemung Pennfine	15 (.33 5 (.1)	x	x	-

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TABLE 3 (cont.)

SEED MIXTURE	Variety	Rate in lbs/ac (lbs/1000 ft2)	SOIL-SITE ADAPTATION: Excessively Drained	Well to Mod Well Drained	Poorly To Very Poorly Drained
15a. Switchgrass* Big bluestem Little bluestem Sand lovegrass Caucasian bluestem	Blackwell/Shelter Niagara Aldous/Camper NE27/Bend	4 (.1) 4 (.1) 2 (.05) 2 (.1) 2 (.17)	x	x	-
NOTE: ALL RATES FOR THIS MIX ARE FOR PLS.***					
15b. Flatpea Perennial pea Crownvetch Tall fescue	Lathco Lancer Penngift/Chemung KY-31/Rebel	10 (.25) 2 (.05) 10 (.25) 10 (.25)	x	x	-
16. Creeping red fescue Ky bluegrass	Ensylva Adelphi/Baron	40 (.9) 20 (.5)	-	x	x
17. Tall fescue	KY-31	100 (2.5)			
18. Tall fescue Redtop Perennial ryegrass Flatpea	KY-31 Common Pennfine Lathco	10 (.25) 2 (.1) 5 (.1) 30 (.7)	x	x	-
19. Creeping red fescue Flatpea	Ensylva Lathco	15 (.33) 30 (.7)	x	x	-
20. Creeping red fescue Tall fescue Crownvetch	Ensylva KY-31 Penngift/Chemung	15 (.33) 10 (.25) 15 (.33)	x	x	-
21. American beach-grass	Cape	Culms**** 58500 (1345)	x	-	-
22. Red fescue Perennial ryegrass	- -	30 (.7) 5 (.2)	x	x	
23. White clover Perennial ryegrass	- -	10 (.25) 2 (.2)	x	x	
24. Wildflower Mix	misc.	various	x	x	x

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TABLE 3 (cont.)

* Wildflowers (#24) may be seeded with these mixtures.
** Reed canarygrass. Use only seed with germination rate of 70% or better that has been tested within past 4 or 5 months.
*** (PLS) Pure Live Seed. Warm season grass seed is sold and planted on the basis of pure live seeds (PLS). An adjustment is made to the bulk weight of seed to compensate for inert material and dead seed.

Pure live seed may be calculated when the percent germination and the percent purity is known.

1. Convert % germination and purity to decimal form.

2. PLS factor = germ X purity.

3. Pounds of seed needed = $\frac{\text{seeding rate in pure live seed}}{\text{PLS Factor}}$

EXAMPLE: Want to seed little bluestem at
2 PLS pounds/acre
seed lot has purity of 65%
germination of 80%

so PLS factor = .65 x .80 = .52

Pounds of Seed needed = $\frac{2}{.52}$ = 3.8 pounds

**** Vegetative culms or stems are used as propagates (not seed). Three culms are typically planted per planting hole.

TABLE 4

TEMPORARY SOIL AND WATER CONSERVATION
SEEDING MIXTURES

SEED	LBS./ACRE	LBS./1000 Sq. Ft.
For Spring Seedings:		
a) Annual ryegrass	30	.7
b) Spring oats	80 (2 1/2bu)	2.00
c) Annual ryegrass	15	.35
and		
Spring oats	64 (2 bu)	1.50
d) Perennial ryegrass	30	.7
For Late Spring & Summer Seedings:		
a) Sudangrass	40 (1.0 bu)	.90
b) Annual ryegrass	30	.7
c) Perennial ryegrass	30	.7
For Late Summer & Fall Seedings:		
a) Annual ryegrass (Common)	30	.7
b) Winter rye (Aroostook)	112 (2 bu)	2.50
c) Winter wheat	120 (2 bu)	2.75
d) Perennial ryegrass (Pennfine)	30	.7

TABLE 5 - GUIDE TO MULCH MATERIALS, RATES AND USES

Mulch Material	Quality Standards	Application Rates per 1000 Sq. Ft.	Application Rates per Acre	Depth of Application	Remarks
Sawdust green, or composted	Free from objectionable coarse material	83-500 cu. ft.	--	1-7"	Most effective as a mulch around ornamentals, small fruits & other nursery stock. Requires 30-35 lbs. N/ton to prevent N deficiency while decaying mulch. One cu. ft. weighs 25 lbs
Wood Chips or Shavings	Green or air-dried. Free of objectionable coarse materials	500-900 lbs.	10-20 tons	2-7"	Has about the same use and application as sawdust, but requires less N/ton (10-12 lbs.). Resistant to wind blowing. Decomposes slowly.
Wood Excelsior	Green or airdried burred wood fibers	90 lbs. (1 bale)	2 tons	--	Decomposes slowly Subject to some wind blowing. Packaged. in 80-90 lbs. bales.
Wood Fiber Cellulose (Partly digested wood fibers)	Made from natural wood usually with green dye & dispersing agent added.	50 lbs.	2000 lbs.	--	Apply with hydromulcher. No tie-down required. Less erosion control provided than 2t hay or straw.
Compost or Manure	Well shredded, free of excessive coarse materials	400-600 lbs.	8-10 tons	--	Use straw manure where erosion control is needed. May create problem with weeds. Excellent moisture conserver. Resistant to wind blowing.

TABLE 5 - GUIDE TO MULCH MATERIALS, RATES AND USES (Cont.)

Mulch Material	Quality Standards	Application Rates per 1000 Sq. Ft.	per Acre	Depth of Application	Remarks
Cornstalks, shredded or chopped	Air-dried, shredded into 8" to 12" lengths	150-300 lbs.	4-6 tons	--	Effective for erosion control, relatively slow to decompose. Excellent for mulch on crop fields. Resistant to wind blowing.
Gravel, Crushed Stone or Slag	Washed; Size 2B or 3A - 1 1/2"	9 cu. yds.	--	3"	Excellent mulch for short slopes and around woody plants and ornamentals. Use 2B where subject to foot traffic.(Approx. 2000 lbs./cu.yd.). Frequently used over black plastic for better weed control.
Hay or Straw	Air-dried; free of undesirable seeds & coarse materials	90-100 lbs.2-3 bales	2 T 100-120 bales	cover about 90% surface	Use straw where mulch is maintained for more than three months. Subject to wind blowing unless anchored. Most commonly used mulching material. Best micro environment for germinating seeds.
Peat Moss	Dried, compressed free of coarse	200-400 cu. ft.	1/2-1	2"-4"	Most effective as a mulch around ornamentals. Subject to wind blowing unless kept wet. 100 lbs. bales (6 cu. ft.). Excellent moisture holding capacity.

TABLE 5 - GUIDE TO MULCH MATERIALS, RATES AND USES (Cont.)

Mulch Material	Quality Standards	Application Rates per 1000 Sq. Ft.	per Acre	Depth of Application	Remarks
Jute Twisted Yarn	Undyed, unbleached plain weave Warp 78 ends/yd Weft 41 ends/yd 60-90 lbs/roll	48" x 50 yds or 48" x 75 yds	--	--	Use without additional mulch. Tie down as per manufacturing specification.
Excelsior Wood Fiber Mats	Interlocking web of excelsior fibers with photodegradable plastic netting	48"x100" 2 sided plastic 48"x180" 1 sided plastic	--	--	Use without additional mulch. Excellent for seeding establishment. Tie down as per manufacturers specifications. Approx. 72 lbs/roll for excelsior with plastic on both sides. Use two sided plastic for center - plastic for centerline of waterways.
Glass Fiber	1/4" thick, 7/16" dia., holes on 1" centers; 56 lb. rolls.	72"x30 yds.	--	--	Use without additional mulch. Tie down with T bars as per manufacturers specifications.
Plastic	2-4 mils	Variable	--	--	Use black for weed control. Effective moisture conservation and weed control for small fruits and ornamentals.
Filter Fabrics	Woven or Spun	Variable	--	--	--
Straw or coconut fiber or combination	photodegradable plastic net on one or two sides.	most are 6.5 ft x 83.5 ft	81 rolls	--	Designed to tolerate higher velocity water flow, centerlines of waterways. 60 sq. yds. per roll.

TABLE 6: MULCH ANCHORING GUIDE

Anchoring Method or Material	Kind Of Mulch To Be Anchored	How To Apply
A. Manual 1. Peg and twine	Hay or straw	After mulching, divide areas into block approx. 1 sq. yd. in size. Drive 4-6 pegs per block to within 2" to 3" of soil surface. Secure mulch to surface by stretching twine between pegs in criss-cross pattern on each block. Secure twine around each peg with 2 or more turns. Drive pegs flush with soil where mowing and maintenance is planned.
2. Mulch netting	Hay or straw	Staple the light-weight paper, jute, wood fiber, or plastic nettings to soil surface according to manufacturer's recommendations. Should be biodegradable. Most products are not suitable for foot traffic.
3. Soil & stones	Plastic	Plow a single furrow along edge of area to be covered with plastic, fold about 6" of plastic into the furrow and plow furrow slice back over plastic. Use stones to hold plastic down in other places as needed.
4. Cut-in	Hay or straw	Cut mulch into soil surface with square edged spade. Make cuts in contour rows spaced 18" apart. Most successful on contour in sandy soils.
B. Mechanical 1. Asphalt spray (emulsion)	Compost, wood chips wood shavings, hay or straw	Apply with suitable spray equipment using the following rates: asphalt emulsion: on slopes use200 gal/ac, on level, use 150 gal/ac; liquid asphalt: (rapid, medium, or slow setting) 0.10 gallons per sq/yd. 400 gal/ac.
2. Wood cellulose fiber	Hay or straw	Apply with hydroseeder immediately after mulching. Use 750 lbs wood fiber per acre. Some products contain an adhesive material.
3. Pick chain	Hay or straw manure compost	Use on slopes steeper than 3:1. Pull across slopes with suitable power equipment.
4. Mulch anchoring tool or disk	Hay or straw, manure/mostly straw	Apply mulch and use a mulch anchoring tool. When a disk (smooth) is used, set in straight position and pull across slope with suitable power equipment. Mulch material should be "tucked" into soil surface about 3".
5. Chemical	Hay or straw	Apply Terra Tack AR 120 lbs/ac in 480 gal. of water or Aerospray 70 (60 gal/ac) according to manufacturer's instructions. Avoid application during rain. A 24 hour curing period and a soil temperature higher than 45° F are required.

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TABLE 7

SPECIES FOR TREE AND SHRUB PLANTINGS

TREES FOR EXCESSIVELY DRAINED SOILS

Scientific Name	Common Name	Mature Height
Robinia pseudoacacia	Black locust	50′
Betula populifolia	Gray birch	30′
Pinus resinosa*	Red pine	80′
Pinus sylvestris*	Scotch pine	60′
Pyrus spp.	Crabapple	25′

SHRUBS FOR EXCESSIVELY DRAINED SOILS

Scientific Name	Common Name	Mature Height
Rhus glabra	Smooth sumac	9-15′
Rhus typhina	Staghorn sumac	30′
Robinia fertilis	Arnot bristly locust	15′
Comptonia peregrina	Sweetfern	3′

TREES FOR SOMEWHAT EXCESSIVELY DRAINED SOILS

Scientific Name	Common Name	Mature Height
Fraxinus pennsylvanica lanceolata	Green ash	60′
Populus alba	White poplar	90′
Ulmus pumila	Siberian elm	75′

SHRUBS FOR SOMEWHAT EXCESSIVELY DRAINED SOILS

Scientific Name	Common Name	Mature Height
Acer ginnala	Amur maple	20′
Berberis thunbergii	Japanese barberry	7′
Corylus americana	American hazelnut	6′
Elaeagnus angustifolia	Rusian olive	20′
Hammamelis virginiana	Common witch-hazel	50′
Juniperus communis*	Common juniper	3-30′
Juniperus virginiana*	Red cedar	10-90′
Kolkwitzia amabilis	Beauty bush	10′
Ligustrum amurense	Amur privet	15′

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TABLE 7

SPECIES FOR TREE AND SHRUB PLANTINGS (cont.)

SHRUBS FOR SOMEWHAT EXCESSIVELY DRAINED SOILS (Cont.)

Scientific Name	Common Name	Mature Height
Myrica pensylvanica	Bayberry	5′
Rhamnus frangula	Alder buckthorn	18′
Rhus aromatica	Fragrant sumac	3′
Rhus copallina	Sumac	30′
Viburnum lentago	Nannyberry	15′

TREES FOR WELL DRAINED AND MODERATELY WELL DRAINED SOILS

Scientific Name	Common Name	Mature Height
Acer platanoides	Norway maple	90′
Catalpa speciosa	Northern catalpa	90′
Picea abies*	Norway spruce	150′
Picea pungens*	Colorado spruce	100′
Pinus strobus*	Eastern white pine	100-150′
Pseudotsuga menziesii*	Douglas fir	100-300′
Salix spp.	Willow	75′
Sorbus americana	American mountain-ash	25′
Thuja occidentalis*	American arborvitae	60′
Tilea cordata	Little-leaf linden	90′
Ulmus parvifolia	Chinese elm	50′
Alnus glutinosa	European black alder	60′

SHRUBS FOR WELL DRAINED AND MODERATELY WELL DRAINED SOILS

Scientific Name	Common Name	Mature Height
Cornus macrophylla	Cornelian cherry	24′
Cornus racemosa	Gray-stemmed dogwood	6′
Corylus americana	American hazelnut	6′
Corylus cornuta	Beaked hazelnut	12′
Elaeagnus umbellata	'Cardinal' autumn olive	20′
Euonymus spp.	Euonymus spp.	1-9′
Forsythia x intermedia	Border forsythia	9
Ilex glabra	Inkberry	5′
Lonicera maackii podocarpa	'Rem Red' honeysuckle	15′
Lonicera tatarica	Tatarian honeysuckle	12′
Myrica pensylvanica	Bayberry	5′
Philadelphus coronarius	Mock-orange	9′

TABLE 7

SPECIES FOR TREE AND SHRUB PLANTINGS (cont.)

SHRUBS FOR WELL DRAINED AND MODERATELY WELL DRAINED SOILS (Cont.)

Scientific Name	Common Name	Mature Height
Rhamnus frangula 'Columnaris'	Tallhedge buckthorn	12'
Rhododendron maximum	Rhododendron	20'
Symphoricarpos orbiculatus	Coralberry	4'
Syringa vulgaris	Common lilac	20'
Taxus cuspidata*	Japanese yew	50'

TREES FOR POORLY DRAINED AND VERY POORLY DRAINED SOILS

Scientific Name	Common Name	Mature Height
Acer negundo	Box elder	60'
Acer rubrum	Red maple	60'
Acer saccharinum	Silver maple	70
Fraxinus pennsylvanica	Green ash	40'
Fraxinus nigra	Black ash	45'
Platanus occidentalis	Sycamore	100'
Picea glauca*	White spruce	80'
Salix spp.	Willows	70'
Thuja occidentalis*	White cedar	60'
Cornus amomum	Silky dogwood	8'
Ilex verticillata	Winterberry	10'
Lonicera maackii podocarpa	'Rem Red' amur honeysuckle	15'
Lonicera tatarica	Tatarian honeysuckle	12'
Vaccinium corymbosum	Highbush blueberry	10'
Viburnum dentatum	Arrowwood	8'
Viburnum trilobum	American cranberrybush	15'

* evergreen

Spacing Distance

For Water Erosion Control:

Small to medium shrubs - 1' x 1' to 2' x 2'
Medium to large shrubs - 2' x 2' to 4' to 4'
Trees - 4' x 4' to 8' x 8'

For Wind Erosion Control:

Small to medium shrubs - 2' x 2' to 4' x 4'
Medium to large shrubs - 4' x 4' to 6' x 6'
Trees - 6' x 6' to 15' x 15'

TABLE 8
GUIDE TO TREES AND SHRUBS FOR DISTURBED AREAS

KIND OF AREA	COMMON NAME	BOTANICAL NAME
SANDY OR GRAVELLY	Arnot bristly locust	Robinia fertilis Ashe
	Sweetfern	Comptonia peregrina LM.Coult
	Sumac	Rhus typhina L.,Rhus glabra L.
	Black alder	Alnus glutinosa (L.) Gaertn.
	Cardinal autumn olive	Elaeagnus umbellata Thunb.
SAND DUNES	Bayberry	Myrica pensylvanica Loisel
	Virginia creeper	Parthenocissus quinquefolia (L.) Planch.
	Beach plum	Prunus maritima Marsh
	Rugosa rose	Rosa rugosa Thunb.
	Emerald seashore juniper	Juniperus conferta Parl.
STREAMBANKS	Streamco purpleosier willow	Salix purpurea L.
	Bankers dwarf willow	Salix x Cottetii
	Ruby redosier dogwood	Cornus stolonifera Michx.
	Indigo silky dogwood	Cornus amomum Mill.
WINDBREAKS AND SCREENS	Cheyenne common privet	Ligustrum vulgare L.
	Amur privet	Ligustrum amurense Carr.
	Hybrid poplars/cottonwood	Poplus spp.
	Tall hedge	Rhamnus frangula L.
	Norway Spruce	Picea abies (L.) Karst.
	Eastern red cedar	Juniperus virginiana L.
	Arborvitae	Thuja occidentalis L.
	Rem red amur honeysuckle	Lonicera maackii Maxim
BIOTECHNICAL SLOPE PROTECTION	Streamco purpleosier willow	Salix purpurea L.
	Bankers dwarf willow	Salix x cottetii
	Sandbar willow	Salix interior Rowl.

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TABLE 9
WILDLIFE AND FISH BENEFITS OF STABILIZING PLANTS

PLANT SPECIES	Rabbits	Deer	Wild Turkey	Ruffed Grouse	Geese	Songbirds	Pheasants	Fish
Forbs*								
Wildflower mix			*	*		*	*	
Grasses*								
Beachgrass, Cape American	NF	-				N	N	
Bluegrass, Canada	F							
Bluegrass, Kentucky	NF	F	F		F			
Bluestem, Niagara big						N	N	
Bluestem, Aldous little						N		
Bromegrass, smooth	N	F	F		N	N	N	
Canarygrass, reed Venture or Palaton	N				N	N	NW	
Deertongue, Tioga	NF					N	F	
Fescue, creeping red	F							
Fescue, tall		F						
Lovegrass, weeping						N	N	
Redtop	NF	F			N	N		
Ryegrass, perennial	NF		F		FN	N	N	
Switchgrass, Blackwell or Shelter	F	F				NF	FNW	
Legumes*								
Crownvetch, Penngift or Chemung		F	F					
Flatpea, Lathco		F						
Trefoil, birdsfoot (Upright varieties)	NF	F	F		N	N	FN	
Trefoil, Empire birdsfoot	NF	F	F				F	
Shrubs								
Alder, European black				F		N		S
Dogwood, Ruby redosier	F	F	F	F		NF	FW	S
Dogwood, silky	F	F	F	F		NF	FW	S
Willow, Streamco purpleosier	F	F				N		S
Willow, Bankers dwarf	F	F				N	W	S
Trees								
Boxelder						N		S
Maple, red	F	F				N		S
Maple, silver						N		S
Sycamore						N		S

* Adult and young bird feed extensively during the summer and early fall on insects associated with most grasses, legumes, and wildflowers (forbs).

Legend F=Food N=Nesting Cover W=Winter Cover S=Shade

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Water

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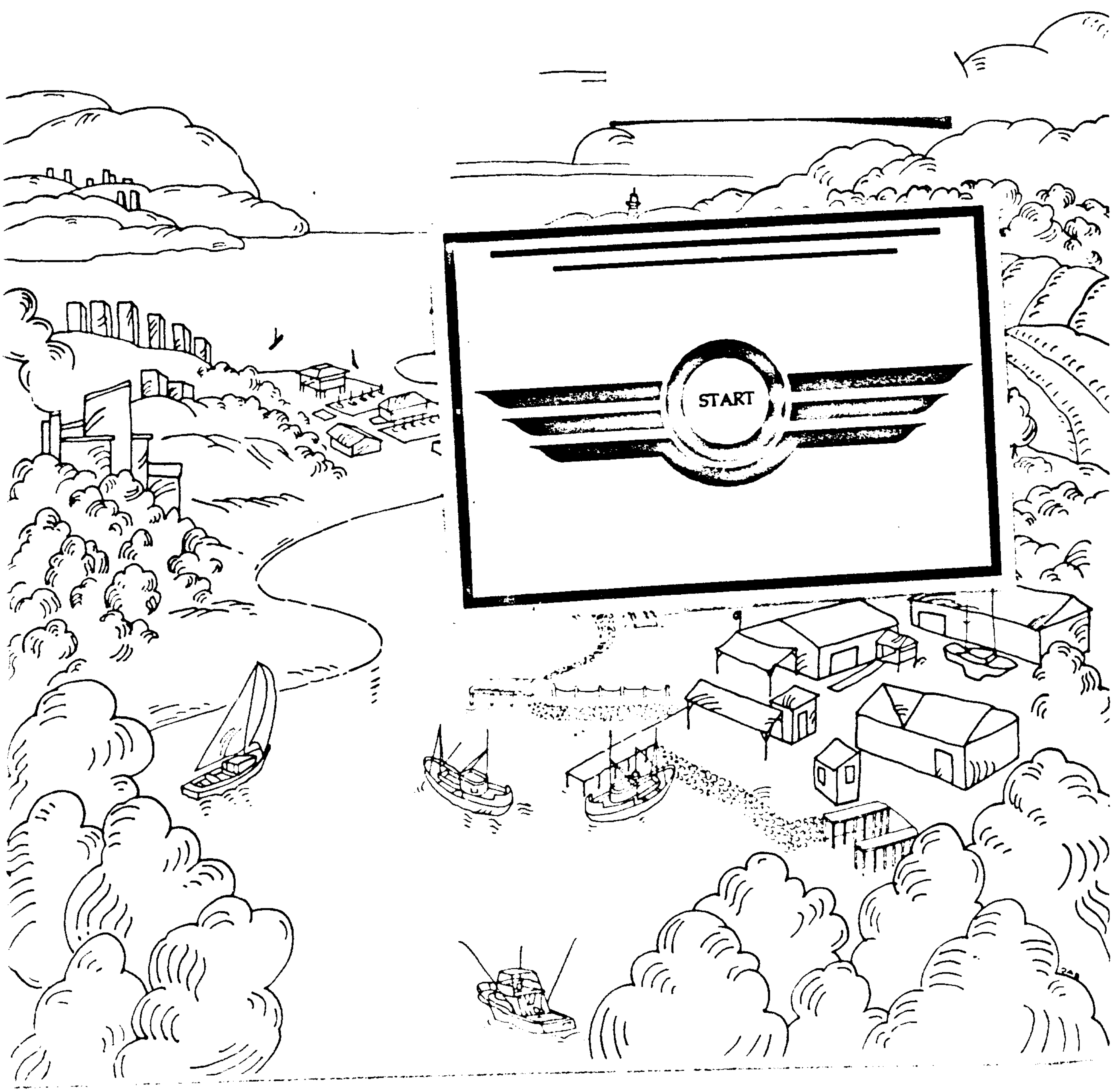
EPA

Saving Bays a…
A Handbook …



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United States
Environmental Protection
Agency

Office of Marine and
Estuarine Protection
Washington, D.C. 20460

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Saving Bays and Estuaries: A Handbook of Tactics

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United States Environmental Protection Agency
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National Estuary Program

Point Source Controls: The Potomac River Cleanup

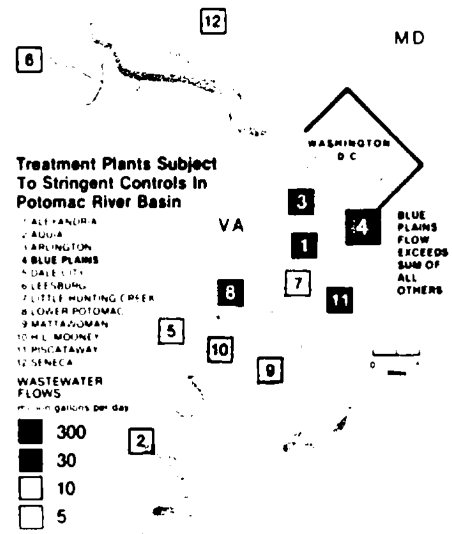
Restoring a river through cooperation and consensus

WASHINGTON METROPOLITAN AREA

Characteristics
- 14,670 square mile drainage basin has approximately 100 tributaries.
- Large quantities (averaging 456 million gallons/day) of treated effluent are released from the Washington, D.C. area.
- Approximately 3 million of the basin's 4 million residents live in the Washington metropolitan area which is adjacent to the estuary; population is projected to increase 20 percent by 2000

Resources
- The river is a major spawning area for anadromous and semi-anadromous fish species, e.g., shad, perch, and striped bass.
- 1985 commercial finfish landings were valued at over $2 million.
- Recreational activities include sport fishing and boating
- Municipal water supply withdrawals averaged approximately 370 million gallons per day (in 1985).

Issues
- Municipal treatment plants are the only major point-source loading
- Nutrient loadings encouraged algal blooms, which have led to low oxygen levels, fishkills, and changes to the ecosystem.
- Estuary cleanup has required a concerted cooperative effort among the Washington region's principal local jurisdictions.



Introduction

In the late 1960's, local, State, and Federal officials began a coordinated and sustained effort to clean up the Potomac River.

Historically, the Upper Potomac River Estuary had suffered from severely degraded water quality. Noxious odors, large mats of floating algae, blue-green algae, depleted oxygen concentrations, and turbid water were frequent conditions. Pollution-sensitive fish (such as large-mouthed bass) and submerged aquatic vegetation had largely disappeared from the river. Bacterial contamination and viruses prevented safe water contact recreation.

Efforts by scientists and local, State, and Federal officials in the past 20 years to implement and upgrade point source controls, however, have dramatically reversed the trend of declining water quality. The States of Maryland and Virginia and the District of Columbia implemented stringent point source discharge limits based on analysis of the upper estuary's assimilative capacity and the capabilities of wastewater treatment technology. These actions have reduced biochemical oxygen demand (BOD) and phosphorus discharges to the upper estuary by 95 percent. Algal blooms are now infrequent, and submerged aquatic vegetation and many species of sportfish have reappeared in the river. Potomac River area residents now benefit from commercial and recreational river uses.

Overview and Characteristics of the Problem

The Potomac River drainage area encompasses portions of the States of Pennsylvania, Virginia, West Virginia, the District of Columbia, and Maryland. About 95 percent of the land in the basin is forested or in agriculture. In sharp contrast, the upper estuary, which extends 54 miles from the northwest boundary of Washington, D.C. to Maryland Point, is highly urbanized. The upper estuary receives the largest volume of flow from treated wastewater discharges. Industrial discharges are insignificant.

The Potomac supports two critical water uses in the Washington area. As a major water supply, the free-flowing part of the river provides about 75 percent of metropolitan Washington's drinking water. The Potomac is also profoundly important to the area as a recreational and aesthetic resource. The river supports boating, fishing, and, in some areas, swimming. Hundreds of miles of parkland border the Potomac, including the Washington, D.C. Tidal Basin, site of several major memorials and tourist attractions.

For much of this century the Potomac has suffered from pollution stresses. During the 1950's it was described as an open cesspool. Rapid development of the Washington metropolitan region was a major factor in the river's decline. Between 1940 and the early 1970's, population growth repeatedly outstripped sewage treatment plant capacity, despite expansions intended to meet demands for years to come. Raw or partially treated sewage was regularly discharged into the Potomac as a consequence of overloaded plants and inadequate sewer capacity.

Of the 11 major treatment plants that serve the Washington metropolitan area, the Blue Plains facility is the largest point source to the estuary. This regional plant, managed by the District of Columbia, serves the city and some of suburban Maryland and Virginia. In 1985, the Blue Plains plant discharged about 309 million gallons a day directly to the estuary—about 65 to 70 percent of the entire wastewater load for the year.

Chronology of the Cleanup Effort

In the late 1950's conferees at the first Federal-State Potomac Enforcement Conference meetings, convened by the U.S. Public Health Service to address water quality problems, recommended secondary wastewater treatment. By 1965, however, water quality in the Potomac had worsened because rapid population growth and accompanying increases in sewage flows had outstripped plant capacities. President Lyndon B. Johnson called national attention to the Potomac when he proposed making it a model for a national water quality improvement campaign. Following his appeal, Congress passed the Water Quality Act of 1965, which required States to establish water quality standards. Jurisdictions in the Washington metropolitan area agreed to adopt a fishable-swimmable standard.

The Federal-State Potomac Enforcement Conference was reconvened in 1969. Conferees developed discharge limits based on an assessment of the estuary's assimilative capacity and available treatment technology. Conferee recommendations, which were strenuously debated, pushed treatment technologies to their limits. Nevertheless, the recommendations were formally accepted in 1970 by the District of Columbia, Maryland, Virginia, and local jurisdictions through the Memorandum of Understanding (MOU) on the Washington Regional Water Pollution Control Plan. upgrades to the Blue Plains regional wastewater treatment plant, allocated capacity for the plant to the District of Columbia and its suburban users, and proposed a schedule for siting and constructing another regional plant to absorb the anticipated increases in treatment demands on the Blue Plains facility.

What appeared to be a workable intermunicipal framework for addressing Potomac pollution problems quickly broke down as the population continued to grow and sewage flows to Blue Plains exceeded jurisdictional flow allocations. Threats of lawsuits to enforce these allocations led to a new agreement in 1971 for interim treatment at Blue Plains. In addition, building moratoria established to restrict sewage treatment demands were not strictly enforced, and demand for treatment continued to grow. Thus, in 1973, the Commonwealth of Virginia filed suit against the Washington Suburban Sanitary Commission (the agency responsible for sewage in the suburban Maryland counties and at that time the prime source of the excess flows). Fairfax County, Va., the District of Columbia, and the Federal government joined the suit.

The parties to the suit ultimately reached an agreement in 1974, the basis for a consent decree that, among other things, limited the amount of sewage each jurisdiction could send to Blue Plains. It also established a formula for jurisdictions using the plant to take responsibility for sludge disposal. A key feature of the decree, lacking in previous agreements, was accountability. Violations, including delays, would constitute a contempt of court and would be punishable.

Throughout the 1970's new treatment technologies were installed and plants constructed and expanded. Potomac water quality began to improve. The upgrading of treatment plants, however, exacerbated an old problem. Advanced waste treatment processes produced substantially larger quantities of sludge than secondary treatment alone had. Difficulties in locating sludge disposal sites led to legal actions in which the District of Columbia sued Maryland's Washington Suburban Sanitary Commission to force disposal of sludge as agreed in the 1974 consent decree.

Anxious to overcome the interjurisdictional squabbling and court battles of the 1970's, representatives from area jurisdictions and treatment plant operators began to form standing committees to negotiate agreements, monitor progress, resolve differences, and plan for future needs on a regular basis. The first and most prominent committee was made up of chief administrative officers (CAO's) representing the principal Blue Plains user jurisdictions and agencies. This committee, known as the Blue Plains CAO's, was organized in 1980 under the auspices of the Metropolitan Washington Council of Governments, which provided neutral grounds for meeting and support staff.

The Blue Plains CAO's Committee undertook the reworking of the wide array of existing agreements, some of which dated back to the 1950's. Committee staff worked diligently, and at one stage met weekly for municipal agreement for managing sewage treatment and sludge disposal through 2010. An informal but important ground rule that has been credited with promoting agreement was the commitment of all participants to stay on at certain critical meetings until the issues at hand had been fully resolved.

The resulting Blue Plains Intermunicipal Agreement was signed by area jurisdictions in September 1985. In addition to sewage and sludge management, the agreement formalized annual funding support to a coordinated program for monitoring and tracking Potomac water quality. This program, managed by the Metropolitan Council of Governments, provides a common and comprehensive data base to enable a scientific approach to water quality planning and decision-making. Another important component of the agreement included the specification of conditions that would regulate or stop a user's commitments for system extensions if its sewage flows exceeded its allocated capacity at Blue Plains. The lack of such a provision in earlier agreements had been a significant problem during the 1970's.

Another important group, the Potomac Studies Policy Committee, was formed in 1985 to develop consensus positions of common interest to the Washington area wastewater treatment community. The policy committee evaluates technical issues associated with Washington area water quality management programs and standards. It addresses estuary-wide problems and the contribution of upstream Potomac pollution loading sources that affect regional water quality, and provides a unified voice for negotiating with water quality regulators. The policy committee strives to achieve balance between treatment technology, costs to users, and water quality standards.

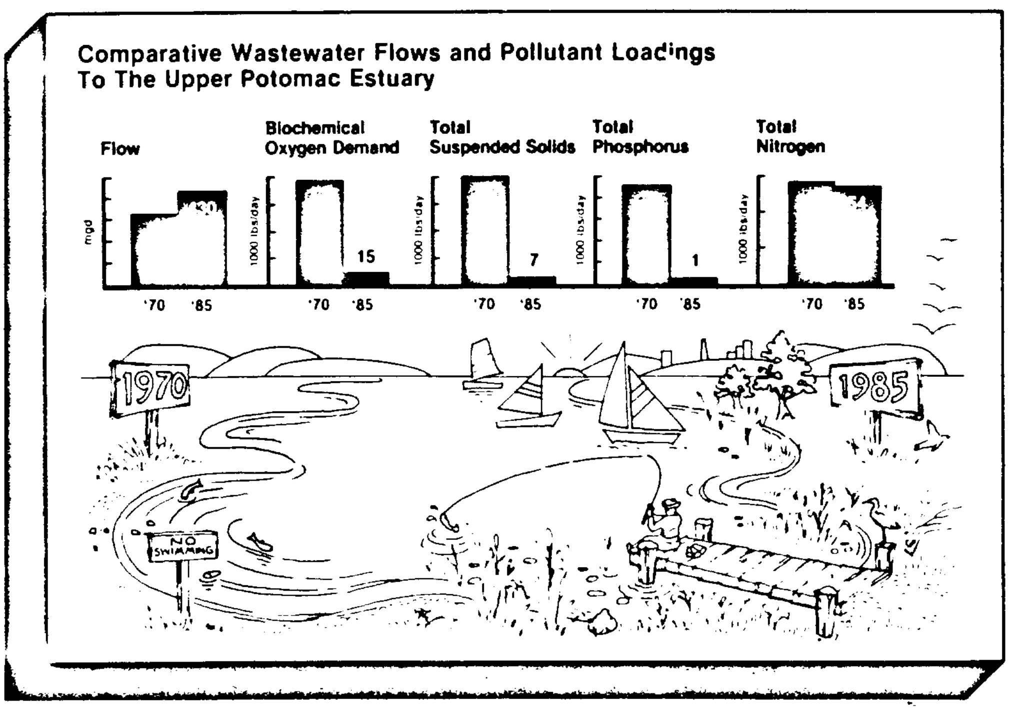
The Blue Plains and Potomac Studies Policy Committees have proven themselves to be valuable forums for ongoing resolution of regional water quality concerns and issues, preventing the crisis atmosphere that pervaded the preceding decade. Participants are pleased with the cooperation achieved between local jurisdictions and wastewater treatment plant operators thus far and are optimistic that it will continue.

Financing

The success of the Potomac cleanup to date has been hard won, taking over 20 years of sustained effort and more than $1 billion investment in capital facility improvements. The 1972 Federal Water Pollution Control Act's Construction Grants Program covered 75 percent of plant construction, expansion, and upgrading costs. Remaining funds came from local government expenditures and State grant programs. The annual operating costs to meet plant discharge requirements now exceed $100 million per year at the Washington region's principal discharges. These costs are financed through local user fees.

Results

Although the original goal, established in the late 1960's, of obtaining fishable-swimmable conditions year-round in the upper estuary remains to be fully real-



ized, significant improvements in Potomac water quality have been made. The improvement in the upper estuary has, in turn, contributed to dramatic improvement in the lower estuary.

Reductions of nearly 95 percent in biochemical oxygen demand and total phosphorus point source discharges highlight the accomplishments.This has been achieved through stringent nutrient limits for municipal wastewater discharges. For example, the current effluent phosphorus limit for Blue Plains is 0.18 mg/L. Effluent limits assigned to Washington area treatment plants could be met only by upgrading secondary treatment plants to advanced waste treatment facilities, which use additional filtration, nutrient removal processes, and chlorination. Improvements to other facilities have also enhanced water quality in the basin. The improvements included increases in sewer transmission and wastewater treatment plant capacities, and improved operational procedures to substantially reduce the incidence of wet weather overflows. Most of the Washington metropolitan area's sewer system is now connected to advanced waste treatment facilities, either on-line or under construction. The Blue Plains plant is one of the largest advanced waste treatment plants in the United States.

Signs of a healthy river that were missing from the estuary during the 1950's and 1960's are now reappearing. Submerged aquatic vegetation and accompanying desirable species of fish and wildlife have returned in abundance to many portions of the river. At the same time, the growth of nuisance blue-green algae has been greatly reduced.

As river water quality has improved, commercial and recreational activities along the river have also reemerged. The waterfront now provides an attractive location for parks, recreational facilities, and restaurants. Boating and fishing are common along the urban stretch of the estuary.

Other sources of pollution have increased in relative significance as Washington area point source loads have been cut. Discharges of nutrients, biochemical oxygen demand, and sediment loadings from upstream point sources, nonpoint sources, and nutrient releases and oxygen demand from river bottom sediments all contribute to pollutant loading inputs to the upper estuary.

The participants in the Potomac cleanup program have turned their attention to meeting the new challenges. The existing regional monitoring network and data base are already being used, and the 1970 Memorandum of Understanding has been revised and reaffirmed. The regional framework developed to confront point source removal is providing a ready forum for addressing emerging issues.

While some pollution problems remain, further progress will require improved wastewater treatment at smaller facilities upstream and downstream of the Washington, D.C. region. Implementation of effective nonpoint source controls, particularly for agricultural nonpoint source loadings, will also be needed.

Lessons Learned

The latest round of Potomac River cleanup activities has taken two decades to reach its current level of success. The effort has been difficult, but it has worked. Its success was due to people who insisted on more than the status quo. They invested in technologies required to meet stringent effluent limits to protect the estuary. They strove for cooperative agreements and held others to them, going to court when necessary. It took technical talent – the scientists who developed the models and analyzed the data, the treatment plant operators and engineers who implemented the requirements. It took money – a combined local, State, and Federal investment exceeding $1 billion in capital facilities, and user fees of over $100 million a year in plant operation costs. Most important, the cleanup succeeded because of the initiative, cooperation, and sustained commitment of local agencies to hammer out and implement the interjurisdictional agreements necessary to make it work.

Improving conditions in the Potomac required an enormous effort to overcome resistance to building moratoria, legal suits, press coverage, and a charged atmosphere among the participants. Ultimately, however, a high level of cooperation among local governments and the regulatory agencies led to the dramatic improvement in water quality conditions that area residents now enjoy. Through the efforts and battles along the way, a strong and lasting framework for cooperation has evolved.

The Potomac's cleanup was facilitated under the regional policy and technical committee structure which evolved in the 1980's to track progress and evaluate future water quality management needs. This structure has proven quite effective as a forum for developing consensus positions on regional water quality management issues and programs. It derives its strength and continuity through a collective local government commitment to the support of a centralized technical staff, data base, and reporting function dedicated to the assessment and resolution of Potomac water quality issues.

But for all the achievements, the greatest lesson from the Potomac's experience may be that strategies for pollution control must be flexible and continually evolving. New problems and questions have emerged as a result of regional successes in reducing point source loadings. For example, environmentally sound and cost-effective sludge management programs, acceptable to both regulatory agencies and local communities, must be found and agreed upon. Area decisionmakers and residents must evaluate to what extent they are willing to protect area water quality and identify the most cost-effective, practical, and acceptable management programs.

For further information, contact Stuart Freudberg or Cameron Wiegand, Metropolitan Washington Council of Governments, Washington, DC, or Mark Alderson, EPA Project Manager, Washington, DC.

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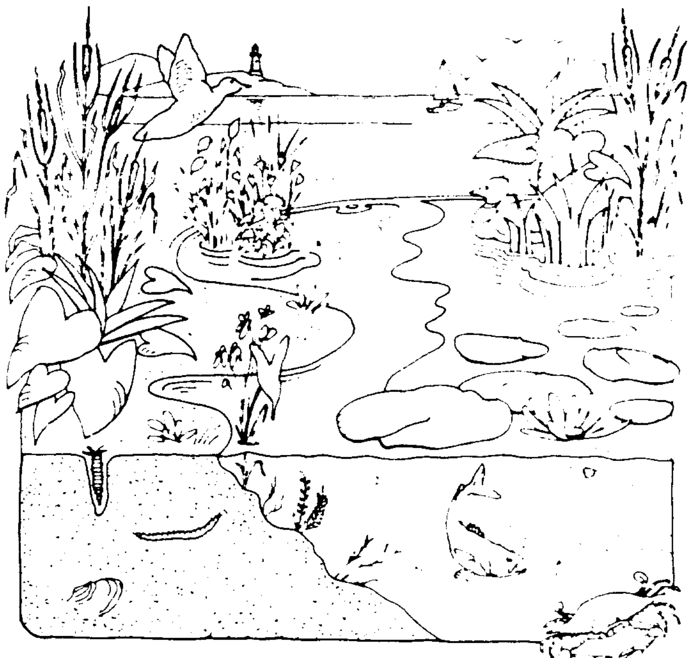
Saving Bays and Estuaries: A Handbook of Tactics

Introduction

VOL 12



Estuaries—where rivers meet the sea, and fresh water mixes with salt—are among the earth's richest and most productive habitats. They serve as the principal spawning grounds and nurseries for at least two-thirds of our Nation's commercial fisheries, provide irreplaceable recreational and aesthetic enjoyment, and are home to valuable and diverse species of fish, shellfish, and wildlife.

They are also home to people. Already, 70 percent of the U.S. population lives within 50 miles of a coastline, and that number is growing. But with people comes pollution, and our estuaries are clearly in trouble, threatened by toxic and bacterial contamination, sewage discharges and agricultural runoff, oxygen-depleted waters, and loss of fish and wildlife habitat.

Learning Through The National Estuary Program

There are no easy answers to these problems, but we have learned some lessons. One is that estuaries are complex ecological systems with subtle dependencies among many species and habitats. If conditions change in one area, they will also change in others. In estuaries, there are very few purely local effects.

We've also learned that conventional, "end-of-pipe" pollution controls are not enough. Agricultural runoff and other nonpoint sources contribute pesticides and excess phosphorus and nitrogen to bays hundreds of miles away; the wind carries in toxics that contaminate bottom sediments in otherwise pristine waters. Yet how do we regulate homeowners who put too much fertilizer on their lawns? How does one State control air pollutants coming from another State on the other side of the country?

Finally, we've learned that saving our estuaries and

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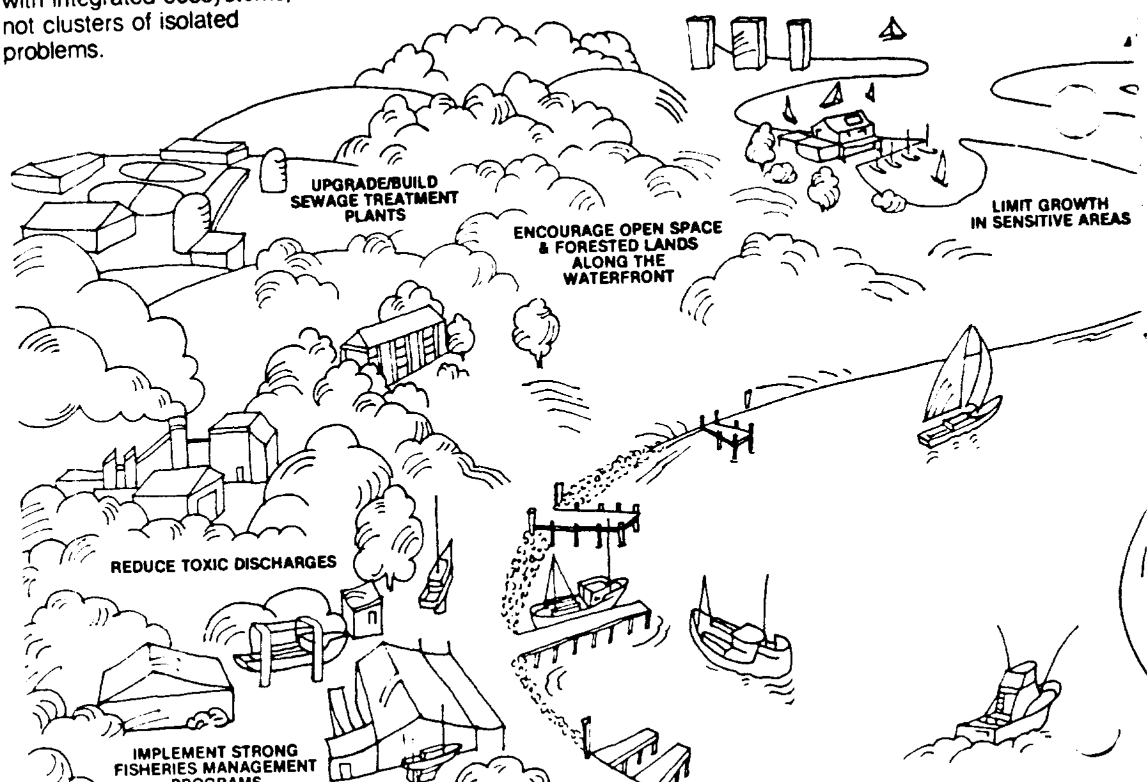
Strategies for Protecti..g

coastal waters is a long-term process. It will demand heavy commitments of time, money, and support from everyone who affects or uses or benefits from their resources. Just as important, it will require a fresh approach to solving environmental problems, one that recognizes we are dealing with integrated ecosystems, not clusters of isolated problems.

EPA's National Estuary Program provides an opportunity to apply these hard-won lessons. Under the law, its mission is to protect and enhance water quality and living resources in estuaries by helping States to develop and carry out basin-wide, comprehensive programs to conserve and manage their estuarine resources.

This handbook shares some of the experience gained in this process in estuary programs throughout the country and demonstrates many innovative tactics for



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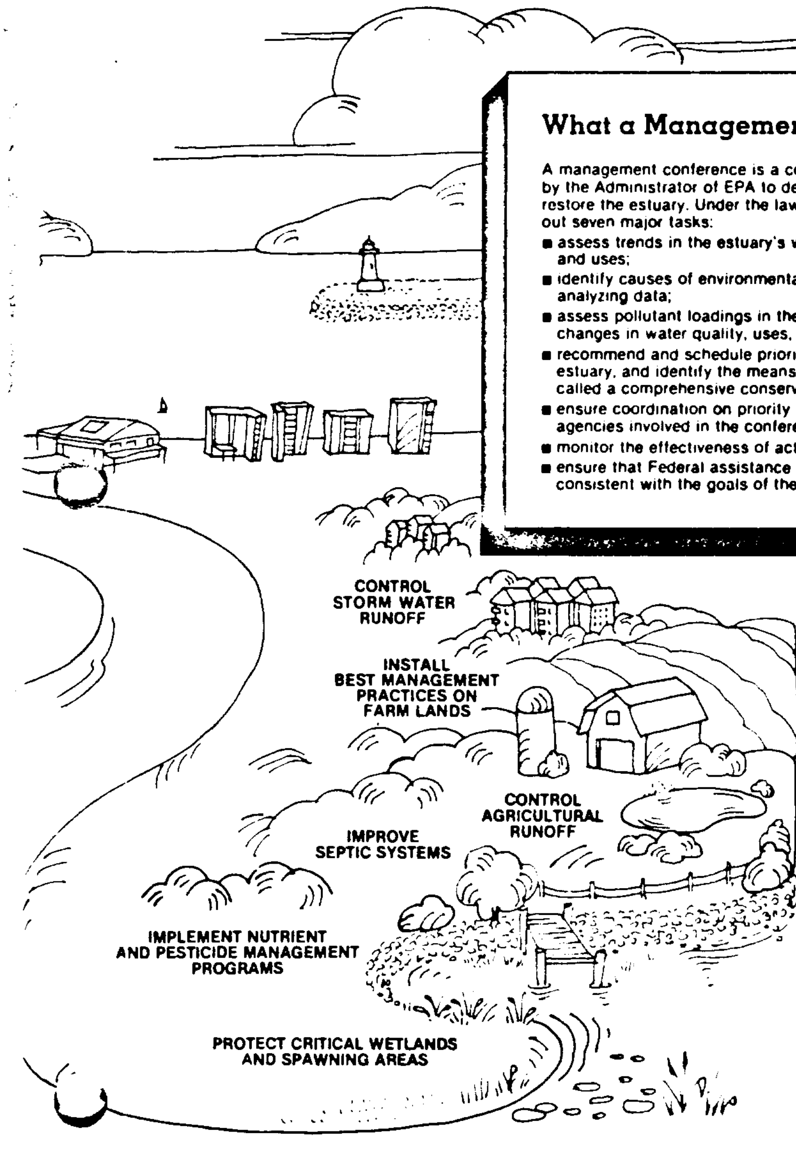
Bays and Estuaries



What a Management Conference Does

A management conference is a committee convened for a specific estuary by the Administrator of EPA to decide what actions to take to protect or restore the estuary. Under the law, a management conference must carry out seven major tasks:

- assess trends in the estuary's water quality, natural resources, and uses;
- identify causes of environmental problems by collecting and analyzing data;
- assess pollutant loadings in the estuary and relate them to observed changes in water quality, uses, and natural resources;
- recommend and schedule priority actions to restore and maintain the estuary, and identify the means to carry out these actions (this is called a comprehensive conservation and management plan);
- ensure coordination on priority actions among Federal, State, and local agencies involved in the conference;
- monitor the effectiveness of actions taken under the plan; and
- ensure that Federal assistance and development programs are consistent with the goals of the plan.

dealing with major estuarine and coastal problems. Three ecosystem management areas are covered: water and sediment quality; living resources; and land and water resources. Other areas of interest include technical support and financial resources.

The case study format is designed to present information clearly and quickly, and also identifies sources of additional information. We encourage readers to use the handbook along with the *Estuary Program Primer*, a manual for establishing and managing estuary programs, and hope that these case studies will alert managers to innovative management tools and help them avoid costly mistakes. We also hope that users will find new ways to apply the lessons presented in these case studies and that participants in other programs will share their experiences. We plan to expand the handbook as new approaches and lessons emerge with experience.

The National Estuary Program welcomes comments and suggestions for additions to this handbook. For more information contact:

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The National Estuary Program

The purpose of the National Estuary Program is to identify nationally significant estuaries, protect and improve their water quality, and enhance their living resources. Estuaries are to achieve these goals through collaborative efforts called *comprehensive conservation and management plans (CCMPs)*; development of CCMPs is carried out by oversight committees called *management conferences*.

The legislation that established the National Estuary Program named 11 estuaries to receive priority consideration to be in the program. These are Albemarle/Pamlico Sounds, Long Island Sound, Buzzards Bay, Narragansett Bay, Puget Sound, San Francisco Bay, Galveston Bay, Sarasota Bay, Delaware Bay, Delaware Inland Bays, and New York-New Jersey Harbor. Santa Monica Bay was added to this list in the Fiscal Year 1988 Appropriations Act.

The Administrator of EPA selects estuaries for the program in response to nominations by State governors, or at the Agency's initiative in the case of interstate estuaries. Estuaries are selected based on their potential to address issues of significant national concern, as well as their demonstrated institutional, financial, and political commitment to carry out protective actions. Once an estuary is selected, the Administrator formally convenes a management conference.

Management conferences provide a framework for interest groups to work together to develop comprehensive plans and timetables (the CCMPs) to protect and restore the estuary and coastal areas. Conference members must include citizen and user interest groups, scientists, government officials, and resource managers from Federal, State, and local agencies.

Representatives from these groups sit on an oversight committee that serves as the formal management conference and oversees development of the CCMP. Other technical, policy, and citizen advisory committees may provide supplemental advice and help. This committee structure approach was first developed in the Chesapeake Bay and Great Lakes programs and has worked very well. We expect it will work equally well for other estuary and near coastal water programs.

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United States Environmental Protection Agency
Office of Water
National Estuary Program

A Phosphorus Strategy for the Great Lakes

Improving water quality through intergovernmental agreements

UNITED STATES/CANADA

Characteristics

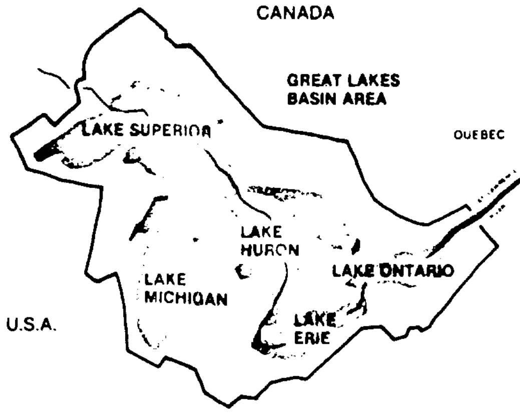
- The largest freshwater bodies in the world, the Great Lakes comprise:
  - 20 percent of the earth's fresh surface water.
  - 95 percent of North America's fresh surface water.
  - 6 billion gallons of water discharged per hour via the St. Lawrence River.
- Retention times for water in the lakes range from less than 3 years to over 200 years.

Resources

- The Great Lakes are the center of U.S. heavy industry.
- $155 billion of economic activity occurs annually.
- $3 billion in recreational activity occurs annually.
- 24 million Americans depend on the lakes for drinking water.

Issues

- Loss of commercial fishing continues.
- Aesthetics and recreation are impaired.
- Drinking water resources are affected.
- Public health risks from food consumption continue.



Introduction

Recognizing the importance of the Great Lakes, the U.S. and Canadian governments have operated a long-term intergovernmental program to control direct and indirect sources of pollution, monitor conditions, and assess trends in the water quality and biological health of the lakes. By the late 1960's the effects of years of pollution in the Great Lakes were alarming, particularly in Lake Erie and Lake Ontario. Eutrophication – a natural process of nutrient enrichment and silting – was accelerated by high levels of phosphorus entering the lake. As a result, oxygen depletion was widespread and many previously abundant fish species and other aquatic organisms were virtually eliminated.

By setting pollution control goals that the two countries could agree on, the Great Lakes Water Quality Agreements of 1972 and 1978 have guided a successful cleanup and restored a viable fishery for the world's largest freshwater system. These joint initiatives address conventional pollutants (such as plant growth-inducing nutrients) as well as toxic contaminants entering the lakes from land-based activities. The nutrient control aspects of the program are discussed here.

Overview and Characteristics of the Problem

The Great Lakes contain 95 percent of the fresh surface water in North America. This vast resource supports commercial and recreational fisheries, water supply, shipping, and aesthetic enjoyment. The five Great Lakes, their interconnecting channels, and the St. Lawrence River outlet to the Atlantic Ocean are integral components of the U.S. and Canadian economies. The Great Lakes basin supports one fifth of all American industry. Over $180 billion in annual economic activity is based on the Great Lakes: the Canadian portion of the Great Lakes Basin accounts for $27 billion in economic activity; the U.S. portion accounts for $155 billion.

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In the past 170 years, the population of the Great Lakes basin has increased more than a hundredfold. Today, the basin is home to nearly 37 million people, comprising a third of the Canadian population and a seventh of the American population. This growth was accompanied by increasing point and nonpoint source pollutant inputs to the ecosystem. By the 1930's, the impacts of these pollutants were becoming apparent in the biological, physical, and chemical components of the Great Lakes ecosystem. Commercial fish species (lake trout, blue pike, whitefish, sauger, and lake herring) declined sharply; the once-abundant mayfly disappeared from western Lake Erie, Green Bay, and Saginaw Bay; and populations of opossum shrimp vanished from Lake Erie. Algal production, however, not only increased, but shifted from predominately free-floating forms valuable as food for fish fry toward more troublesome species typical of elevated nutrient conditions. Long-term changes in both open-lake and near-shore water chemistry reflected eutrophic conditions from nutrient enrichment.

The dramatic changes in fish communities and other aquatic organisms were directly linked to decreased oxygen levels. Linkages were particularly well documented in western Lake Erie, Green Bay, and Saginaw Bay. In the central basin of Lake Erie, for example, roughly 70 percent of the bottom waters developed pronounced oxygen deficits each year.

Program Development

The institutional framework for the Great Lakes cleanup was actually established in 1909 by a Boundary Water Treaty between the United States and Canada. The treaty established the International Joint Commission, which was asked in 1964 by the U.S. and Canadian governments to study the water quality conditions in Lakes Erie and Ontario (the "Lower Lakes") and the St. Lawrence River. In 1970, the commission reported its findings:

- Lake Erie (and particularly the Western Basin) was already in an advanced state of eutrophication, and the eutrophication of Lake Ontario was accelerated. In both cases, current and historic nutrient loadings were at fault.
- Phosphorus is the only nutrient required for growth whose level can be effectively controlled with current technology such as widespread improvements in existing municipal and industrial wastewater treatment plants.
- The major phosphorus source to the lakes is municipal sewage; agricultural runoff and industrial wastes are the only significant nonsewage phosphorus sources.
- Detergents contribute 70 percent of U.S. and 50 percent of Canadian sewage phosphorus.

Based on these findings, the commission recommended that the Governments of Canada and the United States enter into agreement on an integrated phosphorus control program, to include

1. An immediate reduction in detergent phosphorus content (to a minimum practicable level) followed by the complete replacement of detergent phosphorus with environmentally less harmful materials, by December 31, 1972;

2. An 80 percent reduction in nondetergent residual phosphorus in municipal and industrial waste effluents discharging to Lakes Erie and Ontario and the international portion of the St. Lawrence River by 1975, with subsequent reductions to the maximum extent possible by economically feasible processes; and

3. General reductions in agricultural inputs of phosphorus to Lakes Erie and Ontario and the international portion of the St. Lawrence River.

KEY COMPONENTS OF NUTRIENT CONTROL STRATEGY

- PHOSPHATE DETERGENT BAN
- AGRICULTURAL NONPOINT SOURCE CONTROLS
- STRINGENT MUNICIPAL AND INDUSTRIAL POINT SOURCE CONTROLS

The findings and recommendations of the commission indicated the severity of the problem, the need for major pollution control actions, and the need for broad political support. To meet these needs, it was determined that an international agreement must be forged to implement a binational cleanup effort. As a result, the first Great Lakes Water Quality Agreement was signed by the United States and Canada on April 15, 1972, agreeing to the need for a phosphorus reduction program based on commission findings.

Then during the mid-1970's additional modeling work was completed, which

- Quantified how much phosphorus entered the system from point, nonpoint, and atmospheric sources and determined how many tons of phosphorus reduction per year would be needed to meet the target reduction in each lake;
- Set target phosphorus concentrations for each lake to achieve a healthy ecosystem.

Using these modeling tools, a new agreement was signed in 1978 that

- Allocated these phosphorus reduction requirements to each country, and
- Determined how many tons of phosphorus reduction per year would be needed to meet the target concentration for each lake.

Control Program

Point source controls, especially on municipal wastewater treatment plants, provided the basic thrust of the phosphorus reduction program. A treatment level of 1 mg/L phosphorus in treatment plant effluent was established for all plants of 1 million gallons per day or greater capacity under the 1978 agreement. Reaching this level required plants to use advanced wastewater treatment. It was also recognized that effluent controls alone would not meet the goals, and additional reductions from agricultural nonpoint controls and phosphate detergent bans would be necessary.

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Although great progress occurred during the 1970's, the 1983 update of the Great Lakes Water Quality Agreement mandated development of U.S. and Canadian Phosphorus Management Plans. The U.S. plan, submitted in 1986, states that if nonpoint source controls do not achieve the necessary additional reductions in total phosphorus loadings (to be determined in a scheduled 1988 progress review), municipal treatment plants will be required to meet effluent phosphorus levels below the current 1 mg/L limit. The plan further states that the water-quality based controls mandated in the Clean Water Act will be implemented if the combined effect of advanced wastewater treatment and nonpoint source control do not meet the in-lake phosphorus concentrations required by the agreement.

Responsible Authorities and Financing

In the United States, the primary implementing agencies are the U.S. EPA and the eight States bordering the Great Lakes. The Great Lakes National Program Office was established within EPA to monitor the progress and effectiveness of U.S. efforts toward achieving the goals of the agreement, as well as to provide technical and management assistance to States, counties, and local jurisdictions in implementing the agreement. In Canada, primary responsibility for implementing the agreement rests with Environment Canada and Ontario's Ministry of the Environment.

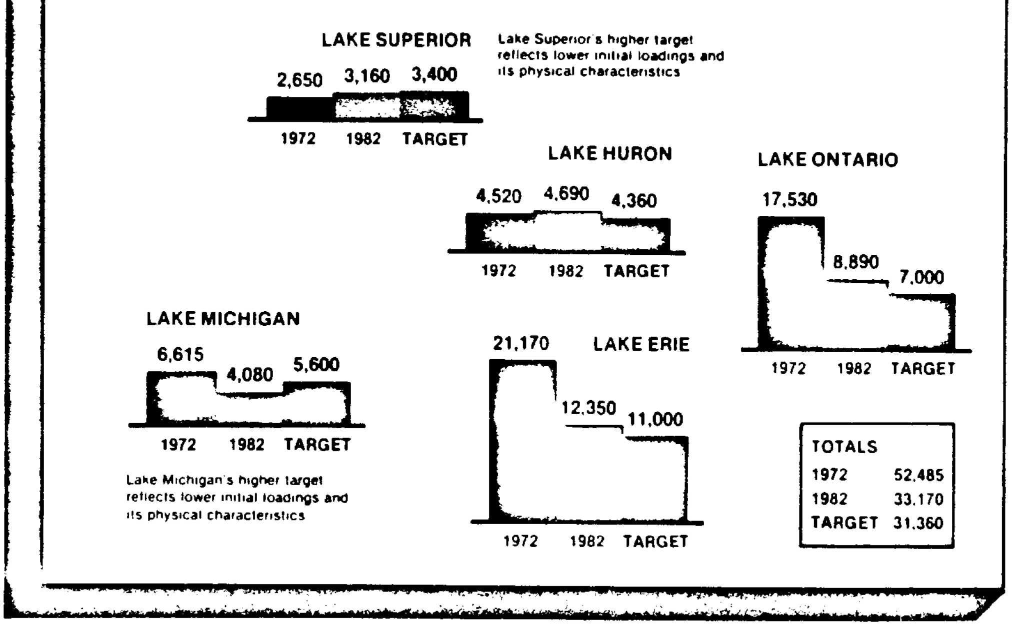
In the United States, new NPDES discharge permits were issued for essentially all major point source dischargers in the 1974-1975 period. EPA tracked these permits with a compliance monitoring system to flag frequent or large violations. Compliance with the permitting system was high, but Federal and State-level administrative enforcement (violation notices, compliance orders, etc.) was also a major factor in the program's success in achieving phosphorus load reductions from point sources.

Nonpoint control programs have centered on controlling soil erosion. A variety of programs conducted by USDA entities (Soil Conservation Service, the Agricultural Stabilization and Conservation Service, Forest Service, Farmers Home Administration, and the Cooperative Extension Service) to promote soil conservation and erosion control have proven useful. Several Federal/State/local cooperative demonstration projects have been conducted to test farm management practices, such as conservation tillage. A major field test of conservation tillage for phosphorus control was funded through EPA's Great Lakes Program Office (under section 108 of the Clean Water Act) in 31 counties in Indiana, Ohio, and Michigan.

Results

Since 1972, over 1,000 municipal treatment plants have been constructed or upgraded. At the same time, in-

Progress in Meeting Phosphorus Targets (In metric tons / year)



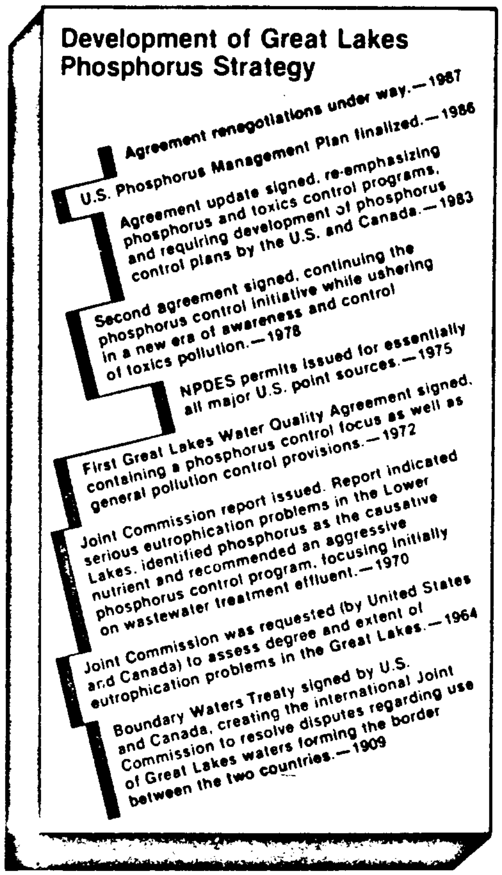
fluent phosphorus loads to these and other plants were reduced through broad enactment of legislation to control phosphorus in household detergents. As a result, most municipal wastewater point sources of over 1 million gallons a day capacity have now achieved or exceeded the 1 mg/L effluent phosphorus limit and the average point source phosphorus load reduction goals of the agreement are being attained. As a result of the phosphorus control provisions of the agreement, significant decreases in phosphorus levels are reported in all the Great Lakes. Excepting certain localized areas, the Upper Lakes (Superior, Huron and Michigan) are no longer overenriched. In the Lower Lakes, Lake Ontario exhibits reduced overall phosphorus concentrations and diminished algal biomass. In Lake Erie, the levels of free-floating microscopic plants in the open water have decreased and shifted toward species found in balanced-nutrient systems. U.S. phosphorus loadings to Lake Erie from municipal treatment plants decreased by 62 percent from 1972 to 1978, and by 1982 the load had dropped to only 16 percent of the 1972 level. Within five years of the 1972 agreement, 64 percent of the municipal treatment plants and 76 percent of the industries on the U.S. side were in compliance with the point source limits established to meet the goals of the agreement. The corresponding Canadian figures were 89 percent and 50 percent, respectively. To date, more than $7.5 billion have been spent or obligated in the United States and Canada for municipal sewage construction in the Great Lakes basin (resulting in an 80-90 percent reduction in municipal phosphorus loads), with another $1 billion from local governments and industries. In the United States, the majority of this money has been spent through the section 201 Construction Grants Program, under the Clean Water Act.

Lessons Learned

A principal reason for the success of the Great Lakes phosphorus control initiative was the degree of commitment made to its objectives at the highest levels of the affected governments. This commitment was backed with Federal legislation and a multibillion dollar grant program.

Another reason for the program's success was the commitment of the government to continual response. Within two years of the International Joint Commission's 1970 report, a point source control program was in effect; within five years, enforceable point source limits for all major municipal and industrial discharges were in effect. Although many technical questions were unanswered in 1972, responsible governmental officials on both sides of the basin decided that sufficient information existed to support a coordinated, programmatic response. Further scientific research on problem definition and understanding has continued in parallel with, and with the financial support of, the overall phosphorus control program.

The Great Lakes Water Quality Agreement provides the legal basis for nutrient management of the Great Lakes ecosystem. Under the authority of the agreement, the Great Lakes National Program Office reviews major municipal and industrial point source discharge permits for adherence to the phosphorus management goals of the agreement. This unique feature ensures that local dischargers conform to the terms of the agreement.



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VOL 12

6437

EPA
United States
Environmental Protection
Agency
Office of Water
National Estuary
Program

A Comprehensive Source Control Program for Protecting Shellfish Waters

Citizen action preserves shellfish resources

TILLAMOOK BAY, OREGON

Characteristics
- The basin has five individual watersheds containing 363,520 acres:
  - -89 percent forestland
  - -6 percent agricultural land with intensive dairy farming adjacent to the bay.
- Annual precipitation averages from 90 to 150 inches

Resources
- Tillamook Bay is the most productive oyster and clam growing water in Oregon.
- Lowland areas are used intensively for dairy farming.
- Recreational activities (e.g., boating, fishing) attract more than a million tourists each year.

Issues
- Concentrated livestock wastes and the region's wet weather create severe runoff problems and contaminated conditions.

FECAL COLIFORM REDUCTIONS IN TILLAMOOK RIVERS

RIVER	% REDUCTION
KILCHIS	30%
MIAMI	78%
TRASK	62%
TILLAMOOK	58%
WILSON	53%

Introduction

The State of Oregon has implemented a program to protect the shellfish in Tillamook Bay from recurring incidents of bacterial contamination. Tillamook Bay is Oregon's most productive oyster and clam growing area—80 percent of the State's commercially harvested oysters come from its waters. The State program, which has been supported by Federal agencies and local governments, focuses on controlling point and nonpoint pollution sources.

The lowland areas surrounding the bay are neither highly industrialized nor densely populated overall. Several small towns exist, but most of the land is devoted to intense dairy farming. Runoff from agricultural operations in combination with sewage treatment discharges from the local towns had created the bacterial contamination problems in Tillamook Bay. High fecal coliform contamination threatened shellfish harvesting and the local economy.

The Oregon Department of Environmental Quality and others addressed the problem by implementing best management practices on the dairy farms and upgrading local sewage treatment plants to control bacterial pollution. These actions have kept the bay open for safe shellfish harvesting.

Overview of Bay Characteristics and Problems

Tillamook Bay drainage basin is located 60 miles west of Portland on the northern Oregon coast. Five major rivers drain 97 percent of the basin and discharge to Tillamook Bay. Most of the bay is shallow. At high tide the bay's average depth is just 6 feet; at extreme low tide, water is confined mostly to the narrow channels. Ninety percent of the basin is steep, mountainous, forested terrain and sparsely populated. Eight percent of the land area is relatively flat and devoted to agriculture and population centers.

Shellfishing in Tillamook Bay includes recreational and commercial clamming, and commercial oyster harvesting. Annual harvest approaches 600,000 pounds of clams and 175,000 pounds of oysters. The bay and its tributaries support a good finfishery for salmonid species (chinook, silver chum, salmon, and steelhead). Because of the popularity of the northern Oregon coast, many tourists camp, fish, and bike along the bay.

In the lowlands, 118 farms with nearly 20,000 cattle line the lower portion of the Tillamook watershed. Approximately 13,000 people live in the bay basin. A little less than half the population is served by sewers; the remainder uses on-site sewage systems. Together, the presence of concentrated livestock wastes (280,000 tons of manure per year) and the region's wet weather (average rainfall 90-150 inches per year) created severe problems of bacterial pollution via runoff.

Following moderate to large storms, fecal coliform counts were often high in the bay. Coliform bacteria reside in the intestinal tract of warm-blooded animals; their abundant presence in water indicates significant fecal contamination. In addition, when fecal coliform counts are high, other more harmful bacteria and pathogens from warm-blooded animals may also be present. These high bacterial counts are the basis for closing the bay to shellfish harvesting. The bacterial problem created a serious human health hazard and threatened an important industry.

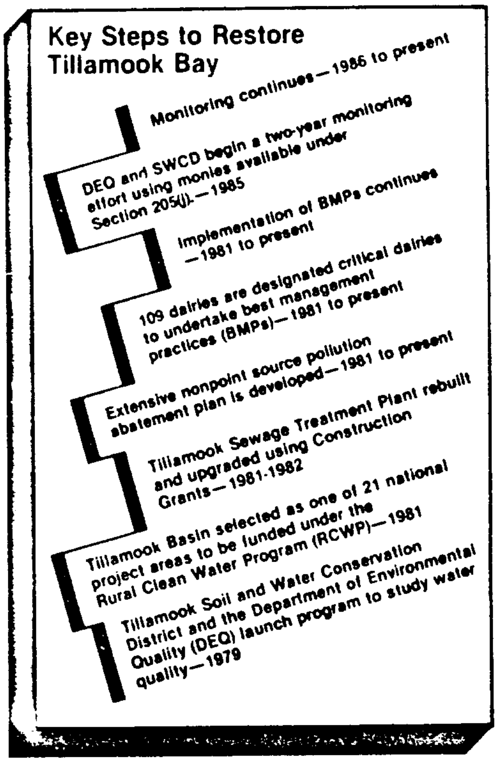
Problem Characterization

In 1979, a program between the Tillamook Soil and Water Conservation District and the Oregon Department of Environmental Quality was set up to monitor water quality in the bay. This program included a review of existing data and collection of additional water quality data. Using information gathered during the initial study, the Department of Environmental Quality conducted a project to specifically identify the sources, extent, and dynamics of fecal pollution occurring in the bay and its watershed. During the investigation six major potential fecal sources were examined: (1) sewage treatment plants, (2) recreation, (3) forestry activities, (4) industries, (5) agricultural operations, and (6) on-site subsurface sewage disposal systems. A comprehensive Tillamook Bay Fecal Waste Management Plan was developed for protecting the shellfish resource.

The study concluded that fecal coliform bacteria detected in the bay originated from farms (manure), poor sewage treatment plants in the river subbasins, and inadequate subsurface drainage. Of these, the study identified malfunctioning sewage treatment plants and dairy operations as the primary sources.

Process

The Tillamook study was conducted through a combined effort of Federal, State, and local government officials and the cooperation of the local dairy industry. Local citizens were actively involved throughout the study and development of a management plan. A group of citizens met regularly to review the data col-



lected and analyzed by the Department. These same people also worked cooperatively with the Department and the Soil Conservation Service to develop the management options for controlling the problem. Dairymen working with the Soil Conservation Service helped develop the solutions to the dairy problems. County and State sanitarians developed control strategies for the septic tank problems. Sewage treatment plant owners and operators developed the strategy for minimizing impacts from their plants.

Meetings as well as phone calls and personal contacts with the study team have involved the public in the policymaking process. Implementation of the management plan was rendered less controversial and more effective because the local citizens knew why a control plan was necessary and were able to communicate their concerns and contribute their suggestions from the beginning. A local coordinating committee, including both State and local officials, continues to meet regularly to discuss the progress of the program. The County Extension Service also organizes important interagency meetings (EPA, FDA, DEQ). The Extension Service conducts a comprehensive educational and information program, including media releases, talks to civic groups, and tours. These tours are often for other farmers from outside the county who are interested in the practices being used in the Tillamook area.

Management Plan Development and Implementation

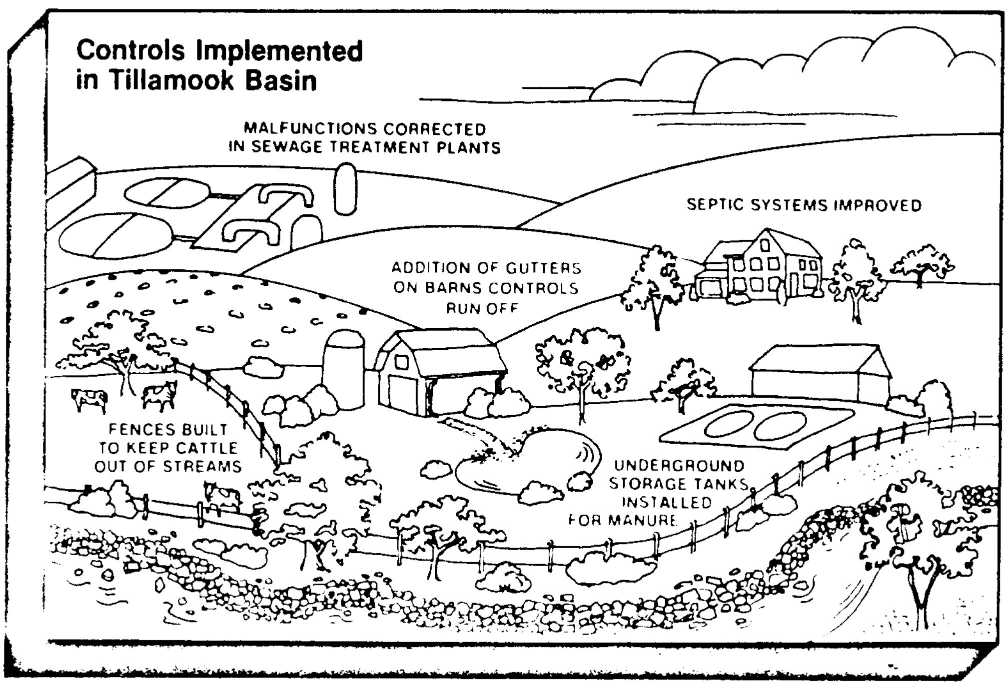
Interested citizens and the Department of Environmental Quality developed three management options to control shellfish contamination: (1) closing the bay to harvesting of shellfish until the problem corrected itself; (2) initiating new types of corrective actions aimed at reducing the pollution potential of the identified fecal sources and developing harvesting criteria for the bay; or (3) strengthening existing pollutant control programs and developing harvesting criteria for the bay. The last option was chosen because it was the most cost-effective and did not negatively impact the shellfish industry, which already had self-imposed limited harvesting during critical runoff periods.

Recognizing the need for immediate action to protect the public health and the long-term nature of the cleanup, the Department adopted a standard procedure for determining when to open or close the bay to shellfish harvesting. This procedure relied on five criteria that were developed by the Department of Environmental Quality and State Health Department. Any one of these criteria could be used to close shellfish beds for 5 to 10 days. The bay is automatically closed when a sewage treatment plant bypass or malfunction occurs, during high river flow, and during periods of frequent rainfall.

Since the dairy waste was considered to be one of the most pervasive problems, the Soil and Water Conservation District and the dairy community developed an extensive cleanup plan to address the animal waste problem. The strategy relied on two principles: (1) prevent rainwater and clean surface water from coming into contact with manure, and (2) when this is not possible, prevent contaminated surface water from reaching the streams or the bay. To implement the plan, 109 dairy farms were designated as critical dairies. To achieve the goal of a 70 percent reduction in fecal coliform loading, all critical dairies were encouraged to undertake best management practices (BMP's). Each farmer developed individual farm water quality plans. Each plan addressed the water quality problems of that farm, best management practices that would be used to alleviate them, and a 3- to 10-year schedule for implementing the practices.

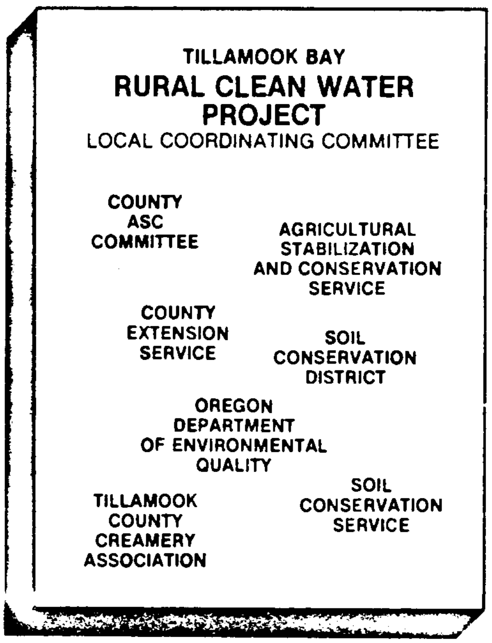
To ensure that the most critical sources were treated first, each farm was ranked based on factors such as the distance of confinement areas to open water, the acreage of poorly drained soils where manure is spread, the number of cattle per acre, and the farm's location in the watershed and floodplain. The BMP's applied by farmers included installing solid and liquid manure storage facilities, roofing animal manure accumulation areas, erecting streambank fencing, and managing roof water.

The other critical problem identified in the plan, sewage waste, was addressed by the Department of Environmental Quality. Sewage treatment levels were determined to be adequate, but malfunctioning equip-



ment problems did occasionally occur. To rectify the problem, alarms and shutdown devices were installed at the sewage treatment plant. The Fecal Waste Management Plan instituted procedures to notify health officials of malfunctions so that shellfish beds could be closed. In addition, many failing septic systems have been eliminated as a pollution source by the expansion of a municipal sewer line.

The Fecal Waste Management Plan and Bay closure criteria were adopted by local and State agencies in July 1981. The criteria were implemented in 1982. Currently, the closure criteria are being re-evaluated based on continuing fecal coliform monitoring results.



Responsible Authorities and Financing

Funding for the program came from a variety of sources. The Tillamook Bay bacteria and water quality management plan study were originally funded by U.S. EPA 208 funds. Upgrades to the Tillamook sewage treatment plant were financed through EPA construction grants. The nonpoint cleanup effort was funded through USDA's Rural Clean Water Program, which provided a cost-share of up to 75 percent of the landowners' costs. The local Agricultural Stabilization and Conservation Service has received more than $4 million through this program to assist dairy owners in the implementation of BMP's. The farmers have also committed more than $3 million of their own money to support this effort. In 1986, the Department of Environmental Quality and the Soil and Water Conservation District began a new monitoring program funded by U.S. EPA 205(j) funds to assess the effectiveness of the management plan.

Results

Water quality and fecal contamination levels are improving basinwide from cleanup activities. Although implementation is not yet complete, the project has been able to show significant water quality improvements in both the rivers and the bay. In 1985 bay closures were invoked less frequently, and employment in Tillamook's oyster industry was the highest since 1952. Industries and dairy farming are still open for business.

Best management practices are working and water quality conditions are approaching desirable levels. Work on the farms is 45 to 50 percent complete. Recent water quality data analysis shows that fecal coliform contamination of the bay has already been significantly reduced between 1980 and 1985. Based upon the projected level of BMP implementation and the decline of fecal coliform concentration already observed, it appears that by 1991 Tillamook Bay will routinely meet shellfish water quality standards, although unusual weather conditions could cause a temporary problem.

Lessons Learned

Continued improvement of the water quality is expected for Tillamook Bay and its tributaries. With the knowledge of who, how, and when sources of pollution operate and discharge in a watershed and bay, point and nonpoint source discharges can be controlled to protect a shellfish industry.

The success of the plan is attributable to a number of factors:

- The County Extension Service Soil and Water Conservation District, the Agricultural Stabilization and Conservation Service, Soil Conservation Service, and the Creamery Association worked together closely from the beginning of the program. These agencies worked cooperatively to create strong public involvement. The involvement of local citizens throughout all phases of the project fostered local pride in the accomplishments and, more important, fostered a pride in the livability of the Tillamook area.
- Cost-sharing money became available and was adequate to show immediate progress.
- The project was very closely tied to an important resource, which made the community highly interested.
- The solutions were fairly easy to develop and implement.

For further information, contact John E. Jackson, Department of Environmental Quality, Portland, OR; or John van Calcar, U.S. Department of Agriculture, Portland, OR; or Mark Alderson, EPA Project Manager, Washington, DC.

EPA
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Strategies for the Preservation of an Estuarine Watershed

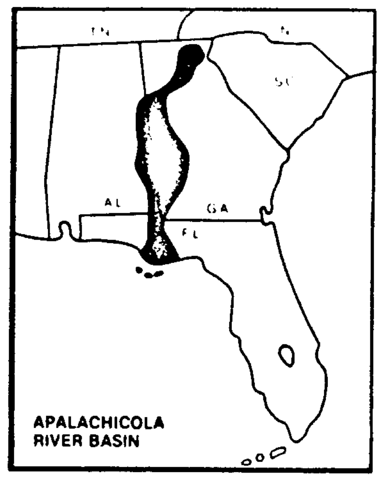
Preserving watersheds through land purchases and protective designations

APALACHICOLA BAY, FLORIDA

Characteristics
- The estuary covers approximately 210 square miles.
- The basin drains 19,600 square miles in Alabama, Georgia, and Florida, with 12 percent of the basin in Florida.
- The Apalachicola River is the largest river in Florida in terms of flow.
- Forty percent of the Apalachicola Bay is suitable for growing oysters.

Resources
- The bay produces 90 percent of the Florida oyster harvest, and 10 percent of the national harvest.
- The bay is a major spawning ground for blue crab and shrimp.
- Annual seafood landings in Franklin County (which surrounds the main estuary) are valued in excess of $14 million.
- The upper basin is an area of unusual biological diversity.

Issues
- The pollution and proposed dredging projects threatened the bay's productive seafood industry.
- Protection and preservation of the river and bay floodplain and sensitive areas around the bay became a priority of the State and local authorities.
- Maintenance of existing flow from northern States was threatened.



Introduction

The Apalachicola River basin may be the most protected estuarine system in the United States. For over 10 years the State of Florida, in conjunction with Federal and local authorities, has taken a variety of actions to preserve the relatively pristine Apalachicola drainage basin. The protection of the unique natural resources of the Apalachicola system has been accomplished by three major types of actions including (1) land acquisition, (2) establishment of protective designations, and (3) basin management. Extensive research to document the ecology of the Apalachicola Bay system helped focus basin management actions.

The Apalachicola River is formed by the convergence of the Chattahoochee and Flint Rivers, which originate in northern Georgia. The river drains into Apalachicola Bay which produces 90 percent of the State's oyster harvest; is a major spawning ground for blue crab and shrimp; and also provides a finfish (spot, croaker, and sea trout) harvest. In the early 1970's the Apalachicola system was threatened by proposed navigation projects that would substantially modify the river's hydrodynamics, clear-cutting in the lower basin that would increase sediment and nutrient loads, development pressures, and poor sewage treatment.

Overview of Bay Characteristics and Problems

The Apalachicola estuary is located on the Gulf Coast of Florida at the mouth of the Apalachicola-Chattahoochee-Flint (ACF) River system. The estuary is a relatively shallow lagoon and barrier island system. It has an average depth between 6 and 9 feet, and covers approximately 210 square miles. The waters of the ACF basin are used for diverse purposes, including commercial and recreational fishing; commercial navigation; recreation; hydropower; municipal, industrial, and agricultural water supply; sewage effluent discharge; and fish propagation.

The major urban areas are in Georgia and Alabama, whereas the Florida portion of the basin is sparsely populated. The six Florida counties adjacent to the basin have low population densities of 30 people per square mile and are predominately forest.

In the early 1970's, periodic closings of the oyster beds in Apalachicola Bay threatened the viability of the local seafood economy. The sewage treatment plant often discharged raw sewage to Apalachicola Bay. At the same time, the Corps of Engineers proposed constructing four dams in the Apalachicola River. Concerns about the freshwater retention incorporated in these proposals increased the interest of the local citizens. Proposed land development for the area added to these concerns.

Major Components of the Program

Protection efforts focused on land acquisition, protective designations, basin management, and research.

Land Acquisition

Public land acquisition has proven to be a cornerstone of the effort to protect the Apalachicola ecosystem. Over 100,000 acres of land have been purchased for a variety of purposes.There are currently two State land acquisition programs active in the region: the State's Conservation and Recreation Lands Program (CARL), and the Save Our Rivers Program.

These programs have purchased lands along the river floodplain, the lower portion of the river, the bay front, and nearby islands.

In CARL, the State has purchased 14,475 acres for $6.4 million. Under Save Our Rivers, the State purchased over 35,000 acres of bottomland hardwood swamp for $10.3 million and is negotiating for the purchase of 42,000 more acres of floodplain. An additional 31,863 acres were acquired through an earlier program at a cost of $22.8 million. Additional acquisitions around the bay have a high ranking on the current CARL list. The Florida Department of Natural Resources is responsible for the selection and negotiations for land acquisition; however, all final purchases must be approved by a six-member interagency committee that includes the Governor and his cabinet.

Protective Designations

State, Federal, and international protective designations have also been instrumental in protecting the river and bay. Each of these designations serves a different role in protecting the system. Together, they have drawn attention to the system, which has impacted permit, treatment, and land use decisions. The primary designations used have been Aquatic Preserve, Outstanding Florida Water (OFW), National Estuarine Research Reserve (Sanctuary), Area of Critical State Concern, and International Biosphere Reserve.

Basin Management

An effort to manage the basin as a system was proposed by the Northwest Florida Management District in 1976, but received no support. In 1979, when the Apalachicola estuary was declared a National Estuarine Sanctuary, a requirement for basinwide management was connected to the release of Federal funds.

In 1982, interest in systemwide management of the basin was revived by the Department of Environmental Regulation. In 1983, an interstate Memorandum of Understanding (MOU) was signed by Florida, Georgia, and Alabama to develop a basinwide drought management plan, a water management strategy for the system, and a navigation maintenance plan.

Major Protective Designations

Outstanding Florida Water

The majority of the Florida portion of the basin is designated as Outstanding Florida Water. This designation prevents a permanent point source discharge from degrading the receiving water. The OFW designation imposes reduced allowances for waste disposal and assimilation. It restricts new long-term pollutant discharges such as sewage, industrial effluent, dredging, and filling. OFW restrictions help to ensure that recreational and ecological integrity of the area are preserved.

National Estuarine Research Reserve

Through the Office of Coastal Zone Management the lower Apalachicola River and Bay was designated as a National Estuarine Sanctuary, now known as National Estuarine Research Reserve. The Apalachicola Reserve is the largest in the country: 193,758 acres, or twice the size of the other 17 reserves combined. The Apalachicola Reserve includes floodplain, fresh and saltwater marshes, open water, and barrier islands. Through this program Federal and State funds are used for land acquisition, research, and education. The Apalachicola National Estuarine Reserve Advisory Council (ANERAC), an 11-member board, serves as a forum for coordination among local interests, State environmental agencies, and the Federal government. The Estuarine Research Reserve plays a key role in the effort to use scientific understanding to manage the resource.

Area of Critical State Concern

The Apalachicola Bay area was designated an Area of Critical State Concern through the Apalachicola Bay Area Protection Act. This designation allows for State oversight and control of government decisions and ordinances. The intent of the act is (1) to protect the water quality of the bay area, (2) to financially assist Franklin County and its municipalities in upgrading and expanding their sewage systems, (3) to monitor activities in the area to ensure resource protection, and (4) to educate the residents of the area in order to preserve its natural resources. The act also puts the Resource Planning and Management Committee in an advisory role to support Franklin County in enacting land development regulations related to stormwater systems, correct onsite sewage treatment systems, and develop a map of pollution-sensitive segments of the critical shoreline. Since its designation the county has imposed an ordinance which provides a buffer between land development and the estuary. The Apalachicola Bay Area Protection Act also provided money to upgrade the municipal sewage system in Apalachicola.

Aquatic Preserve

The estuary was designated an aquatic preserve in 1975. This designation requires the State to develop a management plan to ensure the long-term protection of the aquatic resource.

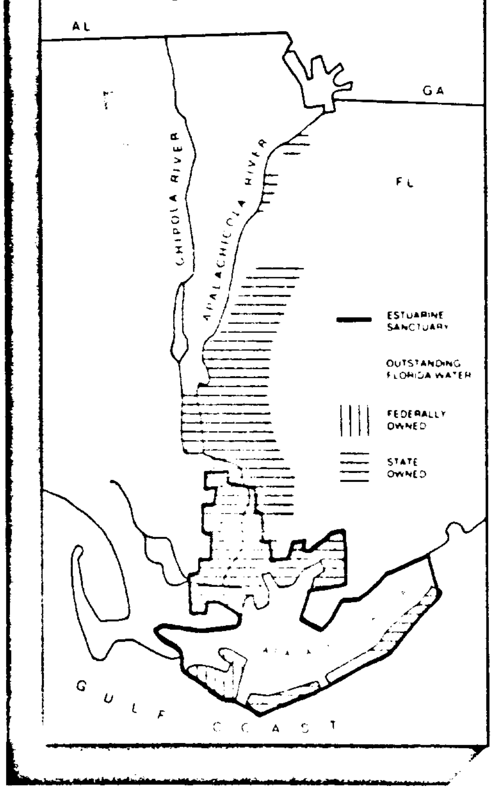
International Biosphere Reserve

This international recognition for the area by the United Nations was received in 1984.

In 1983, the Governor appointed an Apalachicola Task Force to work under the Coastal Zone Interagency Management Committee (IMC) to deal with the problem of frequent closing of the bay to oystering because of sewage. The task force membership includes the Department of Community Affairs, the Department of Health and Rehabilitative Services, Department of Commerce, Department of Natural Resources, and the Department of Environmental Regulation. This task force was instrumental in developing the Apalachicola Bay Protection Act of 1985, which designated the region as an Area of Critical State Concern.

The Navigation Maintenance Plan helped resolve a 10-year-old disagreement between Florida, which resisted year-round use of the river channel on environmental grounds, and Alabama, Georgia, and the Corps of Engineers, which felt Florida's resistance was suppressing the regional economy. The plan allowed navigation if no further degradation of the environment occurred. Some proposed structural modifications were abandoned and maintenance practices revised to meet this goal. The Corps finally judged that, without the structural modifications, flow was not sufficient for year-round use in most years.

Area Designated for Protection



Responsible Authorities and Financing

Major funding and consistent research support have come from the Florida Sea Grant College (National Oceanic and Atmospheric Administration) and Franklin County Board of Commissioners. Supplementary funding has been provided by private industry as well as by State and Federal agencies.

Many of the initiatives to protect the system originated in the Florida Department of Environmental Regulation. In 1979, the Department hired a staff person dedicated to coordinating and resolving problems impacting the river and bay system. After a year, funding for this position was covered by a grant from the Office of Coastal Zone Management until 1985 when the position was made permanent by the Apalachicola Bay Protection Act. Through this position the Department has helped initiate a comprehensive program to manage and protect the system. Money for the CARL Program comes from taxes on minerals, oil and gas, and possibly from real estate taxes in the near future. This money is put into a trust fund for land acquisitions and drawn on as needed. An estimated $40 million in revenue will be put into the CARL program this year.

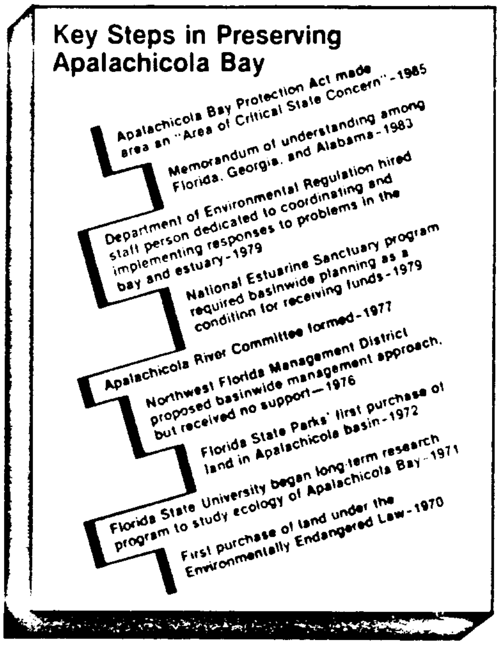
Process

In the early 1970's a broad-based effort to protect the Apalachicola ecosystem was undertaken because the people of Franklin County recognized the need for a management program to protect this resource.

In 1972, a field monitoring program began in Apalachicola Bay to gather scientific information for the purpose of applying it to practical problems. Scientists from Florida State University, United States Geological Service, Fresh Water Fish and Game Commission, Department of Environmental Regulation, and many others have investigated biological, chemical, and physical characteristics of the river and bay. Major contributions for this research have come from Florida Sea Grant College (National Oceanic and Atmospheric Administration) and the Franklin County Board of Commissioners. This monitoring project has continued for over 10 years and continues today.

Local efforts to protect the area have included adoption of county-wide zoning regulations in the 1970's and a comprehensive plan in 1981 in Franklin County. The State and the Northwest Florida Management District efforts have included land acquisitions, a number of protective designations, and a resource planning and a management committee.

A critical factor influencing long-term protection of the resource is communication and coordination among all involved parties. Over the past decade, the State has made a considerable effort to involve local county commissioners, developers, the scientific community, and the public in the decisionmaking process. In 1977, the Apalachicola River Committee was formed to bring the Departments of Environmental Regulation



and Natural Resources and other State and local agencies together to strengthen local planning efforts through the provisions of data and technical assistance. Representatives on the committee included the six counties bordering the river, and State and Federal resource agencies. It was chaired by the Apalachee Regional Planning Council. The committee was especially concerned with navigation issues and since Florida law required local government approval of dredging permits, the committee wielded some power.

In conjunction with the Memorandum of Understanding adopted by the three States and the Corps in 1983, an Interim Coordinating Committee consisting of representatives of each State and the Corps was established. This committee was responsible for dealing with interstate water management and navigation issues and was intended to terminate after three years. However, since the arrangement has worked well, all parties agreed to continue the committee as the Interstate Coordinating Committee. The final Navigation Maintenance Plan (NMP) adopted by this committee included a provision requiring that before any measures listed in the NMP are implemented in Florida, public meetings would be held in the affected areas to provide information and to receive public input.

Results

Efforts to date have left hope and optimism that the foundation exists for the Apalachicola system to be protected over the long term. Continued work is necessary, however, and results are contingent upon the involvement and acceptance of the effort by local government and citizens.

To date the State has purchased over 85,000 acres in the basin. At least 40 percent of floodplain is publicly owned and by the end of 1987 it is hoped that almost 90 percent of the wetlands in the Apalachicola floodplain will be publicly owned. Efforts to acquire more land in the Apalachicola basin will continue, but it is uncertain how much additional land will be purchased. By the end of the land acquisition program the State hopes to have the floodplain of the river intact and in public ownership.

Protective designations have brought significant attention to the system and have provided some measure of protection to the area. These designations, however, can lull the public into a false sense of security. For example, many people mistakenly believed the Estuarine Reserve would impose strict limits and controls on anything and everything that would harm the estuary. The Reserve actually has no authority to regulate development, but instead promotes research and education.

Perhaps most important, all parties are interested in continuing and expanding efforts to protect the system. Several State agencies have full-time staff specifically assigned to working on the system, as does the Florida Defenders of the Environment.

Lessons Learned

The Apalachicola experience shows that a river basin can be managed and protected. Litigation, acquisition, the State permitting process, the education of local citizens, planning and management, and public pressure have all played major roles in this effort. The combined efforts of local, State, Federal, and university programs in the Apalachicola River basin have been extremely important.

The education of all concerned parties has been a key to the program's success. There has been little turnover among State and Federal agency staff, with many having five to 10 years experience working on the system. Consequently, many have become quite knowledgeable about the system. And, after dealing with resource management issues in the basin for the past 10 to 15 years, county officials have also gained an appreciation for the system's ecology and have integrated this to some extent into the decisionmaking process.

For further information contact Pamela McVety, Florida Department of Environmental Regulation, Tallahassee; Stephen Leitman, Florida Defenders of the Environment, Tallahassee; or Mark Alderson, EPA Project Officer, Washington, DC.

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Maryland's Critical Area Program

Managing aquatic resources by controlling land-based activities

CHESAPEAKE BAY

Characteristics

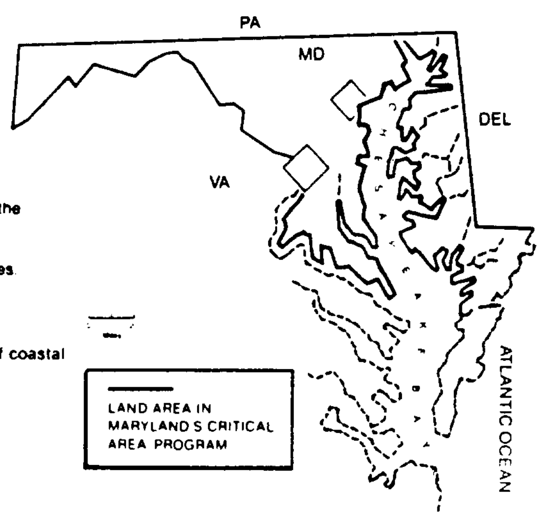
- The area includes 2,900 miles of shoreline and 614,000 acres of land.
- Land usage includes:
  - -35 percent tidal wetlands
  - -25 percent agricultural lands
  - -28 percent forest
  - -12 percent developed area.

Resources

- Over 200 species of finfish and shellfish inhabit the bay at some point in their life cycle.
- Bay produces 50 percent of blue crabs and 33 percent of oysters harvested in the United States.
- Canada geese, ducks, and other migratory waterfowl find winter habitat in the bay area.

Issues

- Development is increasing in the critical area of coastal counties at twice the rate outside critical area.
- Loss of wildlife habitat is a continuing problem.
- Nonpoint source pollution has been identified as major problem.
- Fish and shellfish resources are declining.



Introduction

The Critical Area Law focuses on land-based activities as a source of problems in Chesapeake Bay water quality. It is a program designed to balance the pressure for new development while checking its potential to increase the amounts of pollutants entering the bay from disturbed areas. Equally important, the Critical Area Law emphasizes the need to preserve the bay area's richly diverse habitats for fish, wildlife, and plants and to use its resources wisely.

Historically, the Chesapeake Bay has provided generous harvests of high quality seafood, abundant water-based recreation, deep international shipping lanes supporting Maryland and Virginia's industrial base, and a haven for wildlife. Rapid population growth and development and associated pollutant and sediment loads have threatened the bay's water quality, natural habitats, shoreline, and commercial integrity.

In the early 1980's, subsequent to the release of the Chesapeake Bay Program's research findings, concern for the bay was high – as demonstrated by the passage of 34 legislative and budget measures in the State of Maryland for bay cleanup. The Bay Critical Area Law was a major component of this initiative.

Overview of Bay Characteristics and Problems

Located on the Atlantic coastal plain, the Chesapeake Bay drains over 150 rivers in a 64,000 square mile area. The lands surrounding the bay support diverse uses: farming, forestry, industry, recreation, urban and suburban development, and unique natural habitats. Since the 1950's, these lands have developed rapidly. In fact, in Maryland, 17 percent of new coastal county development has occurred on only 9 percent of the available land area – within 1,000 feet of shoreline.

The health of the bay has been declining. Evidence includes decreased stocks of bay anadromous fish species and degraded water quality, particularly in the upper Chesapeake Bay and tidal estuaries. In these areas, increased nutrients have lowered available oxygen for fish and aquatic life; sediment has

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decreased available light for submerged aquatic vegetation and shipping lanes and other channels; and toxic substances have reduced species diversity.

The Chesapeake Bay Critical Area Law

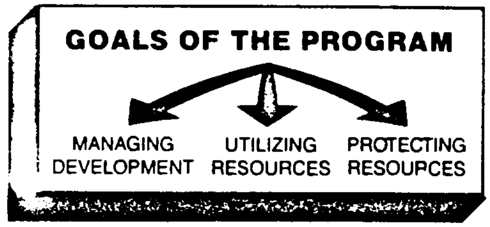
By passing the Chesapeake Bay Critical Area Law, the Maryland General Assembly recognized that land uses near the water's edge have important consequences for water quality and wildlife habitat. The law

- Identified lands within 1,000 feet of mean high water or landward of tidal wetlands as a "Critical Area";
- Defined goals to reduce the impact of development on water quality as well as on fish, wildlife, and plant habitats;
- Created an intergovernmental framework for: comprehensive land use planning and habitat protection.

The law also established a commission of 25 members to develop criteria for implementing the program. The criteria established three broad categories for land use. The law requires local jurisdictions to develop programs to manage lands in the three categories as specified by the characteristics and criteria developed by the commission. The management of these lands is to include measures to address land cover and impervious surfaces; buffer areas; setbacks; open space, water access, and recreation areas; and timber harvesting. Each jurisdiction must submit its program to the Critical Area commission for review.

Goals

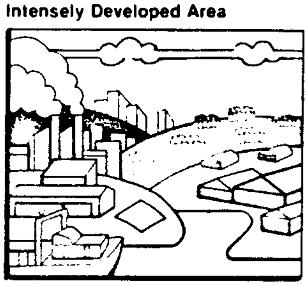
The implementation criteria, which were drafted by the commission with substantial public contribution and approved by the State General Assembly, address three resource management issues: development, resource utilization, and resource protection.



Managing Development. The commission designated three broad land use categories: Intensely Developed, Limited Development, and Resource Conservation Areas. In general, the rationale was to direct new growth in the Critical Area to already built-up areas because this would minimize the impact of growth on protective land uses and natural habitat. In the Limited Development Area, the existing pattern of development could continue, but the commission developed criteria, often in the form of performance standards, so that impacts to water quality and natural habitats would be

Characteristics of Land Classifications in Critical Area, and Criteria for Management

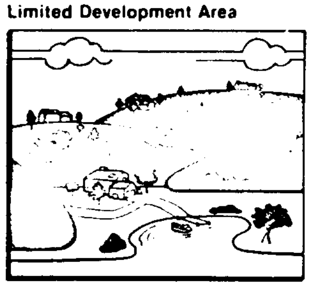
Intensely Developed Area



Characteristics
- Dense residential, institutional, commercial, or industrial uses
- 4 or more dwelling units per acre
- Public sewer and water serving 3 or more housing units per acre

Applicable Criteria
- Reduce pollutant loadings by at least 10% from predevelopment loads
- Reduce nonpoint impacts to streams and tidal waters from redevelopment
- Protect remaining wildlife and fish habitats

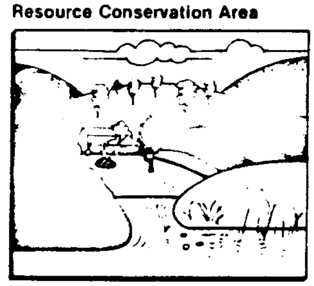
Limited Development Area



Characteristics
- 1 dwelling unit per 5 acres up to 4 per acre
- Areas with public sewer, or water, or both
- Mixture of land usage—not dominated by agriculture, wetlands, forest, or open space

Applicable Criteria
- Replace cleared forest land on an acre-for-acre basis
- Restrict removal of existing forest land to 20% when development occurs
- Restrict impervious areas to 15% of the land area being developed
- Encourage clustering of dwelling units to conserve natural habitats

Resource Conservation Area



Characteristics
- Housing density of less than 1 dwelling unit per five acres
- No public sewer or water
- Primarily open fields, wetlands, forest, and agriculture

Applicable Criteria
- Limit residential development to an overall density not to exceed 1 dwelling unit per 20 acres
- Encourage agriculture and forestry

minimal. The Limited Development Area was defined to include areas containing the protective land uses and natural habitats. The commission then considered the question of how to accommodate some development in the Resource Conservation Areas but still maintain such uses.

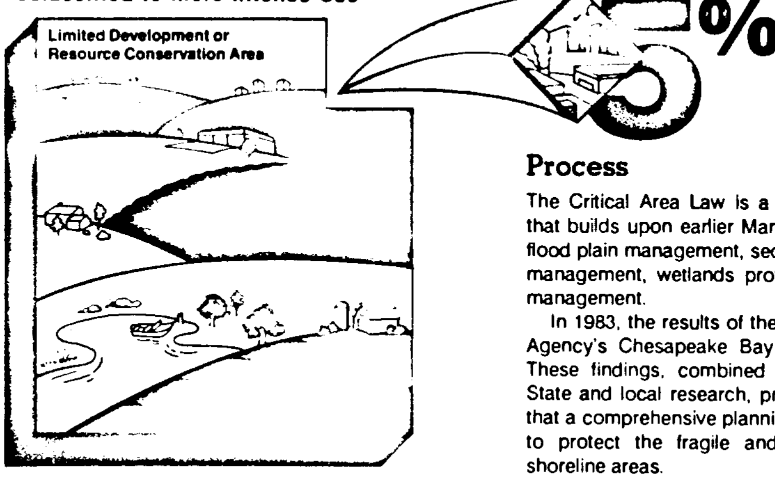
The law required local jurisdictions to assign their lands in the critical area to one of three categories by December 1985.

The criteria also allow for development of pre-existing lots and subdivisions through grandfather provisions and for expansion of development. Intensely Developed Areas and Limited Development Areas may be expanded by up to 5 percent of a county's land area, excluding the acreage in tidal wetlands or federally owned property from the formula. No more than one-half of this allocated expansion may occur directly in the Resource Conservation Area.

Utilizing Resources. The law also calls for improved management of forests, agriculture, and water-dependent facilities within the Critical Area. Specific requirements are

- Commercial tree harvest operations affecting one or more acres per year must have a forest management plan; limitations are imposed on timber harvesting within 1,000 feet of mean high water of the bay or perennial tributary streams;

Only 5% of Land May Be Reclassified to More Intense Use



- Soil conservation and water management plans and implementation of best management practices are required within five years on agricultural lands;
- A 25-foot filter strip must be established along tidal waters and streams until a soil conservation plan is implemented;
- Feeding or watering of livestock is prohibited within 50 feet of the water's edge; and
- New development within 100 feet of shoreline except in water-dependent communities, and new marinas are prohibited in Resource Conservation Areas.

Protecting Resources. The last component of the Critical Area Program provides for protection of nontidal wetlands, threatened and endangered species, species in need of conservation, and plant and wildlife habitat. These habitat and wildlife protection measures require local jurisdictions to

- Inventory and protect fish spawning grounds, threatened and endangered species habitat, colonial water bird nesting sites, historic waterfowl staging and concentration areas, and forest-interior-dwelling bird habitat;
- Create wildlife corridor systems to ensure that any new development in the Critical Area will preserve existing habitats;
- Establish a minimum 25-foot buffer zone around nontidal wetlands to prevent any future habitat modification; and
- Establish a minimum 100-foot naturally vegetated buffer strip around the bay in all nondeveloped areas.

Responsible Authorities and Financing

Implementation of the Critical Area Program is based on a well-defined State/local government partnership. Each of 60 local jurisdictions (16 counties and 44 municipalities) is to develop its own program to implement the Critical Area criteria. The commission performs an oversight function to ensure that these plans meet the stated goals of the criteria and coordinates implementation among the local jurisdictions. The operation of the commission and development of local plans are financed through general State revenues. The State provided funds to develop the maps and local programs.

Process

The Critical Area Law is a comprehensive approach that builds upon earlier Maryland programs, including flood plain management, sediment control, stormwater management, wetlands protection, and coastal zone management.

In 1983, the results of the Environmental Protection Agency's Chesapeake Bay Program were released. These findings, combined with facts uncovered by State and local research, provided powerful evidence that a comprehensive planning approach was required to protect the fragile and economically important shoreline areas.

Following this report, the Governor of Maryland created an interdepartmental task force to respond to the findings of the bay study. The Critical Area Program was one of the legislative and budgetary measures proposed by the task force. Local government participated early in the drafting process through the Maryland Association of Counties and the Maryland Municipal League. Committees of the Maryland General Assembly also reviewed the bill frequently throughout the drafting process. The bill was enacted on June 1, 1984.

From its early stages, the bill's intent was to maintain local planning authority. The enacted legislation provides for both a carefully defined local implementation process and comprehensive State oversight. The membership of the Critical Area Commission was important in developing the criteria, and local jurisdiction played a strong role. Of 25 members, 11 are residents, elected officials, or appointed officials of coastal counties; 8 members represent the commercial, recreational, and environmental interests of the bay. Only six commission members are from State agencies. All members are appointed by the Governor, with State Senate approval. The commission's executive director is selected by the commission chairperson.

Prior to drafting the criteria, the commission held seven public hearings during December 1984, at locations around Maryland's bay coastline, to enable local citizens and bay interest groups to voice their opinions.

Throughout the criteria development process, the commission continued to conduct formal meetings and public hearings. Commission members and staff also made numerous appearances before General Assembly committees, spoke at meetings organized by the many interest groups concerned with bay issues, and conducted television and radio interviews.

Following a final series of nine public hearings during July 1985 to review the proposed criteria, the commission substantially modified the criteria to address public concerns. The revised criteria were signed into law on May 13, 1986, 22 months after enactment of the Critical Area Law. These criteria are now guiding local jurisdictions in their development of Critical Area land use plans.

Program Status

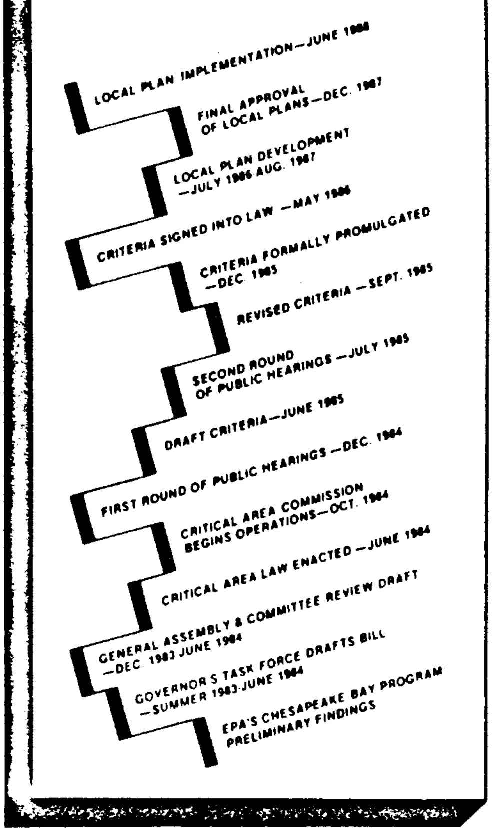
Local jurisdictions are developing program plans and amending their zoning ordinances as needed to meet Program goals. Final approval of all local plans is expected shortly.

The positive results of this process can be seen in local jurisdictions now working together to develop coordinated plans and continued support by citizens at their local government levels. Perhaps as important is the increased contact between State agencies and local jurisdictions – particularly the small jurisdictions – which has improved intergovernmental relations.

Lessons Learned

The Critical Area Program – the Critical Area Law, the commission, and the criteria – is a reality. It demonstrates that support for managing coastal development can be generated; that comprehensive State-level land use restrictions, typically fraught with controversy, can be established; and that a process of local implementation complemented by State oversight can be defined.

Origin and Development of the Critical Area Program



The active involvement of local officials and the public, the clear definition of respective State and local roles, and the protection of local planning authority were fundamental to this program's success.

The Critical Area Program may still face areas of resistance. If fully implemented, however, the program will fairly balance diverse interests and preserve the essential rights of local jurisdictions. By bringing local interests together with State regulators, a strong program was devised to protect the recovery of the bay. For Maryland, a State-level response worked; elsewhere a multi-county or multi-State program might be appropriate to protect estuarine environments.

For further information on this program, contact Dr. Sarah Taylor or Dr. Kevin Sullivan, Maryland Critical Area Commission, Annapolis, MD; or Mark Alderson, EPA Project Manager, Washington, DC.

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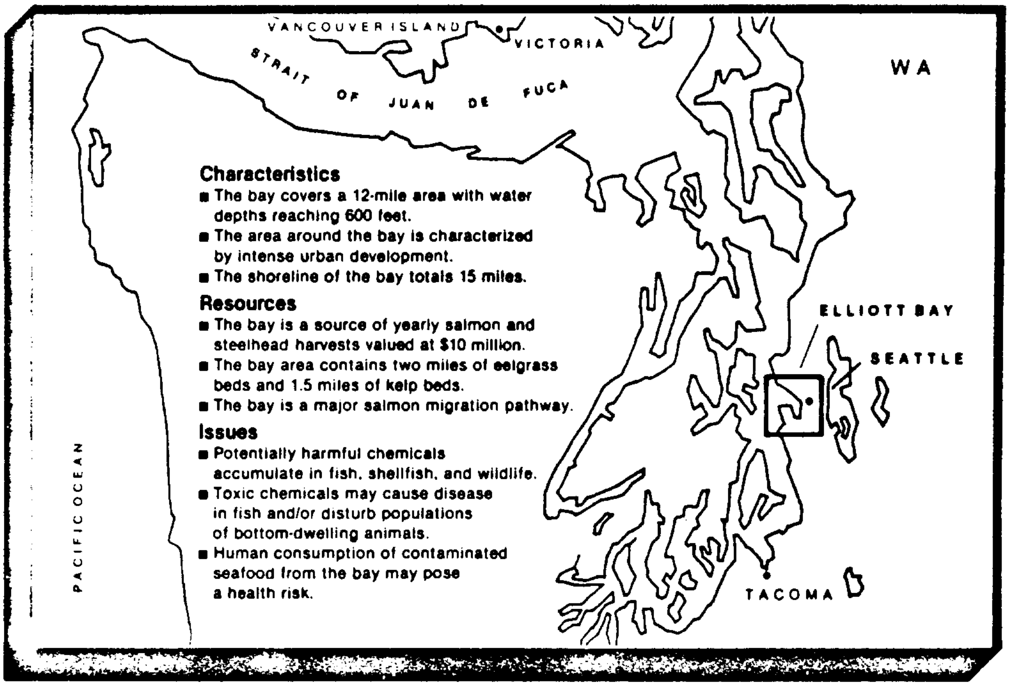
<EPA

United States Environmental Protection Agency
Office of Water
National Estuary Program

An Action Plan for Containing and Reducing Pollutants

Controlling toxic contamination in an urban bay through special enforcement teams and interagency coordination

ELLIOTT BAY, WASHINGTON STATE



Introduction

The Elliott Bay Toxic Action Program is an important part of a much larger effort to minimize toxic contamination in Puget Sound and protect its resources. Focused on the problems of an urban bay, its goal is to control toxic substances at their sources, particularly those toxics contaminating the bottom sediments of Elliott Bay and the Duwamish River. It does this by coordinating the authorities of various governmental agencies to revise discharge permits, enforce hazardous materials regulations, and clean up contaminated sites.

To target these regulatory authorities more effectively, the program relies on a strike force called EBAT--the Elliott Bay Action Team. This special enforcement and compliance team conducts field inspections and follow-up monitoring to ensure that required control actions are actually implemented. Other important components of the program include an interagency work group and a citizens advisory committee.

The Elliott Bay program, by coordinating and targeting various activities, has provided a model for interagency cooperation and management of site-specific toxic contamination.

Overview of Elliott Bay and Its Toxic Contamination Problems

Located on the eastern shore of central Puget Sound near Seattle, Elliott Bay covers a 12 square-mile area

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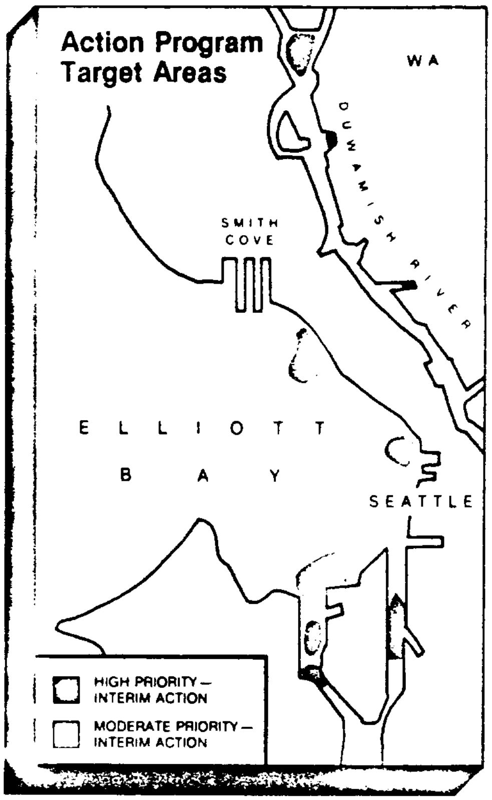

with water depths of up to 600 feet. The bay's drainage basin is extensively developed, and the bay itself receives major industrial and sewage discharges.

Among the living resources of the bay are salmon, flounder, shrimp, squid, and various clam species.

During the 1970s, the U.S. Environmental Protection Agency (EPA), the Municipality of Metropolitan Seattle (Metro), and the National Oceanic and Atmospheric Administration (NOAA) found harmful levels of toxic chemicals in sediments on the bottom of Elliott Bay and the Duwamish River, including potential carcinogens such as polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs), as well as toxic metals such as arsenic and lead. In addition, up to 16 percent of bottomfish caught in contaminated areas have liver tumors, and bottom-dwelling animal populations have dropped overall in the same areas.

Studies have shown that chemical contamination, along with overfishing and habitat destruction, may contribute to declines in some fishery resources. Moreover, NOAA researchers have recently demonstrated that some of the contaminant load discharged from the Duwamish River could move to the main basin of Puget Sound. If pollution is not curtailed, the effects of contamination could become widespread.

Elliott Bay Toxics Action Program

The focus of the Elliott Bay Toxics Action program is to control the sources of toxic contaminants by coordinating compliance and enforcement efforts among Federal, State, and local agencies. Ordinarily, activities such as field investigations, permit and site inspections, and hazardous substance control or cleanup programs are handled under different authorities by separate agencies. Integrating these activities under the "umbrella" of the program increases their effectiveness and provides a framework for identifying priority sites, choosing source controls, appointing appropriate agencies for enforcing controls, and developing a timetable for putting control programs into place.

A key element in this program is EBAT, a special enforcement and compliance team that includes staff from the Washington State Department of Ecology. EBAT was created in September 1985 to carry out site inspections, identify pollutant sources, revise discharge permits as necessary, develop alternative regulatory responses, and help dischargers develop cost-effective solutions to pollution problems. In cases where responsible parties fail to solve pollution problems or do not comply with discharge requirements, EBAT also has authority to take enforcement actions, such as administrative orders and monetary penalties.

In addition to EBAT, two other programs are important to the Elliott Bay Toxic Action Program. These are the Interagency Work Group and the Citizens Advisory Committee.

The Interagency Work Group is the mechanism through which the various agencies integrate their efforts. Chaired by a member of the Department of Ecology, the work group is more broadly based than EBAT. Its role is to coordinate program activities among agencies; circulate technical data and reports from related projects; report on plans and ongoing corrective actions; review work plans, progress, and technical results; and agree on future corrective actions and schedules.

The Citizens Advisory Committee (CAC) is also broad-based. It includes representatives of environmental groups, community organizations, business and industry, and resource users such as sport and commercial fishermen. Its role is to review program objec-

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tives and proposed actions; identify public concerns and issues relevant to action plans; and disseminate information to members of organizations represented on the committee.

Products of the Elliott Bay Toxics Action program are reviewed by the EPA regional office in Seattle, Washington.

Process

The Elliott Bay Toxic Action program evolved from earlier water-quality programs carried out by Metro and the Department of Ecology, although its current organization began with funding by the U.S. EPA early in 1985. At that time, the work group and CAC were established. Together with EPA, they worked to issue a draft report identifying problems in the bay and river, and proposing a sampling and analysis program. This report was the basis of an Interim Action Plan issued in October 1985.

During the same period, Metro and the Department of Ecology established and funded EBAT to carry out field sampling and laboratory analysis. Over 1,000 samples of sediment and biota were analyzed between October 1985 and June 1987. Along with a slide show and periodic press releases, these sampling results helped to publicize and gather support for the Elliott Bay program.

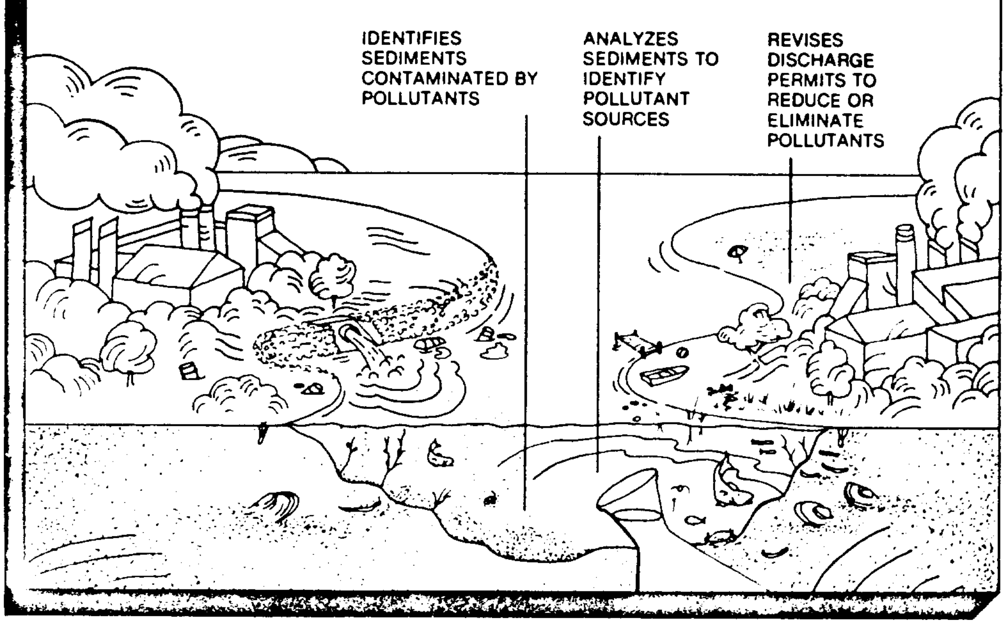
The samples collected are still being studied for evidence of chemical contamination and biological effects. Data from these studies and from continuing EBAT findings will help to redefine problem areas and identify additional pollutant sources.

Results

Since 1985, the Elliott Bay program has identified 42 unpermitted discharges and 15 contaminated upland sites; developed permits incorporating best management practices (BMPs) for shipyards; cleaned up two upland sites and negotiated the cleanup of 12 more.

In addition, EBAT has conducted more than 221 inspections at 124 sites. These inspections have led to termination of some discharges or wastewater reuse in-

What EBAT Does



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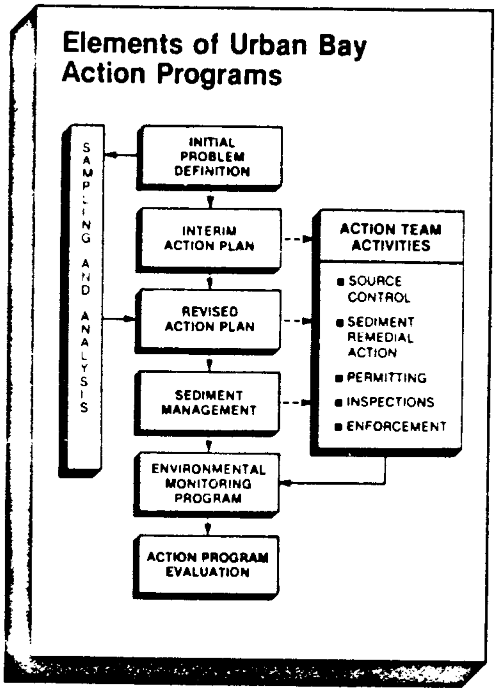

stead of discharge; rerouting of discharges to sanitary sewer systems; modification of existing discharge permits or development of new ones; and enforcement actions against noncomplying facilities, including 36 Notices of Violation, 22 Administrative Orders, and 28 levies of monetary penalties.

Lessons Learned

The experience of the Elliott Bay program demonstrates that a successful urban bay program must include several key elements:

- It must involve citizens, the regulated community, other governmental agencies, resource managers, and scientists in the decisionmaking process.
- It must focus on specific problem areas.
- It should use field inspections and personal contact with facility managers to encourage cooperation and find innovative, cost-effective solutions to identified problems.
- It should use a special task force to focus and carry out coordinated enforcement activities. EBAT, for example, was effective in dealing with localized toxic hot spots because it had sufficient regulatory authority and funding to carry out field inspections and enforcement actions.

The Elliott Bay program also demonstrates the importance of developing pollution control plans based on input from relevant governmental and regulatory agencies. In addition, it shows that wide-ranging public involvement is essential if regulatory actions are to be perceived as both necessary and fair.

Other factors that will affect the long-term success of the program include the development of toxics limitations and tests, issuance of permits for discharges from combined sewer overflows and storm drains, and continued interaction with other efforts in the Puget Sound area. All urban bay action programs can benefit from the sampling activities and source controls required under these programs.

For further information contact Jim Krull, Department of Ecology, Seattle, WA; or John Armstrong, U.S. EPA, Seattle, WA; or Mark Alderson, EPA Project Officer, Washington, DC.

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EPA
United States Environmental Protection Agency
Office of Water
National Estuary Program

Compensatory Mitigation to Protect Critical Fishery Habitats

Protecting fish and wildlife while allowing development

PUGET SOUND/WASHINGTON

Characteristics

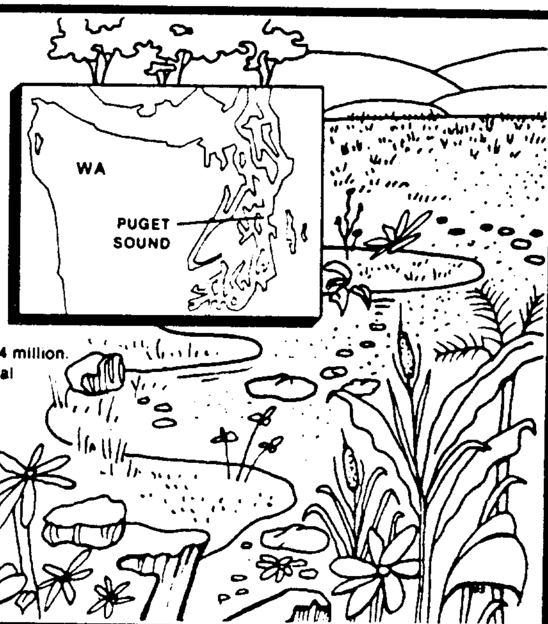
- Puget Sound is a classic, deep fjord with rocky shoreline and steep, jagged cliffs adjacent to the shoreline.
- The basin has nine watersheds containing over 10 million acres:
  - -82 percent forestland
  - -9 percent urban
  - -6 percent farmland
  - -3 percent rural, non-farmland
- Intertidal wetlands are limited due to shoreline configuration, but the nine watersheds support numerous other wetlands systems important to the ecology of the region.

Resources

- The estimated value of fisheries in 1984 was $74 million.
- Nearshore and intertidal wetlands provide critical habitat for economically important species.

Issues

- The Puget Sound area has already lost most of the major wetlands that existed at the mouths of some of the region's major rivers.
- Remaining estuarine wetlands occupy areas under severe pressure for development because of increasing population.
- Critical habitats must be protected without unduly restricting development.



Introduction

Wetlands are extremely important as fish and wildlife habitats and as buffer zones that trap nutrients and sediments and regulate flooding. Yet because of their proximity to the water, and frequent location in highly populated areas, wetlands are increasingly being lost to development. To stem such losses in the Puget Sound area, local officials have adopted a permitting strategy of wetlands replacement known as compensatory mitigation. The goal of the strategy is to prevent the net loss of critical fish and wildlife habitats by requiring the replacement of wetlands lost to the impacts of shoreline development. Because it is very difficult to reproduce adequately the size, diversity, and complexity of natural wetlands ecosystems, however, compensatory mitigation for the most part is allowed only in areas already disturbed by human uses and only if impairment or destruction of habitat is unavoidable.

Experience has also shown that mitigation projects require careful design, area preparation and planting, and follow-up. To ensure better projects, agencies are now requiring developers to prove the technical feasibility of their proposed compensation techniques; a questionable methodology may be grounds for permit denial. In fact, many developers already have recognized that good design is in their own interests, and that each well- executed project makes it more likely that other mitigation proposals will be accepted by permitting authorities.

Compensatory mitigation as a management tool was rare before 1980, but its use has increased in recent years. In Puget Sound, the mitigation programs have al-

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ready taught some important lessons that serve as valuable guides for programs elsewhere in the United States.

Overview of Characteristics and Problems

Puget Sound is a deep, fjord-like estuary connected with the Pacific Ocean through the Strait of Juan de Fuca. The shoreline consists of bluffs and beaches formed during the retreat of glaciers and modified by erosion and deposition. This geology means that many wetlands occupy areas that are also considered highly suitable for development.

The result is that over half of the Sound's wetlands have been lost to development in the last 100 years, and the pressure to build up shoreline areas continues to increase. Many of these areas are important fish and shellfish habitats, as well as resting and feeding spaces for a broad variety of resident and migratory birds. For the most part, these critical habitats are being protected through existing regulatory programs in the state. Compensatory mitigation has been proposed as a way to channel pressures away from pristine or critical habitats by allowing development in areas already affected by human activities.

Critical Value of Nearshore Areas

SALMON
JUVENILE FEEDING
JUVENILE REFUGE FROM PREDATION

HERRING/SMELT
EGG DEPOSITION

GROUNDFISH
JUVENILE FEEDING
JUVENILE REFUGE FROM PREDATION

CLAMS/OYSTERS
PRIMARY HABITAT OF ADULTS AND JUVENILES

CRABS
JUVENILE FEEDING
JUVENILE REFUGE FROM PREDATION

Program Evolution and Responsibilities

The concept of mitigation was first established at the federal level as part of the Fish and Wildlife Coordination Act, but rarely was used for estuarine areas until the National Environmental Policy Act (NEPA) was passed in 1969. The concept was reaffirmed in the Clean Water Act of 1977 and again in the NEPA modifications of 1978. These three statutes govern federal involvement in proposed shoreline development projects.

The lead federal agency is the U.S. Corps of Engineers, which has authority to issue dredging and filling permits. However, this authority is limited somewhat by the U.S. Environmental Protection Agency's authority to review final permits and to prohibit, condition, or restrict permits in any site that may be unacceptably affected. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service also influence the Corps' permitting considerations.

Within the State of Washington, coordinated management of shoreline development began with the passage of the Shoreline Management Act of 1971. The Washington Department of Ecology administers the Act, but other state agencies involved include the Department of Fisheries, the Department of Wildlife, and the Department of Natural Resources.

Developing a Mitigation Plan

For permits involving mitigation, the Corps begins the process by convening meetings at which development proposals and mitigation plans can be reviewed and modified. These meetings are attended by potential developers, representatives of involved government agencies, resource managers, and representatives of Indian tribes dependent on fisheries and other wetland resources.

Although the formal review process begins when a developer applies to the Corps for a permit to develop shoreline and associated wetlands, the Corps prefers to hold preapplication meetings where interested parties can resolve as many issues as possible before formal application is made. A primary goal of the permit review meetings is to provide a forum to raise potential environmental impacts and discuss methods of reducing or avoiding them. Another goal is to agree on appropriate mitigation strategies for those impacts that cannot be avoided.

Most resource agencies in Puget Sound have adopted a goal of "no net loss of in-kind habitat," the aim being to maintain the number and variety of specific habitats. Developers find the one-to-one tradeoff easy to understand and difficult to challenge—if their project will cause habitat loss, they must replace the lost habitat with an equivalent amount of the same kind of habitat, preferably as near as possible to the original site.

In practice, however, adequate replacement often requires two-to-one mitigation to offset adverse effects. At the same time, mitigation techniques are still so new that even one-to-one replacement is seldom achieved. For these reasons, local officials have been extremely conservative in using compensatory mitigation to resolve development/preservation conflicts. Most have chosen to rely instead on avoiding adverse impacts in the first place.

Elements of Successful Plans

Despite the difficulties in implementation, some shoreline development has been allowed using compensatory mitigation as a condition of the permits. To enforce these permits, the Corps must follow criteria that determine whether a proposed plan is feasible. Since 1982, mitigation criteria increasingly have been included in the permit itself. Desirable components of a mitigation plan include:

- baseline data characterizing the extent and value of critical habitats and the abundance and distribution of key species;
- mitigation goals laying out the specific goals and objectives of the mitigation actions;
- detailed work plans describing and specifying mitigation techniques, including maintenance requirements and relevant deadlines;
- performance standards to be used to measure whether mitigation goals are being met;
- monitoring plans describing schedules for collecting data to track mitigation progress;
- contingency plans describing corrective actions if proposed mitigation techniques are inadequate; and
- performance bonds ensuring commitment to fulfill mitigation actions, monitoring, and contingency measures.

Results

Mitigation projects in Puget Sound have taken place chiefly around the cities of Seattle and Tacoma. Most have included plans to modify substrate or create shoreline areas to replace lost habitat. Less-used techniques include transplanting eelgrass and creating marshes.

The U.S. Fish and Wildlife Service has evaluated 20 recently begun or proposed projects in Puget Sound for the completeness of their mitigation plans. The sites for replacement habitat ranged in size from 0.05 acres to 24 acres, and included use of all four techniques. Every mitigation plan in this study provided detailed work plans and monitoring plans, and more than half also included baseline information and contingency plans. However, most of the plans lacked environmental goals, performance standards, and performance bonds.

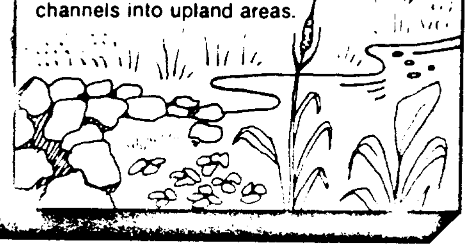
Common Mitigation Techniques Used in Puget Sound

SUBSTRATE MODIFICATION
Manipulation of substrate composition or relief by placement of boulders, cobble, gravel, or fine sand.

SHORELINE CREATION
Construction of shallow-water habitat by excavating upland areas or by filling areas of deeper water.

EELGRASS TRANSPLANTATION
Creation of eelgrass meadows by transplanting.

MARSH CREATION
Construction of marsh habitat by planting emergent aquatic vegetation or excavating channels into upland areas.



These findings reflect the problems Puget Sound agencies have experienced in measuring the success of mitigation projects. Objective evaluations depend on clearly defined environmental goals and performance standards, and these are the elements most often missing from plans. In addition, the lack of standardized monitoring protocols hinders interpretation of collected data, as does the lack of interagency coordination in tracking projects.

A development project for the Port of Tacoma illustrates some of the techniques and problems encountered in the use of compensatory mitigation. In this case, port officials needed to fill in a portion of wetland that serves a critical habitat for the prey of juvenile salmon. To mitigate the effects of this habitat loss, they created a six-acre marsh about half a mile upstream on the Puyallup River by excavating and contouring existing upland areas, connecting the modified area to the Puyallup River, and planting some 50,000 shoots of a hardy marsh plant called Lyngby's sedge. Monitoring after a year showed that:

- the density of Lyngby's sedge had increased by 400 percent.
- other species of marsh grasses were establishing themselves among the Lyngby's sedge;
- densities of invertebrates important as salmon prey had increased substantially;
- juveniles of four different salmon species were remaining in the marsh for several days to feed on the increased prey; and
- other species of fish were also using the marsh.

These data seemed to indicate that the marsh was largely successful in the first year, although an unforeseen problem arose. Sedimentation in the Puyallup River was so high that dredged channels were filling in rapidly, with some channels losing a foot of depth during the year. To correct the problem, these channels are being modified to reduce the effects of sedimentation.

Lessons Learned

The projects in Puget Sound have demonstrated the need for thorough planning. While developers have cooperated well in developing work plans and monitoring plans, the effectiveness of mitigation projects conducted so far is clouded by the lack of clear environmental goals and performance standards. At a minimum, mitigation plans should include baseline data, environmental goals, work plans, performance standards, monitoring plans, contingency plans, and performance bonds.

More importantly, the Puget Sound experience shows the need for tight interagency coordination. Mitigation projects typically involve multiple agencies, each concerned with slightly different issues. Unless they agree at the outset on the basic goals mitigation is expected to achieve, project oversight is fragmented and serious concerns get lost between the cracks. Such agreement could also help establish common, interagency criteria to specify feasible mitigation plans, and the inclusion of such criteria in each permit. Agencies could also agree to standardized monitoring protocols and project tracking systems.

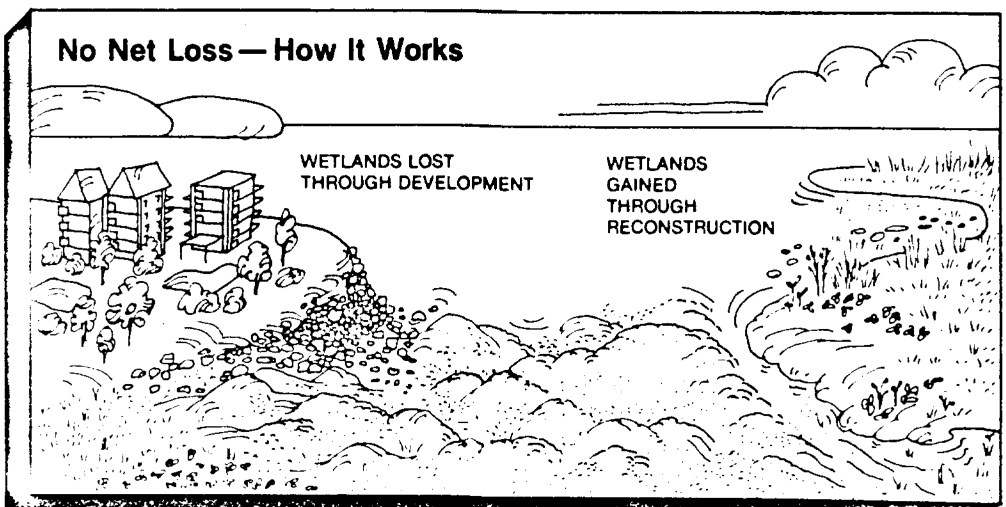
Several other lessons have emerged from the Puget Sound projects, including:

- the value of preapplication meetings in identifying and resolving potential issues at an early stage;
- the recognition that, while the goal of "no net loss of in-kind habitats" is desirable, in practice, it requires a greater than one-to-one replacement ratio; and
- the value of locating mitigation projects as near as possible to the original habitat site.

But the most important lesson from the Puget Sound experience is that compensatory mitigation is not a panacea. Strict replacement is extremely difficult to achieve, and most mitigation plans seek simply to maintain fish and wildlife habitat, rather than to replace the full spectrum of wetlands values.

Compensatory mitigation may prove to be a promising management tool in Puget Sound for protecting critical habitats, but the success of mitigation techniques have yet to be proven.

For further information, contact Kirvil Skinnarland, Puget Sound Water Quality Authority, Seattle, WA; or Michael Rylko, US EPA, Seattle, WA; or Mark Alderson, US EPA, Washington, DC.



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EPA

United States Environmental Protection Agency

Office of Water

National Estuary Program

Special Area Management Plan for Salt Pond Protection

Water quality and resource protection through local planning

RHODE ISLAND

Characteristics

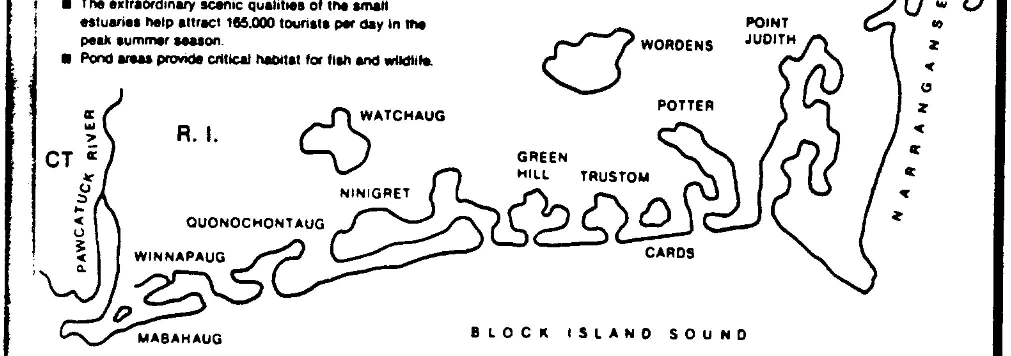
- Nine shallow coastal lagoons are of widely varying size
- A 38 square mile area is included in narrow pond watershed region.
- Land usage as of 1987 includes: wetland, 9 percent; private open land, 45 percent; public open space, 11 percent; developed area, 25 percent; agricultural area, 7 percent; other, 3 percent.

Resources

- The ponds serve as spawning grounds and nurseries for flounder, oysters, scallops, and clams.
- The extraordinary scenic qualities of the small estuaries help attract 165,000 tourists per day in the peak summer season.
- Pond areas provide critical habitat for fish and wildlife.

Issues

- Population is projected to quadruple by the year 2000 unless restrictive zoning is imposed.
- Groundwater contamination from septic systems causes seasonal algae blooms and threatens potable water quality.
- Bacterial contamination has curtailed shellfishing.
- Construction of permanent breachways in larger ponds has changed the salinity regimes.
- Erosion, coupled with misguided development, are endangering existing buildings and natural habitat.



Introduction

Local efforts to protect Rhode Island's ecologically important salt pond region have led to a unique planning partnership among the state's Coastal Resources Management Council, a number of local governments, the University of Rhode Island's Coastal Resources Center, and active citizen groups. This partnership has brought together the technical expertise and local implementation necessary to protect the water quality, habitat, and aquatic resources of a vulnerable coastal lagoon system.

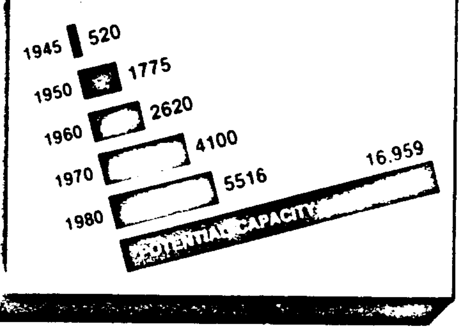
Overview of Salt Pond Characteristics and Problems

Known locally as Salt Ponds, Rhode Island's nine coastal lagoons are separated from the ocean only by a narrow strip of inlet-pierced barrier islands. The ponds have long supported commercial and recreational fisheries, and their associated wetlands provide critical habitat for waterfowl and aquatic species. The area also supports a major tourist industry based on recreational boating, swimming, and canoeing, and its attractive small fishing villages, farms, and old summer colonies have made it the state's most rapidly developing region. This rapid development, however, has brought with it problems that threaten to degrade the environmental quality of the salt ponds, including problems such as groundwater contamination, algae blooms, bacterial contamination of shellfish beds, sedimentation, and changes in fish and shellfish populations.

Developing a Management Initiative for the Salt Ponds

Local concerns were already aroused as the condition of the Salt Ponds worsened. In 1980, however, the

Number of Households in Salt Ponds Area IN THOUSANDS



Coastal Resources Center at the University of Rhode Island published an ecological history of the ponds that traced three centuries of pond use and abuse. The resulting outcry spurred a major research effort at the University of Rhode Island to determine the ecological health of the ponds, assess causes of problems, and determine trends in siltation, aquatic resources, and water quality.

The research verified that human activities were causing much of the ecological degradation in the Salt Ponds. Septic systems located in unsuitable sandy soils were often overloaded or malfunctioning, contaminating groundwater with bacteria and high nitrogen levels. This groundwater was entering the Salt Ponds, where it harmed shellfish habitat, promoted algae blooms, and depleted oxygen in the water. Excess nitrogen also was entering the pond system from fertilizers, stormwater runoff, and animal wastes. In addition, shore breachways had upset estuarine ecology by accelerating sedimentation and altering the circulation patterns and salinity mixtures important to key fish and shellfish species.

These findings clearly called for a broad, ecosystem approach to problem management. Under the auspices of Rhode Island's Coastal Zone Management and Sea Grant programs (both funded through the National Oceanographic and Atmospheric Administration), the Coastal Resources Center convened a Salt Pond Advisory Committee to help develop a Special Area Management (SAM) plan for the ponds. (SAM plans are developed under the Coastal Zone Management Program to provide special protection for designated geographic areas.) Members of the committee included representatives of state agencies, area towns, and local citizen groups who jointly developed and recommended a plan for addressing pond problems. Key issues addressed by the plan included water quality protection, breachway management and sediment controls, fisheries productivity, storm hazards, and land use. The plan also called for a comprehensive approach to management and decisionmaking by requiring that proposals for major developments be reviewed jointly and early on by all concerned local, state, and federal agencies.

After a series of public meetings , Rhode Island adopted the plan in 1984 for implementation by the state's Coastal Resources Management Council. At that point, the Salt Ponds Advisory Committee was replaced by an Action Committee of state agency staff and appointed members from each town. The committee complements the state's regulatory authority by developing nonregulatory initiatives and management strategies, as well as by providing an educational forum for the SAM plan.

The committee has also generated public interest and support for protective actions. The "Pondwatchers" citizen monitoring program, for example, has trained more than 40 volunteers to scientifically monitor water quality conditions in the ponds. Their findings have been used to complement the state's monitoring efforts, detect illegal outfalls, and support decisions on zoning, wastewater management, and shellfish bed closures. Publicized pondwatcher events have built support for the Salt Ponds, and the volunteers themselves have become strong advocates of resource protection initiatives.

The Pondwatchers

Program

- Over 40 trained volunteers monitor water quality conditions in seven ponds every other week from spring through mid-autumn.
- Citizens learn scientifically valid techniques of field sampling and analysis.
- A quarterly newsletter distributed to volunteers summarizes sampling results and tracks pertinent issues.

Outcome

- Pondwatchers have consistently obtained credible water quality data.
- Results have supported local wastewater management and zoning decisions and State policy decisions regarding shellfishing closures and resource management.
- Sampling stations and collection schedules complement State Department of Environmental Management's monitoring efforts, which are severely limited by budget and personnel constraints. At Department's request, Pondwatchers have expanded monitoring efforts to detect illegal outfalls to Salt Ponds. The State is considering a similar volunteer monitoring program for freshwater lakes and reservoirs around the State.
- Frequent press coverage of Pondwatchers' events in the Salt Pond region help build support for the Salt Ponds.
- Associations of Pondwatchers have become vocal advocates of resource protection initiatives.

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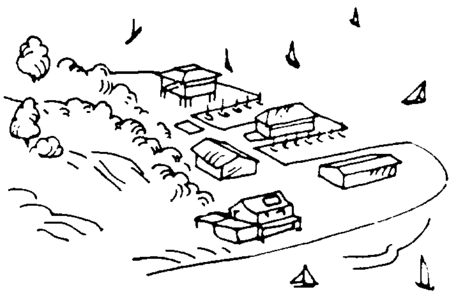
Special Area Management Plan Features

Water Quality Protection

- Development of a coordinated permit procedure among management authorities designed to address flaws in the fragmented permitting process and promote consistent, timely agency responses based on a holistic ecosystem evaluation format.
- Use of land use classifications, density controls, and buffer strips to protect groundwater sources and critical areas.
- Strict limitations on extending infrastructure services such as public water and sewer service into undeveloped areas. Extensions are encouraged in overdeveloped sections.
- Use of denitrification units as part of a septic system maintenance, pumping, and upgrading program.
- Controls on pollution from point sources of runoff using drainage swales, and from petroleum storage tanks and offshore oil spills.
- Installation of sewage pump-out facilities at marinas.

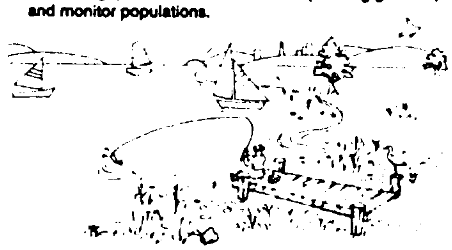


Breachway Management and Sedimentation Controls

- Specific restrictions on navigational dredging and inlet stabilization in designated pond areas, and on dredged material disposal.
- Delineation of compatible improvements to pond facilities.
- Remedial dredging to restore beneficial water circulation and flow conditions; installation of sediment catch basins and tidal gates.

Fish and Fisheries

- Appointment of fisheries stewards for the ponds.
- Establishment of management measures to prevent overfishing, protect brood stocks and spawning grounds, and monitor populations.



Intensifying Use

- Expansion of public access to beaches, boat launches, and recreational fishing areas; expansion of parks and campgrounds.
- Protection of open space and agricultural resources.
- Preservation and promotion of historic sites.

Storm Hazards

- Establishment of strict construction standards in floodzones, including special reconstruction provisions in areas susceptible to flooding.
- Restrictions on filling, removing, grading or restoration of shoreline features.
- Preparation of a regional post-storm restoration plan.

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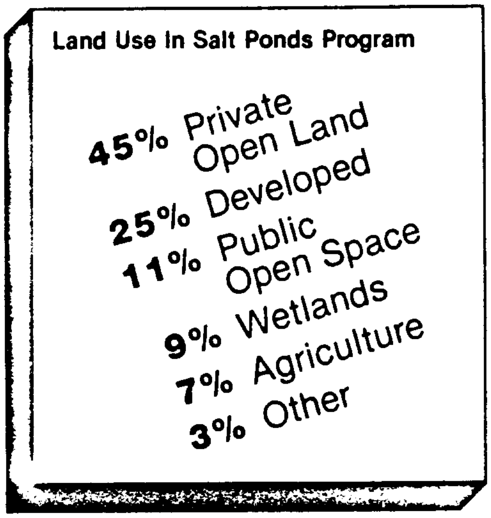


Responsible Authorities and Financing

Funding for research and public education has come primarily through Rhode Island's Sea Grant and Coastal Resources Management programs; implementation of SAM recommendations is supported by the towns and by pass-through funds from the Coastal Resources Management Council.

Results

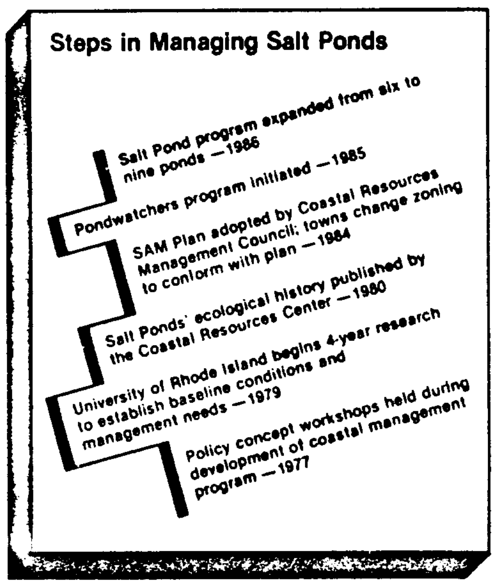
The SAM plan approach—targeting a specific geographic area for comprehensive planning and providing technical expertise for local decision-makers—is providing an effective framework for protecting the Salt Ponds from inappropriate development. Plan implementation has led to a coordinated review process for proposed development and has supported major initiatives to control runoff and upgrade local septic systems. Other protections introduced by the SAM plan include land-use controls such as limits on new public water/sewer service in undeveloped areas and buffer strips to protect groundwater sources and critical areas; breachway management such as restrictions on navigational dredging and disposal and restoration of pond circulation and flow conditions; fisheries management measures such as fishing limits and brood stock and spawning protections; and storm damage controls such as beachfront construction standards and building limitations.

Equally important, the plan has forged promising institutional links between technical experts and local decisionmakers.

Lessons Learned

The Salt Ponds SAM plan works because the causes, effects, and sources of pollution are clearly identified, and its goals well defined and based on an ecosystem management approach. The implementation of the SAM plan has shown that a partnership of local officials, technical experts, and citizens can effectively address difficult issues of resource use and development. It has also demonstrated that local officials can benefit from and use scientific information in the process of making environmental decisions. Finally, the Salt Ponds experience shows that a strong public participation and educational effort helps establish the firm local support and commitment needed to carry out the plan.

Remaining issues to be resolved include ensuring adequate financial support and consistent local support for appropriate planning, permitting, and enforcement.



For further information, contact Grover Fugate of the Coastal Resources Management Council, Wakefield, RI; or Virginia Lee of the Coastal Resources Center, University of Rhode Island, Narragansett, RI; and Mark Alderson, Project Manager, EPA, 401 M Street S.W., Washington, DC 20460

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COASTAL NONPOINT POLLUTION CONTROL PROGRAM

Program Development and Approval Guidance

January 1993

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FOREWORD

As part of the Coastal Zone Act Reauthorization Amendments of 1990, Congress enacted a new Section 6217 entitled "Protecting Coastal Waters". This provision requires states with coastal zone management programs that have received Federal approval under section 306 of the Coastal Zone Management Act (CZMA), to develop and implement Coastal Nonpoint Pollution Control Programs. These coastal nonpoint programs are to be used to control sources of nonpoint pollution which impact coastal water quality.

Section 6217 requires coastal states to submit their coastal nonpoint programs to the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA) for approval. Failure to submit an approvable program will result in a state losing a portion of its Federal funding under section 306 of the CZMA and section 319 of the Clean Water Act.

This document, developed by NOAA and EPA, contains guidance for states in developing and implementing their coastal nonpoint programs. It describes the requirements that must be met, including: the geographic scope of the program; the pollutant sources to be addressed; the types of management measures used; the establishment of critical areas; technical assistance, public participation, and administrative coordination; and, the process for program submission and Federal approval. The document also contains the criteria by which NOAA and EPA will review the states' submissions.

This document should be used in conjunction with the Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters published by EPA in January 1993. Copies of that document can be obtained from EPA, 401 M ST, SW, Washington D.C. 20460.

Trudy Coxe
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EXECUTIVE SUMMARY

This document is the National Oceanic and Atmospheric Administration's (NOAA) and the Environmental Protection Agency's (EPA) *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance* for state Coastal Nonpoint Pollution Control Programs (coastal nonpoint programs) developed under section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). This document should be read in conjunction with EPA's *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, which is discussed below.

Section 6217 requires states to establish coastal nonpoint programs, which must be approved by both NOAA and EPA. Once approved, the coastal nonpoint programs will be implemented through changes to the state nonpoint source pollution program approved by EPA under section 319 of the Clean Water Act (CWA) and through changes to the state coastal zone management program approved by NOAA under section 306 of the Coastal Zone Management Act (CZMA). Beginning in fiscal year 1996, states that fail to submit an approvable coastal nonpoint program to NOAA and EPA face statutory reductions in Federal funds awarded under both section 306 of the CZMA and section 319 of the CWA.

The statute and legislative history indicate that the central purpose of section 6217 is to strengthen the links between Federal and state coastal zone management and water quality programs in order to enhance state and local efforts to manage land use activities that degrade coastal waters and coastal habitats. This is to be accomplished primarily through the implementation of: (1) management measures in conformity with guidance published by EPA under section 6217(g) of CZARA, and (2) additional state-developed management measures as necessary to achieve and maintain applicable water quality standards.

This Program Development and Approval Guidance sets forth NOAA's and EPA's interpretation of the statutory requirements for the state coastal nonpoint programs, and is intended to assist states in developing approvable programs. The document first provides an overview of the legislative goals and requirements of section 6217. It then provides a description of the criteria that NOAA and EPA will use when reviewing coastal nonpoint programs for approval based on NOAA's and EPA's interpretation of CZARA's requirements. Finally, it discusses the program approval process established by NOAA and EPA. A decision by NOAA and EPA to approve or disapprove a state's program will be made on the basis of the applicable laws and regulations as applied to the specific facts presented by the program.

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The following is a summary of the requirements for state coastal nonpoint programs.

6217(g) Guidance Management Measures and Additional Management Measures

The statute requires state programs to provide for the implementation of management measures in conformity with EPA's (g) guidance and for additional management measures for land uses and critical coastal areas adjacent to impaired or threatened coastal waters. Implementation of these additional management measures in combination with the basic (g) management measures must be designed so as to attain and maintain applicable water quality standards under section 303 of the CWA including protecting designated uses. (Section 6217(b)(1) and (2)).

In order to meet these requirements, states will need to include the following elements in their coastal nonpoint programs.

6217(g) Guidance Management Measures

- An identification of those nonpoint source categories and subcategories that impact coastal waters for which applicable (g) guidance management measures will be implemented. States must include a description of and justification for any exclusions from (g) guidance measures. These exclusions are limited to sources within a category (e.g., agriculture) or subcategory (e.g., confined animal facilities) which, individually or cumulatively, do not significantly impact coastal waters.

- A description of the (g) guidance management measures to be implemented, and the technical documentation for any alternative measures selected by the state for implementation in lieu of those in the (g) guidance.

- A description of the procedures that the state will use to ensure implementation of the management measures, including operation and maintenance practices, inspection procedures, certification procedures, and monitoring.

Additional Management Measures

- An identification of land uses and critical coastal areas that will require additional management measures.

- A description of state-developed additional management measures to be implemented to meet water quality standards and protect designated uses.

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Implementation of All Management Measures

- A description of a state program that ensures implementation of both the (g) guidance management measures and the additional management measures, including: designation of a lead state agency for each source category and/or subcategory, a description of the legal authorities to implement the management measures (i.e., enforceable policies and mechanisms), and a description of how the lead agency will implement the program.

- A schedule for full implementation of the (g) guidance management measures within three years of Federal approval and full implementation of additional management measures within eight years of Federal approval. The latter includes a two year period for evaluating the implementation of the (g) measures, and three years to implement the necessary additional measures. New activities will be subject to the applicable management measure requirements at the time of Federal approval.

6217 Management Area and Coastal Zone Boundary Modification

The statute requires each state to include a proposal to modify its coastal zone boundary as the coastal management agency deems necessary to implement NOAA's boundary recommendation.

NOAA has conducted its initial review of each state's coastal boundary. Based on this review, NOAA will make its recommendation to the states on the area to be included in the coastal nonpoint program (i.e., the section 6217 management area) in early 1993. NOAA and EPA expect that states will respond either by modifying the coastal zone boundary to implement NOAA's recommendation or by identifying other authorities that exist or will be established, as necessary, to implement the coastal nonpoint program outside the state's current coastal zone boundary but within the 6217 management area.

Enforceable Policies and Mechanisms

Section 306(d)(16) of the CZMA requires state coastal zone management programs to contain enforceable policies and mechanisms to implement the applicable requirements of the coastal nonpoint programs.

In order to satisfy this requirement, states will need to adopt, at a minimum, enforceable policies and mechanisms to implement the (g) guidance management measures and the additional management measures. These enforceable policies and mechanisms may be state and local regulatory controls, and/or non-regulatory incentive programs combined with state enforcement authority.

Program Coordination

The statute requires the coastal nonpoint programs to be coordinated closely with existing Clean Water Act programs and with approved state coastal zone management plans. In addition, the statute requires the establishment of coordination mechanisms among state agencies and between state and local officials responsible for land use programs and permitting, water quality permitting and enforcement, habitat protection, and public health and safety.

NOAA and EPA expect state coastal nonpoint programs to be well coordinated with all relevant Federal, state and local programs including those administered by EPA, NOAA and U.S. Department of Agriculture (USDA). In addition, states should establish mechanisms to coordinate the relevant state and local programs through joint project reviews, memoranda of agreement, or other mechanisms. Where possible, these mechanisms should build upon existing coordination procedures.

Technical Assistance

The statute requires states to provide technical and other assistance to local governments and the public for implementing the additional management measures.

NOAA and EPA expect states to identify those portions of the coastal nonpoint programs that are to be implemented by local governments and to include a program to provide technical and other assistance to local governments and the public in the state coastal nonpoint program.

Public Participation

The statute requires states to provide opportunities for public participation in all aspects of the coastal nonpoint program.

NOAA and EPA expect that the public will be involved early in the process of developing the coastal nonpoint program. The state must also provide an opportunity for public comment on the final coastal nonpoint program prior to submission of the program to NOAA and EPA, and an opportunity to participate in the implementation of the program.

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Program Submission and Approval

States must submit their coastal nonpoint programs to NOAA and EPA for approval within 30 months of the publication of final management measures guidance (i.e., July 1995). When a state coastal nonpoint program receives final Federal approval, it will be incorporated automatically into the state's coastal management and nonpoint programs. NOAA and EPA have established a voluntary threshold review process to assist states in the development of their programs.

Federal Support for State Coastal Nonpoint Programs

NOAA is authorized under section 6217(f) of CZARA to provide funds to state coastal management agencies to develop coastal nonpoint programs. In addition, funds may be available under section 319 of the CWA to implement coastal nonpoint programs. NOAA and EPA will also work with the states to identify other sources of funds to develop and implement the state programs.

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PROGRAM DEVELOPMENT AND APPROVAL GUIDANCE

I. PURPOSE AND INTRODUCTION

Water quality remains one of the most important environmental problems facing the United States. In coastal areas, beach closures, prohibitions on harvesting shellfish, and loss of biological productivity in coastal habitats are evidence of water quality impairment. Based on an assessment of 75% of United States estuarine waters, current best estimates are that 35% of these waters are impaired and 10% are threatened.

Coastal waters are affected by both point and nonpoint sources of pollution, with the latter a significant and, in many cases, the dominant form of pollution in a given water body. While great strides in controlling point sources of pollution have been made since the passage of the Federal Water Pollution Control Act in 1972, nonpoint source pollution remains a major problem in many coastal areas. The leading nonpoint contributors to estuarine waters are urban runoff (including certain construction activities and onsite disposal systems) and agriculture. Other significant nonpoint contributors in some coastal watersheds include silviculture, marinas, and hydromodification. In addition, the loss and degradation of wetlands and riparian areas has adversely impacted coastal water quality.

Congress enacted section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) in November 1990 to help address the problem of nonpoint source pollution in coastal waters.[1] (A copy of this statute is found in Appendix A.) Section 6217 requires that coastal states with federally approved coastal management programs develop Coastal Nonpoint Pollution Control Programs (hereafter, coastal nonpoint programs).[2] The legislative history indicates that the central purpose of section 6217 is to strengthen the links between Federal and state coastal zone management and water quality programs in order to enhance state and local efforts to manage land use activities that degrade coastal waters and coastal habitats.[3] The state coastal zone management agency designated under section 306 of the Coastal Zone Management Act (CZMA) and nonpoint source management agency designated under section 319 of the Clean Water Act (CWA) will have a dual and co-equal role and responsibility in developing and implementing the coastal nonpoint program.

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[1] Section 6217 does not amend the CWA or the CZMA, but rather contains independent provisions.

[2] The term "state" refers to states, territories and commonwealths having coastal management programs approved under section 306 of the Coastal Zone Management Act.

[3] As defined in section 304 (10) of CZARA and used in this guidance, "land use" includes water uses.

Although nonpoint source pollution is a significant source of pollution in coastal waters, the legislative history states that "the new program will not and ought not bear the full burden of restoring and maintaining coastal water quality, but will operate instead in conjunction with controls on point sources established under the Clean Water Act and associated programs." Therefore, state coastal nonpoint programs under section 6217 are required only to address nonpoint source pollution, and are expected to address, at a minimum, the major sources of nonpoint pollution specified in the (g) guidance.[4]

Thus, a state does not need to provide in its coastal nonpoint program for the implementation of the management measures developed by EPA under section 6217(g) of CZARA for activities that are clearly regulated as point source discharges.[5] However, in the interest of consistency and comprehensiveness, each state may choose to apply the (g) management measures to both point and nonpoint sources throughout the state's section 6217 management area, as long as the specific NPDES requirements are also met for those sources subject to NPDES permitting requirements.

Section 6217 envisions a two-tiered management approach for the control of nonpoint sources of pollution. To receive Federal approval, the state coastal nonpoint program must ensure: (1) the implementation, at a minimum, of management measures in conformity with the guidance developed under section 6217(g) by EPA, in consultation with NOAA and other Federal agencies, to protect coastal waters generally, and (2) the implementation of additional management measures applicable to land and water uses and critical coastal areas identified by the state pursuant to section 6217(b)(1) and (2) so as to attain and maintain applicable water quality standards under section 303 of the CWA and to protect designated uses.[6]

The purpose of the first tier is to protect coastal waters generally, and therefore, is not tied to specific water quality problems. The state must provide for the implementation

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4 Historically, there have been overlaps and ambiguities among programs addressing nonpoint and point sources of pollution. Some of these overlaps, such as those which occur with the National Pollution Discharge Elimination System (NPDES) stormwater permit program (under section 402(p) of the CWA), are discussed in more detail in Appendix B. Many of the techniques and practices used to control point sources, such as channelized urban stormwater, are equally applicable to nonpoint sources, and vice versa. Nevertheless, the programs do not have identical requirements. Certain NPDES requirements may go beyond the management measures specified in the (g) guidance.

5 For simplicity, the guidance containing these management measures, which was published by EPA in January, 1993, will be referred to as the "(g) guidance" in this document. A list of the management measures included in this guidance is provided as Appendix C.

6 In addition to addressing the contribution of pollution through runoff from the land, the state coastal nonpoint program should also consider the infiltration of pollutants into ground water which can result in the pollution of surface waters.

of these management measures in conformity with the (g) guidance which includes management measures for the following categories of nonpoint pollution sources: agricultural runoff; urban runoff; silvicultural runoff; hydromodification, shoreline erosion, and dams; and marinas. In addition, the (g) guidance includes management measures for wetlands protection, riparian areas, and vegetated filter strips, which are effective for several different source categories.

If the general level of protection provided by the first management tier is insufficient to enable coastal waters to meet water quality standards and protect designated uses, then the state must implement the second tier which consists of additional management measures. The purpose of the second tier is to restore coastal waters and, in the case of the critical areas, to protect against future pollution problems.

This document, developed by the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA), contains guidance for developing and implementing coastal nonpoint programs. The first section of this guidance introduces the coastal nonpoint program. The second section provides an overview of the statute's requirements. The third section discusses the specific program requirements, including requirements for coordination with other programs; the geographic scope of the coastal nonpoint program and coastal zone boundary review; implementation of management measures in conformity with EPA's (g) guidance and additional state-developed management measures; technical assistance; public participation; administrative coordination; and enforceable policies and mechanisms. The final section describes EPA's and NOAA's process for review and approval of coastal nonpoint programs submitted by the states, and the schedule for state implementation of the program.

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II. OVERVIEW OF STATUTORY REQUIREMENTS AND PROGRAM APPROVAL PROCESS

Congress enacted CZARA section 6217, entitled "Protecting Coastal Waters," to address the impacts of nonpoint source pollution on coastal water quality.[7] Section 6217(a) requires each state with a federally approved coastal zone management program under section 306 of the CZMA to develop and submit to NOAA and EPA a coastal nonpoint program for approval. The statute states that the purpose of this new state program "shall be to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities."

NOAA and EPA do not expect states to develop and implement stand-alone coastal nonpoint programs, but rather expect that states will develop and implement the coastal nonpoint program through changes to the approved state nonpoint source management program and to the approved state coastal zone management program developed under section 306 of the CZMA, as amended.

All states and territories have EPA-approved nonpoint source management programs or portions of programs and are currently receiving section 319 grants to assist them in implementing the approved programs. Currently, there are 29 federally approved state and territorial coastal zone management programs developed and approved pursuant to the CZMA (see Appendix D).

II.A. Statutory Requirements

Under section 6217, coastal nonpoint programs must contain a number of elements in order to be approvable by NOAA and EPA. The state programs must:

1. be closely coordinated with existing state and local water quality plans and programs developed pursuant to sections 208, 303, 319 and 320 of the CWA, and with state coastal zone management programs.

2. provide for the implementation, at a minimum, of management measures in conformity with the guidance published under section 6217(g) to protect coastal waters generally (discussed in section II.B).

3. provide for the implementation and continuing revision from time to time of additional management measures that are necessary to attain and maintain applicable water quality standards and protect designated uses with respect to:

[7] This section has been codified at 16 U.S.C. § 1455b.

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a. land uses which, individually or cumulatively, may cause or contribute significantly to a degradation of (a) coastal waters not presently attaining or maintaining applicable water quality standards or protecting designated uses, or (b) coastal waters that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources; and

b. critical coastal areas adjacent to coastal waters which are failing to attain or maintain water quality standards or which are threatened by reasonably foreseeable increases in pollution loadings.

4. provide for technical and other assistance to local governments and the public to implement additional management measures.

5. provide opportunities for public participation in all aspects of the program.

6. establish mechanisms to improve coordination among state agencies and between state and local officials responsible for land use programs and permitting, water quality permitting and enforcement, habitat protection, and public health and safety.

7. propose to modify state coastal zone boundaries as the state determines is necessary to implement NOAA recommendations under section 6217(e), which are based on findings that modifications to the inland boundary of a state coastal zone are necessary to more effectively manage land and water uses to protect coastal waters.

This guidance discusses these requirements in greater detail in section III and explains NOAA's and EPA's expectations for state coastal nonpoint programs.

In addition to the provisions of section 6217, CZARA amended section 306 of the CZMA to require that, before approving a coastal zone management program submitted by a coastal state, NOAA shall find that, "...the management program contains enforceable policies and mechanisms to implement the applicable requirements of the Coastal Nonpoint Pollution Control Program of the State required by section 6217...." (section 306(d)(16)). States with federally approved coastal management programs must demonstrate compliance with section 306(d)(16) in order to receive final approval of their coastal nonpoint programs.

The statute requires that states submit their coastal nonpoint programs to NOAA and EPA 30 months after EPA publishes final (g) guidance. The final (g) guidance was published in January 1993; therefore, coastal states must submit their coastal nonpoint programs to NOAA and EPA for approval in July 1995.

II.B. Section 6217(g) Management Measures Guidance

Section 6217(g) requires that EPA, in consultation with NOAA, the U.S. Fish and Wildlife Service, and other Federal agencies publish "guidance for specifying management measures for sources of nonpoint pollution in coastal waters." Management measures are defined in section 6217(g)(5) as:

> "*economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.*"

As provided by section 6217(g)(2), the management measures guidance includes:

> (A) "a description of a range of methods, measures, or practices, including structural and nonstructural controls and operation and maintenance procedures, that constitute each measure;
>
> (B) a description of the categories and subcategories of activities and locations for which each measure may be suitable;
>
> (C) an identification of the individual pollutants or categories or classes of pollutants that may be controlled by the measures and the water quality effects of the measures;
>
> (D) quantitative estimates of the pollution reduction effects and costs of the measures;
>
> (E) a description of the factors which should be taken into account in adapting the measures to specific sites or locations; and
>
> (F) any necessary monitoring techniques to accompany the measures to assess over time the success of the measures in reducing pollution loads and improving water quality."

The (g) guidance provides a basis for the state coastal nonpoint programs.

II.C. Procedures for Program Development and Approval

NOAA and EPA have prepared this program development and approval guidance to assist states in developing approvable coastal nonpoint programs. The states are encouraged to consult with NOAA and EPA as they develop specific program elements. NOAA and EPA have established a voluntary threshold review process to assist states in the development of their programs. This process is discussed in more detail in section IV.B.

NOAA and EPA will jointly review the state program within six months after submission. Because of the inseparable nature of the land use and water quality portions of the coastal nonpoint programs in achieving the statutory goals, NOAA and EPA have determined as a matter of policy that neither agency will grant approval to a state's coastal nonpoint program until the program meets the Federal approval requirements as determined by both agencies.

If a coastal state fails to submit an approvable program within 30 months after publication of the (g) guidance, NOAA and EPA will reduce Federal grant dollars to the state under the coastal zone management and nonpoint source management programs as required by section 6217(c)(3) and (4). The penalty provisions begin in Fiscal Year 1996 with a 10% reduction in funding under both programs, increasing to 15% in FY 1997, 20% in FY 1998, and 30% in FY 1999 and each fiscal year thereafter. In the case of the coastal zone management program, the penalty is based upon the grants otherwise available to a state in the current fiscal year. In the case of the section 319 nonpoint source management program, the penalty is based on the grant amount awarded to the state for the preceding fiscal year.

Under certain limited circumstances, a state may request a conditional approval of its coastal nonpoint program. If a state is granted conditional approval of its program, the penalty provisions of section 6217 will be suspended during the conditional approval period if the state continues to make progress on the workplan and to meet the milestones agreed to with NOAA and EPA as part of the conditional approval. (See discussion of conditional approval in section IV.C.)

II.D. Federal Support for State Coastal Nonpoint Programs

NOAA is authorized under section 6217(f) of the CZARA to provide funds to the designated state coastal management agency to develop its coastal nonpoint program. The Federal funds may not exceed 50% of the cost of developing the program, and the state share of costs must be paid from non-Federal sources. NOAA has published separate guidance on application procedures and allocations. Since funds will be limited, state coastal agencies are encouraged to work closely with state nonpoint source agencies and other appropriate Federal, state, regional and local agencies to develop their coastal nonpoint programs. Funds under section 319(h) of the CWA are available for program implementation.

NOAA and EPA will consider using additional financial incentives and/or disincentives to encourage states to develop effective coastal nonpoint programs within the statutory deadline.

III. SPECIFIC COASTAL NONPOINT PROGRAM REQUIREMENTS

State coastal nonpoint pollution programs must contain a number of components mandated by section 6217. The following section discusses these statutory requirements and the minimum criteria that the state coastal nonpoint program needs to meet to obtain Federal approval.

III.A. Coordination with Existing State Programs

The statute requires that state coastal nonpoint programs be closely coordinated with state and local water quality plans and programs under sections 208, 303, 319, and 320 of the CWA, and with state coastal zone programs. (Section 6217(a)(2)). Some of these programs are discussed in Appendix E. This requirement is necessary to ensure that the new coastal nonpoint program can be integrated into existing state programs upon approval.

During the program development process, NOAA and EPA expect state coastal zone management and nonpoint source agencies to involve the relevant Federal, state, regional and local programs. A number of states already closely coordinate the activities of these programs through their existing coastal zone management and state nonpoint programs. States should develop their coastal nonpoint programs to complement and strengthen existing coastal management and nonpoint source authorities, while minimizing unnecessary duplication or conflicts at the Federal, state or local levels. Components of existing programs that meet the requirements of section 6217 should be incorporated into the states' coastal nonpoint programs.

III.B. Coastal Zone Boundaries and 6217 Management Area

As directed by section 6217(a), the geographic scope of each coastal nonpoint program must be sufficient to ensure implementation of management measures to "restore and protect coastal waters." Section 6217(e), which requires NOAA to conduct a review of each state's coastal zone boundary, refines the focus to require NOAA to determine the geographic area encompassing the land and water uses having a "significant" impact on a state's coastal waters. A significant impact can occur from both the individual and cumulative effects of land and water uses. NOAA and EPA will not approve a state coastal nonpoint program whose geographic scope does not encompass such uses because a program that does not control the significant land and water uses cannot be expected to "restore and protect coastal waters".

Section 6217(e) requires that NOAA, in consultation with EPA, review each state's existing state coastal zone boundary established under the CZMA, and recommend any modification to that boundary needed to effectively manage land and water uses to protect coastal waters. Specifically, the statute directs NOAA, in consultation with EPA, to evaluate whether each state coastal zone boundary extends inland to the extent necessary to control nonpoint source pollution from land and water uses that have a significant impact on a state's coastal waters. See section 6217(e)(1). If NOAA, in consultation with EPA, finds that boundary modifications are necessary for a state to more effectively manage land and water uses to protect coastal waters, then NOAA shall recommend appropriate modifications. See section 6217(e)(2).

Although expressed in terms of a recommendation that a state modify its coastal zone boundary, NOAA's recommendation also defines what NOAA and EPA believe should be the geographic scope of that state's coastal nonpoint program, i.e., "the 6217 management area". A state program need not adopt the exact 6217 management area recommended by NOAA if the state can demonstrate that a smaller geographic area would be adequate to restore and protect coastal waters. Absent such a demonstration, however, NOAA and EPA expect the geographic scope of the coastal nonpoint program to correspond to NOAA's recommendation.

To provide a basis for its recommendation, NOAA conducted a review of states' existing coastal zone boundaries and provided each state with an analysis of its boundary. In conducting this review, NOAA, in consultation with EPA, compared indicators of nonpoint source pollution potential within coastal zone boundaries, and within coastal watersheds. Coastal watersheds were selected because watersheds provide a logical physical unit when dealing with nonpoint source pollution. To provide a uniform framework for evaluation, the review was based on the national hydrologic unit classification system developed by the U.S. Geological Survey (USGS). For purposes of this review, coastal watersheds were defined as the USGS Cataloging Units adjacent to the shore and extending inland along estuaries to include the USGS Cataloging Units that encompass the head of tide.

Within each state, NOAA evaluated each watershed that drains into coastal waters, whether or not that watershed is encompassed within a state's existing coastal zone. Based on nationally available data, NOAA determined for each watershed whether significant indicators of nonpoint pollution potential were present within four analysis areas: (1) the existing coastal zone, (2) the coastal watershed, (3) the area inland of the coastal watershed within the state's borders, and (4) the area beyond the state borders that drain into coastal waters. NOAA has focused on significant indicators of nonpoint source pollution in compliance with section 6217(e) which directs NOAA to evaluate whether the coastal zone extends inland "to the extent necessary to control land and water uses that have a significant impact on coastal waters of the State." (Section 6217(e)(1)).

Based on the review of each coastal watershed, NOAA will develop a preliminary assessment of the appropriate geographic scope of the state's program, i.e., the 6217 management area, and will make a corresponding recommendation for modification to the state's coastal zone boundary. Where the coastal watershed appears to capture most of the significant indicators of nonpoint pollution potential, NOAA will recommend the coastal watershed as the 6217 management area. Where significant indicators of nonpoint source pollution are present inland of the coastal watershed, NOAA will recommend that the 6217 management area extend inland of the coastal watershed.[8]

Finally, in coastal watersheds where an area less than the coastal watershed captures most of the significant indicators of nonpoint source pollution, especially where the existing coastal boundary closely aligns with the coastal watershed, NOAA will recommend that lesser area as the 6217 management area. In no case will NOAA recommend an area less than the existing coastal zone as the 6217 management area.

The geographic scope of the coastal nonpoint program must be based on the impact of land and water uses on coastal waters. NOAA's boundary recommendation will specify a 6217 management area to guide states during program development.[9] In response to this recommendation, states are encouraged to undertake their own analysis of their coastal watersheds. At the time of program submission, a state may propose an alternative 6217 management area, in which case the state must demonstrate to NOAA's and EPA's satisfaction that the management area extends as far as necessary to control sources of nonpoint pollution that, individually or cumulatively, significantly impact the state's coastal waters. NOAA and EPA will evaluate the adequacy of the state's proposed 6217 management area as part of the program review and approval process. Specific criteria for this evaluation are being developed by NOAA and will be published separately.

A state is expected to demonstrate authority to manage the final 6217 management area in one of two ways. First, a state may demonstrate that its coastal zone boundary has been modified to encompass the entire 6217 management area. If the state coastal zone management agency lacks authority to modify the boundary, the coastal nonpoint program must contain recommendations to the appropriate state authority for changes to the coastal zone boundary. Because there is no assurance that the coastal zone boundary will be modified as proposed, NOAA and EPA also expect a state to demonstrate that it

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[8] The nature of the underlying data makes it infeasible for NOAA to recommend a specific distance beyond the coastal watershed. States will be expected to examine these watersheds during program development to analyze indicators of nonpoint pollution and to determine the inland extent of the 6217 management area.

[9] Section 6217(b)(7) requires that each state program contain a proposed or recommended coastal zone boundary modification as necessary to implement the NOAA recommendation.

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has the necessary authorities, including enforceable policies and mechanisms, to ensure implementation of the coastal nonpoint program within the 6217 management area.

Second, because the modification of a state's coastal zone boundary necessarily has other implications besides nonpoint source pollution control, a state may choose not to alter its coastal zone boundary. Areas outside the coastal zone, but within the 6217 management area, would be managed with other state authorities networked into the coastal nonpoint program. Although changing the coastal zone boundary to address NOAA's recommendation may be preferable because it would provide the clearest delineation of the geographic scope of the coastal nonpoint program, the statute does not make this a prerequisite for Federal approval. If the state's 6217 management area extends beyond the state's existing coastal zone boundary, the state must also show that it has the necessary authorities, including enforceable policies and mechanisms, to ensure the implementation of the program's management measures with the 6217 management area.[10]

III.C. Implementation of Management Measures In Conformity with Section 6217(g) Guidance

For program approval, each coastal nonpoint program must "provide for the implementation, at a minimum, of management measures in conformity with the guidance published under subsection (g), to protect coastal waters generally..."(section 6217(b)). In developing the (g) guidance, EPA focused on the significant categories and sources of nonpoint pollution identified in state section 319 nonpoint source assessments. The categories of nonpoint sources addressed in the (g) guidance are: agricultural runoff; urban runoff (including developing and developed areas); silvicultural (forestry) runoff; hydromodification, including shoreline erosion, and dams; and marinas. In addition, the (g) guidance includes management measures for wetlands protection, riparian areas and vegetated filter strips, which apply to a number of sources. A number of specific source subcategories are also discussed in detail in the (g) guidance.

In order to satisfy the statutory requirement to provide for implementation of management measures in conformity with the (g) guidance, state programs must:

1. Identify nonpoint source categories or subcategories that will be addressed;
2. Identify management measures to be implemented for those categories and subcategories; and,
3. Describe the process by which the state will ensure the implementation of the management measures.

[10] In addition, a state may choose to utilize a combination of the two approaches described above.

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These elements are discussed in more detail in the following sections.

In its coastal nonpoint program document, a state must respond to each of the (g) management measures by either: (1) providing for the implementation of that measure or an alternative as effective as the (g) measure; or (2) justifying why the management measure is not included in the program. This justification must be based on the exclusion of certain nonpoint categories or subcategories using the process described in section III.C.1.

III.C.1. Identification of sources to be addressed

For program approval, states must provide for the implementation of management measures for each of the nonpoint source categories (e.g., agriculture) and subcategories (e.g., confined animal facilities) identified in the (g) guidance to protect coastal waters generally. States must also provide for the implementation of management measures specified for wetlands and riparian area protection. In addition, a state may include management measures for sources not identified in the (g) guidance (e.g., mining operations not subject to permitting under section 402 of the CWA), if the state determines such management measures are necessary to protect coastal waters generally.

NOAA and EPA may allow a state to exclude some categories, subcategories or sources from the requirements of its coastal nonpoint program. An exclusion may occur under two scenarios: (1) if a nonpoint source category or subcategory is neither present nor reasonably anticipated in the 6217 management area, or (2) if a state can demonstrate that a category, subcategory or particular source of nonpoint pollution does not and is not reasonably expected to, individually or cumulatively, present significant adverse effects to living coastal resources or human health.

Under the first scenario, a state can exclude one or more nonpoint source categories or subcategories in coastal watersheds or parts of coastal watersheds. To do so, a state must clearly demonstrate that each of those nonpoint source categories or subcategories is neither present nor reasonably anticipated in such areas. If such a demonstration is made, the state need not develop and provide for the implementation of management measures for those nonpoint source categories or subcategories. For example, if a state does not have and does not foresee the establishment of an animal feeding operation in the 6217 management area, it need not develop a program to control such operations. It should be noted, however, that when the exclusion applies only to a portion of the area or a particular coastal watershed, the state must still provide for the implementation of the management measures in all other portions of the 6217 management area where the categories or subcategories are present or anticipated.

Under the second scenario, states may exclude certain sources within retained categories and subcategories. To do so, the state must adequately demonstrate that those sources, individually and cumulatively, do not and are not reasonably expected to present significant adverse effects to living coastal resources or human health. Factors that may be considered to exclude such sources include, but are not limited to:

- pollutant loadings or estimates of loadings from the sources;
- intensity of land use; and
- ecological and human health risk associated with the source.

In general, this second type of exclusion is designed to exclude sources that are present in the 6217 management area but that, individually or cumulatively, do not and are not reasonably expected to cause significant adverse effects to living coastal resources or human health. In determining the significance of adverse effects, states should consider both direct and indirect adverse effects. An example of a source that may be excluded under this approach could include an on-site disposal system located a considerable distance from surface coastal waters and above the groundwater table.

NOAA and EPA wish to emphasize the limited applicability of this second type of exclusion. For this reason, NOAA and EPA have expressly placed the burden upon the states to demonstrate that any excluded sources will not and are not reasonably expected to present adverse effects to living coastal resources or human health, and that the application of the (g) measures to the remaining sources will protect coastal waters generally.

For either type of exclusion, states must submit a description and documentation of the data and rationale relied upon for excluding the sources. The documentation should include information contained in existing state water quality assessments (including those developed under sections 305(b) and 319 of the CWA), other information sources listed in Section III.D., and existing data (or modelling results) that indicate the insignificance of the loadings or hydrologic impacts caused by sources that the state proposes to exclude.

EPA and NOAA will review the states' submissions, including the adequacy of the assessments, to determine whether the category or subcategory needs to be addressed by the coastal nonpoint program. The issue of assessment adequacy may be discussed through the threshold review process. In addition, NOAA and EPA will, at a state's request, consider proposed exclusions during the threshold review process discussed in section IV.B.

In the "Applicability" section of many management measures in the (g) guidance, EPA has already established minimum sizes below which the measures do not apply (e.g., marinas with less than 10 slips) based on economic achievability analysis. In such cases, state programs should address all sources above those minimum levels, except where a state can document, as described above, that a less stringent level in a particular geographic area will still allow protection of coastal waters generally.

It should be noted that sources excluded from the (g) measures implementation nevertheless may be subject to additional management measures discussed in section III.D.

III.C.2. Identification of management measures to be implemented

For program approval, states must specify the management measures that will be implemented to address each category or subcategory of sources identified through the process in section III.C.1 of this guidance document. Section 6217(b) requires state management measures to be in conformity with those measures specified in the (g) guidance. A state management measure is "in conformity with" those specified in the (g) guidance if it is identical to, or is demonstrated to be as effective as, the (g) guidance measures.

In order to accommodate variabilities relating to source, location and climate, or other local conditions that could affect the implementation of the (g) guidance management measures, the (g) guidance also lists a number of practices that can be used to implement each management measure. States have considerable flexibility in choosing management practices to achieve the management measures and are not restricted to specifying or implementing the practices described in the (g) guidance. The practices or system of practices chosen, however, must ensure the effective implementation of the management measures. For program approval, the coastal nonpoint program must describe the process the state will use to select practices that will result in the effective implementation of the (g) guidance management measures.

Selection of Alternative Management Measures

In developing management measures in conformity with the (g) guidance, states may select "alternative management measures" under two conditions: (1) states have conditions that make the 6217(g) measures inapplicable or unsuitable, or (2) other measures that equal or exceed the effectiveness of the 6217(g) measures already exist or are scheduled to be implemented under existing state laws or programs. The use of alternative management measures in these situations is supported not only by the statute, which acknowledges that the (g) measures may be adapted to specific sites or locations (section 6217(g)(2)(E)), but also by the legislative history which directs NOAA and EPA to accord states flexibility in selecting management measures.

States may use these alternative measures instead of the (g) measures in their coastal nonpoint programs only if they can demonstrate that such alternatives are as effective in controlling nonpoint pollution as the measures specified in the (g) guidance. For program approval, a state electing to specify an alternative management measure for implementation will need to demonstrate that the alternative is at least as effective as the (g) guidance management measure it intends to replace. States should use the best available information to make this showing.

Management measure effectiveness can be evaluated or described in many ways: pollutant loading, pollutant loading reductions, pollutant concentration in discharge, peak concentration reductions, mean concentration reductions, habitat impacts (including impacts resulting from changes in flow), impacts to fisheries, impacts to macroinvertebrates, wildlife impacts, effects on support of designated uses, direct impacts to the water resource of concern, the extent to which the source is actively managed, or other factors. States may use any combination of these factors to demonstrate the effectiveness of alternative management measures.

For approval of an alternative management measure, the state will need to demonstrate that the alternative management measure (or a combination of measures or a series of measures applied over time) is as effective as the measure set forth in the (g) guidance when applied in the specific state or local area. For example, when management measures in the (g) guidance specify certain storm events, design criteria or pollutant reduction levels, the alternative management measures must specify similar storm events, design criteria or pollutant reduction levels. In addition, the state will need to demonstrate that the operation and maintenance procedures for the alternative are feasible and adequate to maintain a level of pollution control as effective as the (g) guidance measure over the lifetime of the measure. In choosing an alternative management measure, states should take into account possible adverse impacts of these alternative measures on other coastal resources such as ground water or wetlands.

In support of its alternative management measure, a state will need to identify the procedures used to evaluate the measure and the results of that evaluation, and provide specific technical documentation of the evaluation as part of their coastal nonpoint programs. In general, information used to document that an alternative management measure is as effective as a (g) guidance measure should be comparable in scope and depth to that provided in EPA'S (g) guidance. States must support the evaluation of alternative management measures with appropriate technical documentation. Although sources such as "refereed" technical journals are preferred, other publications, such as Federal and state technical guides, are acceptable. Fliers, fact sheets, and other general public materials generally are not adequate sources of information without additional supporting information.

In addition, or as an alternative to relying on written studies, the state may wish to convene a technical review group consisting of experts knowledgeable in the subject area covered by the management measure. This may be especially useful where the state is interested in pursuing innovative approaches. The technical review group should provide a report describing the evaluation procedure that was used to assess the effectiveness of the alternative management measure. The report should be submitted to NOAA and EPA as part of the program review process. EPA and NOAA will, at the state's request, consider proposed alternative management measures during the threshold review process and/or approval process discussed in section IV.

Innovative Market-Oriented Incentive Mechanisms

EPA and NOAA are interested in encouraging states to propose innovative market-oriented incentive mechanisms to implement the (g) measures or alternative management measures at lower costs. An important example of incentive mechanisms that could serve to lower substantially the costs of obtaining a given level of loadings reductions is the trading of pollution reduction credits.

Trading programs are proving to be a successful and cost-effective approach under the Clean Air Act for reducing air pollutant emissions. Several case studies in North Carolina, Colorado, and Wisconsin show that the trading of pollution credits holds considerable promise for reducing water pollutant loadings as well, particularly nutrients. See Appendix H for short descriptions of these cases. Appendix H also presents several brief summaries of relevant technical publications. These publications indicate that pollutant trading programs may hold potential for achieving substantial cost savings while attaining pollution reductions equivalent to those established by the (g) measures guidance.

Conceptually, sources with low control costs would make trading arrangements directly with sources facing high control costs. The low-cost sources would undertake additional abatement efforts in exchange for financial compensation from the high-cost sources. Sources with higher abatement costs would undertake less control efforts, while acquiring additional reductions from other lower cost sources. Increased loadings from the high-cost sources would be offset by the additional abatement efforts of low-cost sources, so that the total loadings would be the same as if no trading occurred. In this manner, the private incentives of polluters would be harnessed for public purposes. Thus, more pollution abatement would be undertaken where it was cheapest, and less would be undertaken where it was costly, reducing the overall cost while achieving the same overall level of control. Such a trading scheme can minimize the total cost of achieving the required reduction in loadings.

EPA and NOAA encourage states to propose innovative approaches such as the theoretical case outlined above and as described in Appendix H. Any such proposal, of course, must be consistent with the requirements of CZARA. At a minimum, in order for EPA and NOAA to approve a market-based proposal as achieving implementation of particular (g) measures, states would need to demonstrate that the proposal would result in expected pollutant reductions equalling or exceeding those that otherwise would be achieved in the same watershed if each participant separately implemented the (g) measures. Finally, as with the implementation of any management measure, a trading program would also need to meet the requirements for enforceable policies and mechanisms described in section III.H.

States may consider trading schemes which involve trading of pollution credits among nonpoint and point sources as well as among nonpoint sources alone. States may also consider trading among sources inside and outside of the geographic area subject to the (g) measures guidance, as long as such sources are within the same watershed. States may also consider trading arrangements involving different pollutants (such as nutrients) with similar environmental effects, to the extent that the state demonstrates that any net environmental benefit is expected to result from the trading program. However, these trading schemes should take into account uncertainties such as those associated with measurements or predictions of pollutant loadings of a pollutant from the array of sources involved. States should consider whether trading ratios should be established to account for such uncertainties.

The likelihood of success of trading programs can be increased if states carefully define the responsibilities of sources involved. Trading programs should provide assurance that the validity of trading agreements will be preserved. Trades between sources are most promising if they shift the responsibility for the agreed-to controls entirely from the buyer to the seller, who would then be subject to the enforceable policies and mechanisms referenced above. If buyers are required to adopt additional controls when sellers fail to implement agreed-to controls, then trading programs are less likely to succeed. Similarly, trades are most promising if they are based only on the validity of the agreement, and not on the success of the controls agreed to by the seller. Otherwise, the risks to buyers of trading -- that is, having to pay twice -- may prevent many trades and undermine the effectiveness of a trading program.

EPA and NOAA encourage states to focus on minimizing the costs of transacting trades. Delays and uncertainty in arranging specific trades, as well as direct application fees, can serve to raise the costs of transacting trades, to hinder trades, and to lower the likelihood that such trades will reduce compliance costs. Similarly, arbitrary requirements that trades substantially reduce net expected pollutant loadings can serve to raise transaction costs and deter trades. Finally, states should establish guidelines for sources to follow in arranging trades. Such guidelines should help reduce unnecessary delays, avoid any later invalidation of trades, and lower transaction costs by increasing the likelihood that trades will be approved in advance.

When proposing a trading program to control nonpoint sources, a state would need to determine from EPA's (g) measures guidance and other sources the pollutant loading reductions that must be achieved from a group of sources within a watershed over a specified period, such as a season or a year. This establishes the baseline that the trade would need to achieve. For example, implementing the (g) guidance control measures on a dairy farm of given characteristics could be expected to reduce nutrient loadings by a certain amount. Each source would be required to reduce loadings by the necessary amount, by implementing controls on-site, or off-site through appropriate trading arrangements. Sources that believe their costs of achieving the necessary loading reductions are high could finance incremental controls at other sources with lower costs, expecting such trades to be approved. Compliance would be ascertained through demonstration that the necessary loadings reductions are achieved either on-site by implementing control measures, or off-site through appropriate trading arrangements, consistent with enforceable policies and mechanisms established elsewhere by the state in its coastal nonpoint program.

Multiple Management Measures

Section 6217(g)(5) of CZARA requires that management measures be economically achievable. In its economic achievability analysis, EPA estimated costs of selected combinations of multiple management measures applicable to sources. EPA focused its analysis on those cases which it believes are most likely to occur. Multiple measures which EPA concluded are economically achievable include (1) erosion control, confined animal feedlots, and grazing management measures, (2) combination of all forestry measures, (3) new development requirements such as stormwater, erosion and sediment control, and septic tanks, (4) all marina requirements; and (5) municipality requirements such as stormwater, erosion and sediment control, bridge maintenance, salt storage, street sweeping, wetlands protection, stream stabilization, and dam-related expenses.

EPA and NOAA recognize that it is impossible to determine economic achievability for all possible combinations of management measures. For example, a dairy farm might be responsible for control of discharge from animal feedlots, grazing, erosion, streambank stabilization, and wetlands preservation. In this case, EPA has found that a combination of management measures for erosion, feedlots and grazing are economically achievable, but not in combination with wetlands protection and streambank stabilization. In situations where EPA has not considered a specific combination of management measures in its economic achievability analysis, states may be granted flexibility to re-examine whether a particular combination of multiple management measures is economically achievable for a group of sources. If, in its program submission or in subsequent revisions, a state finds that EPA did not consider the economic achievability of multiple management measures that apply to a group of sources when added together, the state may propose a fresh determination of management measures applicable to that group of sources. When making these determinations, states will need to meet the requirements of CZARA, including section 6217(g), which defines management measures as reflecting the greatest degree of pollutant reduction economically achievable. States may take into account direct and indirect costs and may consider incremental costs relative to incremental reductions in loadings.

III.C.3. Description of the implementation process and authorities

For program approval, the state will need to provide detailed information on how it will ensure implementation of the management measures in conformity with the (g) guidance. This information should be provided for each nonpoint source category or subcategory as identified in section III.C.1.

At a minimum, for each category and subcategory, the state coastal nonpoint program will:

a. Describe the scope, structure, and coverage of the state implementation program.

b. Describe the organization, structure and authorities of the state or local agency or agencies that will have responsibility for administering the implementation program, including:

i. an identification of the designated lead agency for the program addressing each category or subcategory. If the designated lead agency is not the section 319 or coastal zone management agency, the description must specify how the lead agency and its authorities have been incorporated into the coastal nonpoint program.

ii. a description of how the lead agency expects to implement the program including, for example, the number of staff and general responsibilities, cost of the program and potential funding sources.

c. Include a schedule for each nonpoint source category or subcategory with milestones for achieving full implementation of the management measures within three years as described in section IV.D.

d. Identify enforceable policies and mechanisms to ensure that each management measure identified in the coastal nonpoint program is implemented in accordance

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with section III.H. of this guidance. States must submit copies of the appropriate legislative and administrative documents to demonstrate that authorities exist to support implementation of the management measures. Furthermore, if the enforcement authority will not be exercised directly by the state coastal zone management or section 319 agency, the state coastal nonpoint program must include provisions to ensure that the governmental body with the statutory authority exercises that authority as set forth in the state's coastal nonpoint program. States must submit documentation such as memoranda of understanding, executive orders or administrative directives which embody agreements to ensure this conformity. These authorities must be incorporated into the coastal nonpoint program.

e. Describe mechanisms to improve coordination among state agencies and among state and local officials responsible for land use programs and permitting, water quality permitting and enforcement, habitat protection, and public health and safety as required by section 6217(b)(6). States will need to include copies of any memoranda of agreement or provisions for joint project review. (See discussion in section III.G.)

f. Describe a process to identify practices to achieve the management measures.

g. Describe activities to ensure continuing performance and long term effectiveness of the measure through proper operation and maintenance. States should follow the operation and maintenance programs described in the (g) guidance or, where the state has developed its own measures, describe the operation and maintenance requirements for the alternative measures. Activities to monitor implementation and enforcement should include a program for the comprehensive survey of sources that are required to implement the management measure, and a program for periodic inspections of sources.

h. Describe state activities to monitor the effectiveness of the (g) measures based on accepted water quality monitoring protocols such as those described in Chapter 8 of the (g) guidance.

States may meet any of these requirements by: (1) identifying existing program activities currently being implemented effectively under state coastal zone management programs, state nonpoint source management programs, or by other state programs; (2) providing the information discussed above for the existing programs; (3) developing new enforceable policies, as necessary; and (4) incorporating these programs into the new coastal nonpoint program.

III.D. Requirements for Implementation of Additional Management Measures

For program approval, state coastal nonpoint programs must provide for the implementation of "additional management measures" where coastal water quality is impaired or threatened even after the implementation of the management measures specified in the (g) guidance. See Section 6217(b).[11] These additional measures apply both to existing land and water uses that are found to cause or contribute to water quality impairment and to new or substantially expanding land uses within critical coastal areas adjacent to impaired or threatened coastal waters. Specific statutory requirements for implementation of additional management measures can be found in sections 6217(b)(1), (2) and (3) of CZARA.

As described by the amendment's sponsor in a floor statement on CZARA, the additional management measures provide a "second tier of pollution control efforts" and "are targeted to those coastal land uses that are recognized to cause or contribute to water quality problems generally." See 136 Cong. Rec. E. 3590, October 27, 1990. In addition, the legislative history describes the additional management measures provision as also requiring "the identification of important coastal areas -- as contrasted to individual land uses under paragraph (1) [section 6217(b)(1)] -- that need additional measures to protect against anticipated pollution problems. Unlike paragraph (1), the imposition of additional measures are not contingent upon identified water quality problems, and are to be established as a preventative step to avoid water quality problems that might otherwise develop." Id.

For program approval, states will need to do the following:

1. identify coastal waters that are not attaining or maintaining applicable water quality standards or protecting designated uses, or that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources;

2. identify land uses that individually or cumulatively cause or threaten water quality impairments in those coastal waters;

3. identify critical coastal areas;

4. develop a process for determining whether additional measures are necessary to attain or maintain water quality standards in the waters identified above;

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[11] For purposes of section 6217(b), the definitions for water quality standards and designated uses are those found in section 303 of the Clean Water Act and in 40 C.F.R. Part 131.

5. describe the additional management measures the state will apply to the identified land uses and critical coastal areas; and,

6. develop a program to ensure implementation of the additional management measures within the time frame described in section IV.D.

These elements are discussed in greater detail in the following sections.

III.D.1. Identification of coastal waters that are not attaining or maintaining water quality standards

For program approval, states must, at a minimum, identify the following as threatened or impaired waters:

a. coastal waters identified in a state's most recent report under section 305(b) of the CWA as "partially meeting" or "not meeting" designated uses or as "threatened";

b. coastal waters listed by a state in accordance with the requirements of section 303(d)(1)(a) of the CWA requiring Total Maximum Daily Load calculations if listing is due at least in part to nonpoint sources;

c. coastal waters listed by a state under CWA section 304(l) as impaired by nonpoint source pollution;

d. coastal waters identified by a state as impaired or threatened by nonpoint source pollution in an assessment submitted to EPA under section 319 of the CWA or in any updates of the assessment.

States should also consider the results of water quality monitoring associated with assessing the effectiveness of the (g) measures in attaining and maintaining water quality standards when identifying impaired or threatened waters.

States should also identify coastal waters for which existing dilution calculations or predictive models indicate nonattainment of water quality standards. Other organizations and groups should be actively solicited for research they may be conducting or reporting. For example, volunteer monitoring organizations, university researchers, the USDA, NOAA, USGS, and the U.S. Fish and Wildlife Services and a wide variety of state agencies can be good sources of field data. In addition, states should examine waters for which coastal water quality problems have been reported to the state by local, state or Federal agencies, members of the public, or academic institutions.

States should use the most current data available, including information generated in evaluating the effectiveness of the (g) measures, and must describe the validity of the data used to determine threatened or impaired waters. States should consider the following in evaluating the validity of the data:

a. whether the assessments are based on monitored or evaluated data;

b. the limits on the availability of water quality information for coastal wetlands, estuaries and groundwater resources that affect coastal waters; and,

c. the difference between each coastal waterbody's current condition and the condition needed to support the designated uses that the state has identified in its water quality standards. (See Appendix F for examples of designated uses and support levels).

NOAA and EPA require each state to identify its impaired and threatened coastal waters in order to evaluate both the adequacy of the state's identification of land uses required by section 6217(b)(1) and the critical coastal areas required by section 6217(b)(2), and the adequacy of its determination that additional management measures need to be implemented. As part of the threshold review process (see section IV.B.), NOAA and EPA will work with the state to evaluate the state's water quality information. If the information is incomplete, the state may be asked to develop reasonable additional information on water quality impairments. States are encouraged to complete water quality assessments for coastal waters and estuaries. In addition, states are encouraged to adopt water quality standards for marine waters and for common nonpoint source pollutants such as nutrients.

III.D.2. Identification of land uses causing or threatening water quality impairments

Once threatened and impaired coastal waters have been identified, as described in section III.D.1, states must then identify those land uses that individually or cumulatively cause or contribute to coastal water quality impairments. The land uses should include the general nonpoint sources categories and subcategories described in the (g) guidance and other land uses not mentioned in the (g) guidance that are or may be sources of runoff and infiltration to coastal waters such as landfills and certain mining operations. States should use the most current land use information available (local and state land use maps, Geographic Information Systems, etc.) to identify these land uses. NOAA and EPA encourage states to use maps to display identified land uses.

Water quality impacts may occur where a land use involves: (1) substantial disturbance to the land or water resource; (2) substantial treatment, introduction, or creation of a nonpoint source pollutant; or (3) a substantial temporary or permanent change to the hydrology or other natural characteristics of a land area or water resource.

Once general land use patterns and potential water quality impacts have been identified, states should consider more specific land use characteristics to help determine whether current or future uses are likely to cause or contribute to water quality impairments. State should consider the biological and physical impacts of these land uses within the watershed adjacent to the impaired or threatened waterbody or segment. States should consider physical characteristics such as: topography/slope; soil characteristics (erodibility, etc.); shoreline erosion characteristics; hydrology, in particular groundwater linkages to coastal waters and high water tables; and the presence of forest and other vegetated areas that may provide natural buffers or nutrient sinks. States should also consider habitat and other biological impacts that may be caused by specific land uses.

The preferred source of information on the relationship between land uses and water quality is "refereed" technical journals. However, other sources often will be needed to fill gaps caused by a shortage of information relating land use to nonpoint source impacts. Additional sources could include Federal and state publications, generally accepted models (e.g., loading coefficients), and similar information. Sources used by the state in identifying and evaluating the land uses should be cited in its coastal nonpoint program.

III.D.3. Identification of critical coastal areas

For program approval, a state must also identify and map critical coastal areas -- as contrasted to individual uses identified under paragraph (1) of section 6217(b) -- that need additional measures to protect against current and anticipated nonpoint pollution problems. See section 6217(b)(2). The establishment of critical coastal areas should focus on those areas in which new or substantially expanding land uses may cause or contribute to the impairment of coastal water quality.

States have flexibility in their approach to delineating critical coastal areas. The following two examples illustrate approaches for the establishment of critical coastal areas.

Under the first approach, a state could establish the critical coastal area as a strip of land along the portion(s) of the shoreline adjacent to threatened or impaired coastal waters. Some states have programs that specify a land area along the shoreline of a waterbody and that extend inland a uniform distance from the shoreline or from landward boundaries of wetlands or heads of tides. Within this area, special controls such as setbacks and low density zoning can be employed to protect coastal waters.

In establishing a critical coastal area along the shoreline, a state may omit areas where recent water quality assessments demonstrate that the coastal waterbody is neither impaired nor threatened, and where a state can demonstrate that new land uses or expansions of existing land uses will not contribute to a future threat or impairment of the waterbody. For example, shoreline segments could be omitted if: (1) a state can demonstrate that its coastal area is predominantly in Federal or state conservancy, the use of which will not threaten coastal water quality, and that changing or expanding land uses are not a concern; or (2) existing ordinances for an adjacent area effectively manage new or expanding land uses (e.g., by controlling the extent of impervious surfaces and/or the density of development along the coastal waters).

Under a second approach, a state could rely on site specific evaluations to determine the extent of a critical coastal area. The critical coastal area could be established on an ecosystem basis for the impaired or threatened coastal waters.[12] Under this approach, states may include broader geographic areas in the critical area designation, starting with shoreline segments adjacent to threatened or impaired coastal waters, and extending inland to encompass significant coastal features or resources further inland. These broader areas may include entire watersheds or portions of watersheds adjacent to coastal waters, and may encompass significant biological features such as wetlands.

In selecting an approach, states should consider the following factors:

- The nature of the coastal water quality problem(s) caused by nonpoint sources.
- The extent to which the nonpoint sources are located adjacent to the waterbodies as opposed to further inland.
- The physical and biological characteristics of the adjacent lands, such as those described in the previous section on land use, that will affect the extent to which uses of these lands will cause nonpoint source pollution problems. (See section III.D.2.).
- Important biological features that should be included as a whole in critical coastal areas, e.g. wetlands.
- The type(s), density and characteristics of the new or expanding land uses that are anticipated and their expected effect(s) on water quality.

[12] Ecosystem is defined as a biological community whose environment functions as an ecological unit.

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- The extent to which the above effects can be prevented or reduced by implementation of (g) management measures and/or the additional management measures for land uses.

NOAA and EPA also encourage states to consider including other previously designated areas within the critical coastal areas under this program. Such areas may include: areas of particular concern designated as part of state coastal zone management programs; National Estuarine Research Reserves; National Marine Sanctuaries; and, significant watershed areas within National Estuaries designated by EPA under section 320 of the CWA. NOAA and EPA expect that this approach will help to fully integrate and coordinate this new coastal nonpoint program with other existing programs.

III.D.4. Process to implement additional management measures

Once the land uses and critical coastal areas, described above, have been identified, states must describe additional management measures applicable to those land uses and areas in order to address the sources of nonpoint pollution. <u>See</u> section 6217(b)(3). States will also need to develop a continuing process, including milestones, for implementing, evaluating and, as necessary, revising the additional measures.

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NOAA and EPA expect that it may be necessary for a state to provide for the implementation of some additional management measures immediately and others only if implementation of the (g) measures are shown to be insufficient to protect and restore water quality. The two categories of additional management measures are:

1. **Immediate Implementation**: For the waterbodies identified in section III.D.1., states should evaluate the relative contributions from point and nonpoint sources. Where a threat or impairment of a particular water or waterbody segment is due to nonpoint sources, the state should determine whether existing pollution prevention activities and/or the implementation of the (g) measures will be adequate to address the threat or impairment. If existing information indicates that the implementation of the (g) measures will not be adequate to attain or maintain water quality standards of the coastal waters or waterbody segment due to contributions from nonpoint sources, then the state program must specify, at the time of program submission, additional management measures applicable to the appropriate land uses and critical coastal areas. Implementation of these additional measures should begin at the time program approval is granted. Two instances where additional management measures are most likely to be needed immediately are: (1) where the (g) measures (or their equivalents) are already being implemented under existing nonpoint source programs but water quality is still impaired due to identifiable nonpoint sources; and (2) where states have identified critical coastal areas pursuant to the description in III.D.3. because new

or expanding land uses threaten or impair coastal waters notwithstanding existing nonpoint source controls.

2. **Implementation based on performance of (g) measures:** States should also specify a continuing process for identifying, implementing, and revising, as necessary, additional management measures after the program's (g) measures have been implemented. As the (g) measures are implemented, the states should monitor their effectiveness and should verify whether water quality standards are being attained or maintained and designated uses protected. If a state determines that nonpoint sources contribute in whole or in part to water quality impairment even after implementation of the (g) measures, then the state will need to provide for the implementation of additional management measures. As discussed in section IV.D. (Schedule for Program Implementation), additional measures under these circumstances must be fully implemented within eight years of Federal approval of the coastal nonpoint program. The additional management measures also must be monitored to assess their effectiveness in attaining and maintaining water quality standards and protecting designated uses. Further refinements to these management measures, the use of other additional measures, or enforcement action may be necessary if water quality goals are still not met.

III.D.5. Selection of additional management measures

Having determined the need for additional management measures under III.D.4., states will then need to select the additional measures to be implemented. Like the (g) measures, these measures can include a broad range of structural and nonstructural nonpoint source controls. Unlike the (g) measures, the additional measures need not apply to all similar land uses throughout the 6217 management area. Rather, the additional management measures apply only to those identified land uses and critical coastal areas where further nonpoint source controls are necessary to ensure that coastal water quality standards are attained or maintained and designated uses are protected.

For program approval, states are expected to provide the following information on the additional management measures that will be implemented:

a. a discussion of the measure and the land uses and pollutants it is designed to address;

b. evidence of the anticipated effectiveness of the measure in reducing nonpoint pollution to meet water quality standards; and,

c. a process for evaluating the effectiveness of the measures once they are implemented, and a schedule for revising such measures, as necessary, to meet water quality standards.[13]

A number of alternatives are available to states in selecting the additional management measures.

- States can select management measures not specified in the (g) guidance. Under this alternative, states or local governments could develop very specific additional management measures that could include buffer zones, low density zoning, cluster development ordinances, conservation zoning, or other land use measures best developed at the local level.

- States can apply the measures specified in the (g) guidance more intensively (e.g., require a wider stream-side management area for certain forestry operations than that necessary to achieve the (g) guidance measures for stream-side management).

- States can apply the measure specified in the (g) guidance more stringently (e.g., require a higher removal rate for suspended solids for new urban development than that specified in the (g) guidance measure).

- States can provide management measures for land and water uses not identified in the (g) guidance, or for sources excluded under the process described in section III.C.1.

- States can employ innovative approaches as additional management measures. For example, where there is adequate information, states could consider the use of pollution trading for discharges from nonpoint and point sources or among nonpoint sources in watersheds in order to attain or maintain water quality standards in coastal waters and to protect designated uses.

Given the focused nature of additional management measures and the opportunity to tailor the measures to local conditions, the requirement provides an excellent opportunity to use local land use measures to control nonpoint source pollution. Thus states are encouraged to work closely with local governments to develop and implement these measures.

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13 EPA and NOAA will establish a schedule for evaluating the need for management measures revision, which may be tied to 305(b) biennial water quality assessments. If these assessments indicate that water quality is not improving, the additional management measures already in place will need to be revised.

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III.D.6. Using Innovative Pollutant Trading Techniques

One innovative approach that states could consider as they develop additional management measures is pollutant trading. Pollutant trading is a concept that enables one or more sources to meet less stringent treatment levels in exchange for other sources meeting more stringent treatment levels than the levels they would otherwise be required to meet. In appropriate situations, trading can result in more cost-effective pollutant control.

There are two types of nonpoint source trades that are possible:

(1) Point-nonpoint source trading. A point source that has complied with its technology-based requirements may be able to avoid or lessen more stringent water-quality-based treatment requirements by obtaining the requisite (water-quality driven) reductions from nonpoint sources.

(2) Nonpoint-nonpoint source trading. A nonpoint source may apply more stringent treatment than another one, and together the sources obtain the requisite reductions.

Pollutant trading, to date, has been used only sparingly under the Clean Water Act. Point-nonpoint trades have been approved in the Dillon Reservoir, Colorado (for phosphorus) and for North Carolina's Tar-Pamlico watershed (for nitrogen).

The following factors, developed at a recent EPA conference on pollutant trading, should be considered before considering the use of trading techniques[14]:

1. Trading is a potentially valuable tool, but its usefulness has not been fully demonstrated.

2. Trading cannot be applied uniformly nationwide; it is site-specific and local in nature.

3. Cause and effect water quality data, improved predictive modeling, and definitive information on nonpoint source control effectiveness are all crucial technical elements for trading.

4. Education and monitoring are both essential to the success of any trading program.

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[14] A summary of that conference, "Administrator's Point/Nonpoint Source Trading Initiative Meeting" (August 1992) is available from EPA.

Despite the formidable technical and administrative difficulties, EPA and NOAA continue to believe that trading offers some potential water quality benefits and will work to help state and local governments identify opportunities for beneficial trades and to implement such trades.

III.E. Technical Assistance

For program approval, state coastal nonpoint programs will be required to provide for technical and other assistance to local governments and the public for implementing the additional management measures (section 6217(b)(4)). This may include "assistance in developing ordinances and regulations, technical guidance, and modeling to predict and assess the effectiveness of such measures, training, financial incentives, demonstration projects, and other innovations to protect coastal water quality and designated uses." States are also encouraged to provide assistance to local governments and the public on the implementation of the (g) measures.

In order to tailor the type and scale of their technical assistance activities, states should identify those aspects of the program requiring implementation at the regional or local level and the situations where regional entities or localities may need additional expertise and/or experience. In designing the assistance program, NOAA and EPA expect that states will consult with regional and local governments regarding their concerns about implementation, and with the public about its needs and concerns. For certain management measures, training sessions and certification programs conducted by the state for regional and local officials may be appropriate. For others the financing of demonstration projects may be an effective means of enhancing implementation. NOAA and EPA will provide support to states in the implementation of this technical assistance, as requested.

The statute states that technical and other assistance shall be provided to the public as well as to local governments. The technical assistance to the public should include help in solving individual problems and information on how citizen groups can participate in the development and implementation of state programs (e.g., monitoring).

At a minimum, the state coastal nonpoint program should discuss the types of technical assistance that will be provided to support implementation of additional management measures for each of the major land use categories identified in a state's program. States should identify the agency that will provide the technical assistance, the intended recipients of the assistance, and a schedule of when such assistance will be available.

NOAA and EPA are committed to providing technical assistance to the states in the development and implementation of their coastal nonpoint programs. EPA has assembled a great deal of technical information during development of the (g) guidance, and is continuing to add to this collection. This information will be available to the states in a variety of formats, including bibliographies and summaries, both in hard copy and by electronic bulletin board. NOAA and EPA will hold a series of national and regional meetings with state and local officials to discuss their technical assistance needs. Throughout the development and implementation of the coastal nonpoint programs, NOAA and EPA will maintain a dialogue with the states and will provide technical assistance whenever possible. NOAA and EPA will also work with other Federal agencies and will encourage them to use their expertise to assist the states in the development and implementation of the state programs.

III.F. Public Participation

For program approval, states must provide opportunities for public participation in all aspects of the program (section 6217(b)(5)). Congress intended the public to have the opportunity to be extensively involved in the development and implementation of the state coastal nonpoint programs, calling not only for public participation, but also for public education.

As an integral part of the coastal nonpoint program, the goals of the public involvement and education program should be defined by the state before it begins to develop its coastal nonpoint program. The public will need to be involved as early as possible in the development and implementation of the coastal nonpoint program, and the process should seek to promote and maintain the public's long-term commitment to the program. Each state must demonstrate that its coastal nonpoint program has undergone public review and comment prior to submittal to NOAA and EPA. Specifically, a state will need to demonstrate that it has provided opportunities for public comment prior to determining which management measures will be used, what enforceable policies and mechanisms should be employed to ensure implementation of the identified measures, the geographic scope of the coastal nonpoint program, the identification of land uses and critical coastal areas, and the selection and implementation of additional management measures. Depending on the type of threshold review a state selects, there may also need to be public participation as part of that process (see section IV.B.).

The public involvement and education program should include a schedule for initial public contact and education activities, and milestones for further involvement throughout the development and implementation of the coastal nonpoint program. These milestones will need to address public participation, particularly in the development phase, and public education, particularly in the implementation phase. The coastal nonpoint program should also describe how the state expects to fund the public involvement and education programs, including both program development and implementation activities (e.g., Federal funds, state and local funds, or the innovative use of private sector dollars).

As part of the public participation and education programs, states should describe how they will periodically evaluate the effectiveness of these programs.

Public education programs are expected to target several types of audiences, including those regulated or affected by the program (e.g., farmers, building contractors, and marina operators) and those that can assist with program implementation (e.g., conservation organizations and county extension agents). In the implementation phase of the coastal nonpoint program, volunteers may be a very valuable source of assistance. For example, Federal and state funds often are limited for water quality monitoring programs, but volunteers can help to fill the gap. While clearly supplemental to professional data collection, a number of states have successfully used volunteers in their programs. Although costs will be incurred for training volunteers and supporting staff time to coordinate the volunteer efforts, studies and reports demonstrate that volunteers can effectively provide accurate, useful long-term water quality monitoring data.

III.G. Administrative Coordination

For program approval, the coastal nonpoint program must include administrative coordination mechanisms (section 6217(b)(6)). At a minimum, the coastal nonpoint program must include a list of state, regional and local agencies that will play a role in developing and implementing the state nonpoint program. The list should describe the mission, structure and operation of the agencies as they relate to nonpoint source pollution control, and identify the specific role to be played by each agency in the coastal nonpoint program.

A variety of mechanisms can be used to improve coordination among the agencies involved in the coastal nonpoint program and to ensure that the various programs are fulfilling their responsibilities to implement the applicable provisions of the program. These mechanisms include, but are not limited to:

- Memoranda of Agreement/Understanding describing specific agency roles and points of coordination
- Joint permitting processes
- Formal interagency comments during other agencies' permitting processes
- Cross training of staff in other agencies' programs
- Temporary assignment of staff to other agencies, e.g., Intergovernmental Personnel Agreements

- Interagency task forces (e.g., those associated with national estuary programs)
- Interagency advisory committees
- Regularly scheduled interagency staff meetings
- State statutes/regulations describing expectations for interagency cooperation and coordination

The mechanisms selected to ensure coordination among participating agencies should be in place when the coastal nonpoint program is submitted to NOAA and EPA for review and approval. The coastal nonpoint program should also explain how the state will measure the effectiveness of program coordination and should provide a schedule for periodic evaluation and reporting of the results to NOAA and EPA.

NOAA and EPA will work with other Federal agencies at the national level to ensure their understanding and cooperation in the development of the coastal nonpoint programs. NOAA and EPA will also work to assist in resolving conflicts that may occur between states and Federal agencies during the development and implementation of the state coastal nonpoint program.

III.H. Enforceable Policies and Mechanisms

Section 306(d)(16) of the CZMA states that, "[b]efore approving a management program submitted by a coastal state, the Secretary shall find the following: ... [t]he management program contains enforceable policies and mechanisms to implement the applicable requirements of the Coastal Nonpoint Pollution Control Program of the State required by section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990." The Act further provides that, "[e]ach State which submits a management program for approval under section 306 of the Coastal Zone Management Act of 1972, as amended by this subtitle (including a State which submitted a program before the date of enactment of this Act), shall demonstrate to the Secretary -- ... that the program complies with section 306(d)(16) of that Act by not later than 30 months after the date of publication of final guidance under section 6217(g) of this Act."

The statute includes a definition of "enforceable policy" in section 304(6a) of the CZMA: "[t]he term "enforceable policy" means State policies which are legally binding through constitutional provisions, laws, regulations, land use plans, ordinances, or judicial or administrative decisions, by which a State exerts control over private and public land and water uses and natural resources in the coastal zone."

NOAA interprets the term "applicable requirements" in section 306(d)(16) of the CZMA to include the implementation, at a minimum, of: (1) management measures in conformity with the guidance developed under section 6217(g) in order to protect coastal waters generally, and (2) such additional management measures applicable to land uses and critical areas identified in the program as are necessary to maintain or restore coastal water quality and protect designated uses.

States can design a coastal nonpoint program that uses a variety of effective regulatory and/or non-regulatory approaches in order to meet the requirement for enforceable policies and mechanisms. Non-regulatory approaches must be backed by enforceable state authority which ensures that the management measures will be implemented. States are expected to demonstrate that they have the authority to take enforcement actions where incentive or other programs do not result in implementation of management measures, or where significant harm to coastal waters is found or threatened. The selection and design of enforceable policies can be tailored to specific state or local circumstances. The approaches states choose should take into account the nature of the activity and existing institutions and authorities. States may also want to evaluate the costs and benefits of various approaches. States may include existing and/or new enforceable polices and mechanisms in their coastal nonpoint programs. Whatever enforceable policies and mechanisms a state uses, they must meet the threshold test in section 306(d)(16) of ensuring implementation of the applicable requirements, (e.g., management measures as described above).

Enforceable policies may be established through state, regional or local authorities. Where implementation occurs at the regional or local levels, the state must be able to exert or retain authority to ensure local implementation in accordance with the federally approved coastal nonpoint program.

As reflected in the section 6217(g) management measures guidance, a state may need to develop different approaches or requirements for new and existing sources. For example, the (g) guidance specifies separate management measures for the installation of new onsite disposal systems and for the operation of existing onsite disposal systems. States may want to consider these differences in designing enforceable policies and mechanisms for implementing the various management measures to restore and protect coastal waters.

To ensure the effective implementation of the enforceable policies and mechanisms, states should educate the public about the importance of the management measures and should provide technical assistance to local governments and the affected interests. While public education and technical assistance programs alone may not be used to fulfill the requirement for enforceable policies and mechanisms (except as noted below), these programs can enhance the success of both regulatory and non-regulatory programs.

Although the (g) guidance includes educational programs as practices under a number of management measures, only the measures for urban pollution prevention and marina public education require educational programs as part of the management measures itself. For these measures, a demonstration that the state will conduct educational activities will be adequate, and, therefore the state programs need not include enforceable policies and mechanisms for these two measures.

Similarly, the guidance contains management measures which call for the state to promote the restoration of wetlands and riparian areas, and the use of engineered vegetated treatment systems such as constructed wetlands or filter strips. A demonstration that the state will promote these efforts will be adequate to respond, and the state will not be required to include enforceable policies and mechanisms in its coastal nonpoint program for these two measures.

The next two subsections describe examples of the various approaches that a state might consider in developing enforceable policies and mechanisms. The presence in a state coastal nonpoint program of enforceable policies and mechanisms identical to the examples does not necessarily guarantee approval of these approaches because NOAA and EPA will need to evaluate a state's enforceable policies and mechanisms in the context of that state's complete coastal nonpoint program.

III.H.1. Regulatory approaches

One way to implement the requirement for enforceable policies and mechanisms in the coastal nonpoint program is the traditional regulatory approach. Examples of regulatory approaches include permit programs, local zoning, or direct requirements contained in state statutes.

Permit programs

If a state chooses a permitting approach, it has flexibility in the type of permits it uses: individual and general. An individual permit is written for a specific entity. For example, states and localities can issue individual permits for onsite sewage disposal systems prior to home construction. These permits can require implementation of the management measures related to the siting, design, installation, operation, inspection, and maintenance of new systems. These permits also may be renewed periodically to ensure that the system continues to operate properly and/or is pumped out at specified intervals. Implementation of the management measures for the operation of onsite sewage disposal systems can be accomplished through these permit renewals. Other types of individual permits such as coastal development, building, or grading permits can be used to ensure that a number of the urban management measures are implemented.

A state can also issue general permits for specific source categories. These permits prescribe management measures that must be adopted by all entities that meet the category definition. The state would conduct an education program to notify the targeted entities that they must comply with the conditions of the general permit. Individual permits may be issued or penalties imposed for non-compliance.

For example, a general permit can require farmers to adopt management measures for various facets of their operation: e.g., nutrient management, pesticide management, and livestock management. Farmers would choose site-specific management practices from technical guidance provided by the state.

In another example, general permits are currently allowed for certain storm water discharges under section 402(p), e.g., construction activities. Persons engaged in construction activities would have to undertake certain sediment and erosion control practices as conditions of a general permit. If recipients of a general permit fail to meet conditions of the permit by not adopting the management measures, they may face enforcement actions or could be required to apply for an individual permit containing more detailed management, reporting, and inspection requirements.

Local zoning

Many local governments already use zoning ordinances to set conditions on development. For example, local zoning ordinances may restrict the siting of marinas to protect sensitive areas such as shellfish beds, and could, therefore, be used to implement the management measures for marina siting. States could provide oversight of these local decisions by setting the standards by which the zoning ordinances are adopted and by retaining appeal of local decisions if they do not meet the state standards. In addition, local zoning may be an effective mechanism to implement additional management measures. For example, a state may direct local governments to adopt provisions restricting land uses in critical coastal areas to protect and restore water quality.

Direct state statutory requirements

A state may adopt laws that directly require or prohibit certain activities in certain areas as a way to implement some of the management measures. While not requiring a permit per se, state forest practices acts can require forest operators to maintain streamside management areas as part of their plans of operation. This mechanism could provide a way to implement a number of forestry management measures.

Enforcement of Regulatory Approaches

Enforcement under the regulatory approach could be triggered for failure to obtain or comply with a permit, zoning ordinance, or direct statutory requirement. Enforcement actions may include cease and desist orders, administrative orders, fines, or in certain cases, criminal penalties. Fines can be punitive or can be based on the economic benefit an entity gained from not implementing the management measures or the cost of restoring the environment from harm caused by the noncompliance. Enforcement may be triggered when inspections or monitoring programs show that operators are failing to implement the (g) measures or the additional management measures.

III.H.2. Non-regulatory approaches

Although regulatory approaches may be well suited for certain nonpoint sources, they may be difficult to design and implement for other sources. In addition, efforts to control some nonpoint sources historically have relied almost solely on non-regulatory programs. Accordingly, a state has the flexibility to employ economic incentive, disincentive, or innovative approaches to address these types of sources, provided that the state can ensure such approaches will result in the necessary implementation of the (g) management measures and additional management measures. States will have to include back-up enforcement authority for voluntary programs. Such back-up authority could include sunset provisions for incentive programs. For example, a state could provide that if too few operators participate in a tax incentive program, the state would develop additional incentives or mandatory requirements to achieve the necessary implementation of management measures.

Non-regulatory approaches may use financial mechanisms to encourage or discourage certain behaviors. State tax credits, tax deductions, tax rebates, cost-share programs, performance bonds, or loan programs are economic incentives that are often used to encourage changes in behavior. Economic disincentives include increased taxes, fees, or pricing structures. There are a variety of economic tools that states can use; however, each state should analyze the relative effectiveness of the tools in implementing the management measures before applying them in a given situation.

Economic incentives

State economic incentives can be used to provide financial support to guarantee mplementation of some management measures. For example, as a condition of the ·eceipt of state agricultural cost-share funds, farmers can be required to fully mplement specific management measures (e.g., sediment and erosion control, nutrient nanagement, pesticide management). Cost-share funds can also be used to ensure that some of the forestry management measures are implemented (e.g., road construction/reconstruction, road management, revegetation of disturbed areas).

State tax credits, deductions, or rebates could be granted or pricing structures created to encourage the adoption of water efficiency measures to implement urban management measures for onsite disposal systems (e.g., marginal cost water pricing to encourage conservation of water, installation of low-flow plumbing fixtures). States could set up grant or low interest loan programs to help individuals finance capital expenditures associated with management measures such as replacing failing onsite disposal systems, installing animal waste controls, stabilizing eroding shorelines using vegetative methods, or constructing pumpout facilities for marinas.

Although economic incentive programs can be very effective in many cases, states should recognize their limitations. Incentive programs can be very expensive for a state to administer and implement, and state revenues will be required to support them. In addition, if such approaches are used alone, it may be difficult to establish the rate of cost-share or tax credits at a level that guarantees widespread adoption of the management measures. As a state raises the level of financial support, the costs of the incentive program will increase.

Economic disincentives

States can also develop economic disincentive programs to implement some management measures. Fees, taxes, or price increases on specific items can be used to reach the level specified in the management measures. For example, increased prices may be used to stimulate water conservation (or modifications to pricing structures that inadvertently encourage high consumption). Similarly, taxes or fees may be levied on products to discourage their inefficient use.

States also should recognize the limitations on the effectiveness of disincentive programs. The success of these approaches depends on the level of the tax or fee relative to the price of the good. If a tax or fee is too high, it may change behavior more than is necessary to meet the management measure. If a tax or fee is too low, it may not change behavior sufficiently to adequately implement the management measures. However, a fee could be supplemented by other approaches to meet the measure. Despite these limitations, the use of mechanisms such as taxes and fees has the advantage of generating program revenues.

Other innovative approaches

States also may use more innovative approaches to encourage management measure implementation. Trading of pollution control requirements among point and nonpoint sources or among nonpoint sources may be a useful tool in implementing additional management measures to meet water quality standards in a particular waterbody. (See discussion in section III.D.6.)

States may require that performance bonds be posted before an entity engages in an activity requiring management measure implementation. For example, prior to authorizing a channelization project, a state could require a developer to post a bond to ensure that proper design and construction activities occur. When the developer complies with the practices, the bond will be returned. If not, the bond will be forfeited to the state. Bonds can also be used to ensure that proper operation and maintenance activities occur.

As mentioned earlier, states may enhance the success of these non-regulatory approaches through education programs. For example, as part of an existing pesticide applicators' licensing program, states may require that applicators be educated on management measures and appropriate practices and may require certification of course attendance.

In conclusion, NOAA and EPA expect that states will employ a range of approaches in crafting enforceable policies and mechanisms to implement the (g) management measures and additional management measures. A state coastal nonpoint program should indicate clearly what approaches and authorities the state will rely on to meet the requirement for enforceable policies and mechanisms and should describe how the approaches will ensure the necessary implementation of the management measures.

IV. PROGRAM SUBMISSION, APPROVAL AND IMPLEMENTATION

The legislative history of section 6217 states that "coastal nonpoint pollution control programs are not intended to supplant existing coastal zone management programs and nonpoint source management programs. Rather, they are to serve as an update and expansion of existing programs." Id. See also section 6217(a)(2). The legislative history indicates that the central purpose of section 6217 is to strengthen the links between Federal and state coastal zone management and water quality programs and to enhance state and local efforts to manage land use activities that degrade coastal waters and coastal habitats.

The sections below describe several aspects of the approval process. States may elect to undertake "threshold reviews" with NOAA and EPA. Under certain circumstances, NOAA and EPA may grant "conditional approvals" for state coastal nonpoint programs. The last step in the process is "final approval" by NOAA and EPA. When a state coastal nonpoint program receives final approval, it will automatically be incorporated into the state's coastal management and nonpoint source programs.

IV.A. Program Submission and NOAA/EPA Review

Within 30 months after the publication of EPA's (g) guidance, states must submit their coastal nonpoint programs to NOAA and EPA for approval. Appendix G contains a listing of the information that needs to be included in the state's submission.

The statute requires the Secretary of Commerce to make a determination whether the portions of the state's program under the Secretary's authority meet the requirements of section 6217, and likewise, the Administrator of the EPA must make a determination whether the portions under the Administrator's authority meet the requirements of section 6217. If both officials determine that the requirements of section 6217 have been met and each agency official concurs with the other's determination, then the program will be approved. As stated previously, NOAA and EPA have determined as a matter of policy that neither agency will approve a state's coastal nonpoint program until the program meets all the Federal approval requirements as determined by both agencies. NOAA and EPA (including both headquarters and regional offices) will coordinate their review of the coastal nonpoint program.

IV.B. Threshold Review

A state may request that NOAA and EPA conduct a threshold review of its proposed coastal nonpoint program. The threshold review is an initial review by NOAA and

EPA of a state's approach to specific elements of its coastal nonpoint program. The review would address key issues and decision points (e.g., identification of sources, geographic scope, alternative management measures) that a state may wish to discuss prior to drafting its coastal nonpoint program. The intent of this early review is twofold. First, the process would allow the state, NOAA and EPA to discuss the state's approach to certain program elements before the state invests substantial resources in program development. Second, it would help states set priorities and focus early on the final program, particularly on elements, such as enforceable policies and mechanisms, that may take time to adopt. Threshold reviews may take the form of informal consultations or a more formal process. The requirements for each type of review are discussed below.

Informal Review

The first type of threshold review would be an informal consultation between a state and NOAA and EPA. The informal threshold review should occur as early in the program development process as is practical.

A state would initiate the threshold review by developing a threshold review package that briefly describes how it expects to address the requirements for the coastal nonpoint program. NOAA and EPA will provide additional information for states to use in preparing for the threshold review.

NOAA and EPA will review the information and will work with the state coastal and nonpoint agencies to refine the state's approach, as necessary. Public participation in an informal threshold review is not required; however, states may decide to involve the public in some aspects of the process.

Formal Review

States may wish to undertake a more formal review of specific program elements prior to submitting their final program. NOAA and EPA may issue preliminary findings on the approvability of elements of the program. The purpose of these findings would be to increase the predictability of the final review process, although these findings would still be subject to the outcome of review of the program in its entirety.

As with the informal review, a more formal review is optional. However, if a state wishes to take advantage of this form of threshold review, it should submit, at a minimum, the following information: a description of the portion(s) of the coastal nonpoint program which the state wishes to have reviewed, an analysis of how that portion(s) meets the program requirements, the specific management measures addressed by that portion(s) of the program, a description of opportunities for public review and comment, and to the extent possible, how that portion(s) would fit in with and relate to the remainder of the program.

Unlike the informal threshold review, the formal review process must include opportunities for public participation and review. Prior to seeking formal review, the state must provide a minimum period of 30 days in which the public is given the opportunity to review and comment upon all portions of the program being submitted to NOAA and EPA for their preliminary findings. The public notice for the review period must indicate that the state is seeking such findings from the Federal agencies on the specific portions of its coastal nonpoint program. It must also include a description of the submitted portions and how they address the 6217 requirements. NOAA and EPA also expect the state to consider any comments received prior to finalizing the submitted portion(s) of the program.

NOAA and EPA will review the submissions and determine, as a preliminary matter, whether they meet the specified program requirements. NOAA and EPA will provide the state with written preliminary findings. Elements that have received preliminary findings would still be subject to the final approval process, including public participation, as part of the state's submission of its final coastal nonpoint program.

IV.C. Conditional Approvals

States are expected to submit a coastal nonpoint pollution control program that meets all the requirements of section 6217 at the time of the statutory deadline for program submission. However, NOAA and EPA recognize that in limited situations, a state might submit a program for which all state enforceable policies and mechanisms necessary to implement the applicable program requirements are in place, but that will require further development of state, regional, or local authorities, or administrative mechanisms, to ensure close coordination with existing plans and programs as required by 6217(a)(2). In other cases, a state might have a substantial majority of the required state enforceable policies and mechanisms in place, but need additional time to develop other state enforceable policies and mechanisms to ensure implementation of all applicable program requirements.

In either situation, NOAA and EPA may elect to exercise their discretion and grant conditional approval of the state coastal nonpoint program. Final approval of the program would be conditioned upon the state's ability to demonstrate that all necessary enforceable policies and mechanisms are in place. It should be noted, however, that a conditional approval will not postpone the date by which NOAA and EPA expect full implementation of the (g) measures. As discussed in section IV.D. below, these measures are to be fully implemented within three years of the first Federal approval action regardless of whether that approval is final or conditional.

Conditional approval of the program will be granted only in situations where the state can demonstrate its ability to ensure adoption of the necessary regulations or local ordinances or obtain state authorities for the remaining portions of the program. NOAA and EPA will consider the following factors in evaluating a state's submittal for conditional approval:

- Scope and significance of nonpoint sources addressed and the geographic coverage for the enforceable policies and mechanisms already in place;

- Status of efforts to date to obtain the remaining enforceable policies and mechanisms;

- The state's plan and reasonable timetable for obtaining the remaining enforceable policies and mechanisms; and,

- The presence, in the submitted program, of enforceable policies and mechanisms for additional management measures to be implemented immediately to protect and improve coastal water quality.

In cases in which NOAA and EPA grant conditional approval of a state's program, the state and local enforceable policies or mechanisms necessary to satisfy the conditions will be required to be adopted within one year from the date of conditional approval. Under very limited circumstances, NOAA and EPA may grant a state an additional year to obtain the required enforceable policies and mechanisms. If the state is able to satisfy the conditions within the required period, final approval of the program will be granted. Conditional approval does not alter the program implementation schedule described in section IV.D. below.

If NOAA and EPA find that a state fails to submit an approvable program or fails to meet the conditions for full approval, both section 319 and section 306 funds will be withheld according to the schedule described below.

IV.D. Schedule for Program Implementation

NOAA and EPA expect states to fully implement management measures, including alternative measures in conformity with the measures specified in the (g) guidance, within three years of Federal approval of the program and to fully implement additional measures within eight years of that Federal approval.[15] That is, if state

[15] "Federal approval" as used in this section means the first Federal approval action, whether final or conditional. For states receiving conditional approval, the implementation schedule begins to run at the time that conditional, rather than final, approval is granted.

programs are submitted in July, 1995 and approved by NOAA and EPA in January, 1996, the (g) measures must be fully implemented by January, 1999 and the additional measures by January, 2004. The period for implementation of additional measures includes a two year period for evaluating the implementation of the (g) measures and a three year period for implementing the additional management measures.

Under the statute, the purpose of the states' coastal nonpoint programs is to protect and restore coastal waters. This purpose is advanced by establishing a schedule that requires management measure implementation as soon as possible. In addition, NOAA and EPA believe that states should begin implementing certain additional management measures at the time of program approval to ensure that the statutory goal of attaining and maintaining coastal water quality standards is achieved. However, it is recognized that it may be necessary to defer implementation of other additional management measures until the (g) measures are in place and their effectiveness is monitored. The statute also requires continuing revision of the additional management measures to ensure that water quality standards are met.

For new sources, NOAA and EPA interpret full implementation to mean that new sources within each identified nonpoint source category or subcategory would be subject to the management measures at the time of Federal approval. Full implementation of management measures for existing sources (e.g., existing agricultural operations or existing urban development) means that each identified category and subcategory of existing sources is expected to implement the management measures to which they are subject not later than three years after Federal approval.

The state coastal nonpoint program should include milestones established at appropriate intervals within the three year implementation period, by which progress toward full implementation can be assessed in terms of management measures in place and water quality protection achieved. This schedule should ensure that sources having the most significant impact on coastal waters are addressed first. NOAA and EPA will monitor progress of state implementation as part of program and grant reporting requirements under section 319 of the CWA, section 306 of the CZMA, and regular program evaluations under section 312 of the CZMA. States not making satisfactory progress in meeting their milestones may be subject to loss of funds awarded under section 319, as well as to sanctions imposed under section 312 of the CZMA.

State coastal nonpoint programs must also include a schedule and milestones for implementation of additional measures. Implementation of additional management measures for critical areas and for those land uses (sources) for which state authorities already require management measures in conformity with the (g) management measures but where coastal water quality is still threatened or impaired, should begin at the time of Federal approval.

IV.E. Program Approval Standards, Implementation and Penalties

Both EPA and NOAA will base their review of a state's coastal nonpoint program on whether the state has met the requirements of the statute. NOAA and EPA will perform their review consistent with the interpretation set forth in this guidance. NOAA and EPA will consult with the states during the six month review period above. The states will have an opportunity to amend their submission, if necessary, subject to the public participation requirements and time constraints.

If either NOAA or EPA determines that a state has failed to submit an approvable coastal nonpoint program, the relevant penalties will be levied both on section 306 coastal management grants and section 319 nonpoint source grants. The penalties start at 10% in fiscal year 1996, and increase to 15% in FY 1997, 20% in FY 1998, and 30% in FY 1999 and each fiscal year thereafter. In the case of the coastal zone management program, the penalty is based upon the grants otherwise available to a state in the current fiscal year. In the case of the section 319 nonpoint source management program, the penalty is based on the grant amount awarded to the state for the preceding fiscal year. Given the joint approval process, no state will experience penalties to only one program. Funds withheld by NOAA and EPA will be made available to states with approved coastal nonpoint programs.

APPENDICES

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APPENDIX A: Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990

P.L. 101-508

SEC. 6217. PROTECTING COASTAL WATERS.

(a) IN GENERAL.–

(1) PROGRAM DEVELOPMENT.–Not later than 30 months after the date of the publication of final guidance under subsection (g), each State for which a management program has been approved pursuant to section 306 of the Coastal Zone Management Act of 1972 shall prepare and submit to the Secretary and the Administrator a Coastal Nonpoint Pollution Control Program for approval pursuant to this section. The purpose of the program shall be to develop and implement management measures for nonpoint source pollution to restore and protect coastal waters, working in close conjunction with other State and local authorities.

(2) PROGRAM COORDINATION.–A State program under this section shall be coordinated closely with State and local water quality plans and programs developed pursuant to sections 208, 303, 319, and 320 of the Federal Water Pollution Control Act (33 U.S.C. 1288, 1313, 1329, and 1330) and with State plans developed pursuant to the Coastal Zone Management Act of 1972, as amended by this Act. The program shall serve as an update and expansion of the State nonpoint source management program developed under section 319 of the Federal Water Pollution Control Act, as the program under that section relates to land and water uses affecting coastal waters.

(b) PROGRAM CONTENTS.–Each State program under this section shall provide for the implementation, at a minimum, of management measures in conformity with the guidance published under subsection (g), to protect coastal waters generally, and shall also contain the following:

(1) IDENTIFYING LAND USES.–The identification of, and a continuing process for identifying, land uses which, individually or cumulatively, may cause or contribute significantly to a degradation of–

(A) those coastal waters where there is a failure to attain or maintain applicable water quality standards or protect designated uses, as determined by the State pursuant to its water quality planning processes; or

(B) those coastal waters that are threatened by reasonably foreseeable increases in pollution loadings from new or expanding sources.

(2) IDENTIFYING CRITICAL COASTAL AREAS.–The identification of, and a continuing process for identifying, critical coastal areas adjacent to coastal waters referred to in paragraph (1)(A) and (B), within which any new land uses or substantial expansion of existing land uses shall be subject to management measures in addition to those provided for in subsection (g).

(3) MANAGEMENT MEASURES.–The implementation and continuing revision from time to time of additional management measures applicable to the land uses

and areas identified pursuant to paragraphs (1) and (2) that are necessary to achieve and maintain applicable water quality standards under section 303 of the Federal Water Pollution Control Act (33 U.S.C. 1313) and protect designated uses.

(4) TECHNICAL ASSISTANCE.–The provision of technical and other assistance to local governments and the public for implementing the measures referred to in paragraph (3), which may include assistance in developing ordinances and regulations, technical guidance, and modeling to predict and assess the effectiveness of such measures, training, financial incentives, demonstration projects, and other innovations to protect coastal water quality and designated uses.

(5) PUBLIC PARTICIPATION.–Opportunities for public participation in all aspects of the program, including the use of public notices and opportunities for comment, nomination procedures, public hearings, technical and financial assistance, public education, and other means.

(6) ADMINISTRATIVE COORDINATION.–The establishment of mechanisms to improve coordination among State agencies and between State and local officials responsible for land use programs and permitting, water quality permitting and enforcement, habitat protection, and public health and safety, through the use of joint project review, memoranda of agreement, or other mechanisms.

(7) STATE COASTAL ZONE BOUNDARY MODIFICATION.–A proposal to modify the boundaries of the State coastal zone as the coastal management agency of the State determines is necessary to implement the recommendations made pursuant to subsection (e). If the coastal management agency does not have the authority to modify such boundaries, the program shall include recommendations for such modifications to the appropriate State authority.

(c) PROGRAM SUBMISSION, APPROVAL, AND IMPLEMENTATION.–

(1) REVIEW AND APPROVAL.–Within 6 months after the date of submission by a State of a program pursuant to this section, the Secretary and the Administrator shall jointly review the program. The program shall be approved if–

(A) the Secretary determines that the portions of the program under the authority of the Secretary meet the requirements of this section and the Administrator concurs with that determination; and

(B) the Administrator determines that the portions of the program under the authority of the Administrator meet the requirements of this section and the Secretary concurs with that determination.

(2) IMPLEMENTATION OF APPROVED PROGRAM.–If the program of a State is approved in accordance with paragraph (1), the State shall implement the program, including the management measures included in the program pursuant to subsection (b), through–

(A) changes to the State plan for control of nonpoint source pollution approved under section 319 of the Federal Water Pollution Control Act; and

(B) changes to the State coastal zone management program developed under section 306 of the Coastal Zone Management Act of 1972, as amended by this Act.

(3) WITHHOLDING COASTAL MANAGEMENT ASSISTANCE.–If the Secretary finds that a coastal State has failed to submit an approvable program as required by this section, the Secretary shall withhold for each fiscal year until such

a program is submitted a portion of grants otherwise available to the State for the fiscal year under section 306 of the Coastal Zone Management Act of 1972, as follows:

(A) 10 percent for fiscal year 1996.
(B) 15 percent for fiscal year 1997.
(C) 20 percent for fiscal year 1998.
(D) 30 percent for fiscal year 1999 and each fiscal year thereafter.

The Secretary shall make amounts withheld under this paragraph available to coastal States having programs approved under this section.

(4) WITHHOLDING WATER POLLUTION CONTROL ASSISTANCE.–If the Administrator finds that a coastal State has failed to submit an approvable program as required by this section, the Administrator shall withhold from grants available to the State under section 319 of the Federal Water Pollution Control Act, for each fiscal year until such a program is submitted, an amount equal to a percentage of the grants awarded to the State for the preceding fiscal year under that section, as follows:

(A) For fiscal year 1996, 10 percent of the amount awarded for fiscal year 1995.

(B) For fiscal year 1997, 15 percent of the amount awarded for fiscal year 1996.

(C) For fiscal year 1998, 20 percent of the amount awarded for fiscal year 1997.

(D) For fiscal year 1999 and each fiscal year thereafter, 30 percent of the amount awarded for fiscal year 1998 or other preceding fiscal year.

The Administrator shall make amounts withheld under this paragraph available to States having programs approved pursuant to this subsection.

(d) TECHNICAL ASSISTANCE.–The Secretary and the Administrator shall provide technical assistance to coastal States and local governments in developing and implementing programs under this section. Such assistance shall include–

(1) methods for assessing water quality impacts associated with coastal land uses;

(2) methods for assessing the cumulative water quality effects of coastal development;

(3) maintaining and from time to time revising an inventory of model ordinances, and providing other assistance to coastal States and local governments in identifying, developing, and implementing pollution control measures; and

(4) methods to predict and assess the effects of coastal land use management measures on coastal water quality and designated uses.

(e) INLAND COASTAL ZONE BOUNDARIES.–

(1) REVIEW.–The Secretary, in consultation with the Administrator of the Environmental Protection Agency, shall, within 18 months after the effective date of this title, review the inland coastal zone boundary of each coastal State program which has been approved or is proposed for approval under section 306 of the Coastal Zone Management Act of 1972, and evaluate whether the State's coastal zone boundary extends inland to the extent necessary to control the land and water uses that have a significant impact on coastal waters of the State.

(2) RECOMMENDATION.–If the Secretary, in consultation with the

Administrator, finds that modifications to the inland boundaries of a State's coastal zone are necessary for that State to more effectively manage land and water uses to protect coastal waters, the Secretary, in consultation with the Administrator, shall recommend appropriate modifications in writing to the affected State.

(f) FINANCIAL ASSISTANCE.–

(1) IN GENERAL.–Upon request of a State having a program approved under section 306 of the Coastal Zone Management Act of 1972, the Secretary, in consultation with the Administrator, may provide grants to the State for use for developing a State program under this section.

(2) AMOUNT.–The total amount of grants to a State under this subsection shall not exceed 50 percent of the total cost to the State of developing a program under this section.

(3) STATE SHARE.–The State share of the cost of an activity carried out with a grant under this subsection shall be paid from amounts from non-Federal sources.

(4) ALLOCATION.–Amounts available for grants under this subsection shall be allocated among States in accordance with regulations issued pursuant to section 306(c) of the Coastal Zone Management Act of 1972, except that the Secretary may use not more than 25 percent of amounts available for such grants to assist States which the Secretary, in consultation with the Administrator, determines are making exemplary progress in preparing a State program under this section or have extreme needs with respect to coastal water quality.

(g) GUIDANCE FOR COASTAL NONPOINT SOURCE POLLUTION CONTROL.–

(1) IN GENERAL.–The Administrator, in consultation with the Secretary and the Director of the United States Fish and Wildlife Service and other Federal agencies, shall publish (and periodically revise thereafter) guidance for specifying management measures for sources of nonpoint pollution in coastal waters.

(2) CONTENT.–Guidance under this subsection shall include, at a minimum-

(A) a description of a range of methods, measures, or practices, including structural and nonstructural controls and operation and maintenance procedures, that constitute each measure;

(B) a description of the categories and subcategories of activities and locations for which each measure may be suitable;

(C) an identification of the individual pollutants or categories or classes of pollutants that may be controlled by the measures and the water quality effects of the measures;

(D) quantitative estimates of the pollution reduction effects and costs of the measures;

(E) a description of the factors which should be taken into account in adapting the measures to specific sites or locations; and

(F) any necessary monitoring techniques to accompany the measures to assess over time the success of the measures in reducing pollution loads and improving water quality.

(3) PUBLICATION.–The Administrator, in consultation with the Secretary, shall publish–

(A) proposed guidance pursuant to this subsection not later than 6 months after the date of the enactment of this Act; and

(B) final guidance pursuant to this subsection not later than 18 months after such effective date.

(4) NOTICE AND COMMENT.–The Administrator shall provide to coastal States and other interested persons an opportunity to provide written comments on proposed guidance under this subsection.

(5) MANAGEMENT MEASURES.–For purposes of this subsection, the term "management measures" means economically achievable measures for the control of the addition of pollutants from existing and new categories and classes of nonpoint sources of pollution, which reflect the greatest degree of pollutant reduction achievable through the application of the best available nonpoint pollution control practices, technologies, processes, siting criteria, operating methods, or other alternatives.

(h) AUTHORIZATIONS OF APPROPRIATIONS.–

(1) ADMINISTRATOR.–There is authorized to be appropriated to the Administrator for use for carrying out this section not more than $1,000,000 for each of fiscal years 1992, 1993, and 1994.

(2) SECRETARY.–(A) Of amounts appropriated to the Secretary for a fiscal year under section 318(a)(4) of the Coastal Zone Management Act of 1972, as amended by this Act, not more than $1,000,000 shall be available for use by the Secretary for carrying out this section for that fiscal year, other than for providing in the form of grants under subsection (f).

(B) There is authorized to be appropriated to the Secretary for use for providing in the form of grants under subsection (f) not more than-

(i) $6,000,000 for fiscal year 1992;

(ii) $12,000,000 for fiscal year 1993;

(iii) $12,000,000 for fiscal year 1994; and

(iv) $12,000,000 for fiscal year 1995.

(i) DEFINITIONS.–In this section–

(1) the term "Administrator" means the Administrator of the Environmental Protection Agency;

(2) the term "coastal State" has the meaning given the term "coastal state" under section 304 of the Coastal Zone Management Act of 1972 (16 U.S.C. 1453);

(3) each of the terms "coastal waters", and "coastal zone" has the meaning that term has in the Coastal Management Act of 1972;

(4) the term' "coastal management agency" means a State agency designated pursuant to section 306(d)(6) of the Coastal Zone Management Act of 1972;

(5) the term "land use" includes a use of waters adjacent to coastal waters; and

(6) the term "Secretary" means the Secretary of Commerce.

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APPENDIX B: National Pollutant Discharge Elimination System

A. Urban Runoff

Historically, there have always been overlaps and ambiguity between programs designed to control urban runoff nonpoint sources and those designed to control urban stormwater point sources. For example, runoff may often originate as a nonpoint source but ultimately be channelized and become a point source. Two statutory requirements have resulted in additional confusion about program applicability. Section 402(p) of the Clean Water Act, establishes permit requirements for certain municipal and industrial storm water discharges, and Section 6217 of CZARA, which requires EPA to promulgate and States to implement management measures to control nonpoint pollution in coastal waters. The discussion below is intended to clarify the relationship between these two programs and describe the scope and applicability of the coastal nonpoint program to urban runoff in coastal areas.

B. The Storm Water Permit Program

The storm water permits program is a two-phased program enacted by Congress in 1987 under section 402(p) of the Clean Water Act. Under Phase I, National Pollutant Discharge Elimination System (NPDES) permits are required to be issued for municipal separate storm sewers serving large or medium-sized populations (greater than 250,000 or 100,000 people, respectively), and for storm water discharges associated with industrial activity. Permits are also to be issued, on a case-by-case basis, if EPA or a State determines that a storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. EPA published a rule implementing Phase I on November 16, 1990.

Under Phase II, EPA is to prepare two reports to Congress which assess remaining storm water discharges; determine, to the maximum extent practicable, the nature and extent of pollutants in such discharges; and establish procedures and methods to control storm water discharges to the extent necessary to mitigate impacts on water quality. Then, EPA is to issue regulations which designate storm water discharges, in addition to those addressed in Phase I, to be regulated to protect water quality, and EPA is to establish a comprehensive program to regulate those designated sources. The program is required to establish (A) priorities, (B) requirements for State storm water management programs, and (C) expeditious deadlines.

These regulations were to have been issued by EPA not later than October 1, 1992. However, due to the numerous discharges to be covered by the studies and regulations, EPA has not yet issued these regulations.

C. Scope of Urban Runoff in Coastal Nonpoint Pollution Control Programs

As discussed above, Congress enacted section 6217 of CZARA in late 1990 to require that States develop coastal nonpoint pollution control programs that are in conformity with the management measures guidance published by EPA. Although EPA's management measures guidance includes measures to address certain urban runoff, EPA is excluding from coverage under this Section 6217(g) guidance all storm water discharges that are covered by Phase I of the NPDES storm water permit program. Thus EPA is excluding any discharge from a municipal separate storm sewer systems serving a population of 100,000 or more; any point source discharge associated with a permitted industrial activity; any discharge which has already been permitted; and any discharge for which EPA or the State makes a determination that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. All of these activities are clearly addressed by the storm water permit program and thus are excluded from the coastal nonpoint pollution control program.

EPA is adopting a different approach with respect to other (non-Phase I) storm water discharges. At present, EPA has not yet promulgated its regulations that would designate additional storm water discharges, beyond those regulated in Phase I, that will be required to be regulated in Phase II. It is thus not possible to determine at this point which additional storm water discharges may be regulated by the NPDES program and which will not. Furthermore, due to the great number of such discharges, it is likely that it would take many years to permit all of these discharges, even if EPA allows for relatively expeditious State permitting approaches such as the use of general permits.

Therefore, to give effect to Congressional intent that coastal waters receive special and expeditious attention from EPA, NOAA, and the States, discharges that potentially may be ultimately covered by Phase II of the storm water permits program are covered by the management measures guidance and will be addressed by the coastal nonpoint pollution control programs. Any storm water discharge that ultimately is issued an NPDES permit will become exempt from this guidance and from the coastal nonpoint pollution control program at the time that the permit is issued.

In addition, we note that some other activities are exempt from the NPDES permit requirements and thus are covered by the coastal nonpoint pollution control program. Most important, construction activities on sites less than five acres, which are not currently covered by the NPDES Phase I stormwater application requirements, are covered by the coastal nonpoint pollution control program.[1] Similarly, discharges from wholesale, retail, service or commercial activities, including gas stations, which are not covered by Phase I of the NPDES stormwater program, are covered instead by the

[1] The provision exempting construction activities on sites less than five acres from the NPDES permit requirements is currently being reviewed by EPA in response to a recent court decision.

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coastal nonpoint pollution control program. Further, on-site disposal systems, which are generally not covered by the stormwater permit program, are covered by the coastal nonpoint pollution control program.

Finally, EPA emphasizes that while different legal authorities may apply to different situations, the goals of the NPDES and CZARA programs are complementary. Many of the techniques and practices used to control urban runoff are equally applicable to both programs. Yet, the programs do not work identically. In the interest of consistency and comprehensiveness, States have the option to implement the CZARA section 6217(g) management measures throughout the State's coastal zone, including Phase I stormwater areas, as long as the NPDES requirements are met for areas subject to NPDES requirements. In general, States are encouraged to develop consistent approaches to addressing urban runoff throughout their coastal zones.

D. Marinas

Another specific overlap between the stormwater program and this coastal nonpoint source program occurs in the case of marinas. EPA intends that the management measures guidance for marinas and recreational boating apply only to sources that are not currently required to apply for and receive an NPDES permit. In the (g) guidance, EPA has attempted to avoid addressing marina activities that are clearly regulated point source discharges. Any stormwater discharge that is ultimately issued an NPDES permit will become exempt from this guidance and from the coastal nonpoint pollution control program at the time that the permit is issued.

Marinas contributing stormwater runoff to municipal sewer systems serving a population of 100,000 or more are a part of the municipal NPDES permit and are not covered by the coastal nonpoint source program. Marinas are also required to obtain permits for those portions of the marina that are involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication) and equipment cleaning operations. However, many marinas are not currently required to apply for and receive NPDES permits. The (g) management measures are applicable to marinas and the parts of marinas that are not required to apply for NPDES permits.

E. Other Point Sources

Overlapping areas between the point source and nonpoint source programs occur in addition to storm water and marinas. For example, concentrated animal feeding operations that meet particular size or other criteria are defined and regulated as point sources under the section 402 permit program, while other confined animal feeding operations are not currently regulated as point sources. Overlaps may occur with respect to aspects of mining operations, oil and gas extraction, land disposal, and other activities.

EPA intends that the coastal nonpoint pollution control programs to be developed by the States apply only to sources that are not currently required to apply for and receive an NPDES permit, and that the management measures similarly apply only to sources that are not required to apply for and receive an NPDES permit. In the (g) guidance, EPA has attempted to avoid addressing activities that are regulated point source discharges.

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APPENDIX C: List of Section 6217(g) Management Measures

Management Measures for Agriculture Sources

Erosion and Sediment Control Management Measure

Management Measure for Facility Wastewater and Runoff from Confined Animal Facility Management (Large Units)

Management Measure for Facility Wastewater and Runoff from Confined Animal Facility Management (Small Units)

Nutrient Management Measure

Pesticide Management Measure

Grazing Management Measure

Irrigation Water Management

Management Measures for Forestry

Preharvest Planning Management Measure

Streamside Management Areas (SMAs)

Road Construction/Reconstruction Management Measure

Road Management

Timber Harvesting

Site Preparation and Forest Regeneration Management Measure

Fire Management

Revegetation of Disturbed Areas

Forest Chemical Management

Wetlands Forest

Management Measures for Urban Areas

New Development Management Measures

Watershed Protection Management Measure

Site Development Management Measure

Construction Site Erosion and Sediment Control Management Measure

Construction Site Chemical Control Management Measure

Existing Development Management Measure

New Onsite Disposal Systems Management Measure

Operating Onsite Disposal Systems Management Measure

Pollution Prevention Management Measure

Management Measure for Planning, Siting and Developing Roads and Highways

Management Measure for Bridges

Management Measure for Construction Projects

Management Measure for Construction Site Chemical Control

Management Measure for Operation and Maintenance

Management Measure for Road, Highway, and Bridge Runoff Systems

Management Measures for Marinas and Recreational Boating

Marina Flushing Management Measure

Water Quality Assessment Management Measure

Habitat Assessment Management Measure

Shoreline Stabilization Management Measure

Storm Water Runoff Management Measure

Fueling Station Design Management Measure

Sewage Facility Management Measure

Solid Waste Management Measure

Fish Waste Management Measure

Liquid Material Management Measure

Petroleum Control Management Measure

Boat Cleaning Management Measure

Public Education Management Measure

Maintenance of Sewage Facilities Management Measure

Boat Operation Management Measure

Management Measures for Hydromodification: Channelization and Channel Modification, Dams, and Streambanks and Shoreline Erosion

Management Measure for Physical and Chemical Characteristics of Surface Waters

Instream and Riparian Habitat Restoration Management Measure

Management Measure for Erosion and Sediment Control

Management Measure for Chemical and Pollutant Control

Management Measure for Protection of Surface Water Quality and Instream and Riparian Habitat

Management Measure for Eroding Streambanks and Shorelines

Management Measures for Wetlands, Riparian Areas, and Vegetated Treatment Systems

APPENDIX D: List of States and Territories with Approved Coastal Zone Management Programs

ALABAMA	NEW HAMPSHIRE
ALASKA	NEW JERSEY
AMERICAN SAMOA	NEW YORK
CALIFORNIA	NORTH CAROLINA
CONNECTICUT	NORTHERN MARIANA ISLANDS
DELAWARE	OREGON
FLORIDA	PENNSYLVANIA
GUAM	PUERTO RICO
HAWAII	RHODE ISLAND
LOUISIANA	SOUTH CAROLINA
MAINE	VIRGIN ISLANDS
MARYLAND	VIRGINIA
MASSACHUSETTS	WASHINGTON
MICHIGAN	WISCONSIN
MISSISSIPPI	

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APPENDIX E: Overview of Existing National Efforts to Control Nonpoint Source Pollution

Section III.G of this document describes the statutory requirement for administrative coordination. It also describes EPA's and NOAA's expectation that state coastal nonpoint source programs build on and complement, rather than duplicate and conflict with, other Federal statutory requirements and state-implemented programs. The following section describes several existing and on-going efforts to control nonpoint source pollution. State coastal zone and nonpoint source agencies are encouraged to work with these programs in implementing their coastal nonpoint programs.

EPA Programs

1. Clean Water Act Section 319 - Nonpoint Source Program

A number of local, state and Federal programs have been implemented over time to address nonpoint source pollution. However, the first national program to authorize Federal funding for the control of nonpoint sources began in 1987 when Congress passed the Water Quality Act of 1987, enacting section 319 of the Clean Water Act, which established a national program to control nonpoint sources of water pollution. Section 319 requires that, in order to be eligible for federal funding, states develop an assessment report detailing the extent of nonpoint pollution, and a management program specifying nonpoint source controls. Section 319 authorizes EPA to issue grants to states to assist them in implementing their nonpoint source management programs or portions of management programs that have been approved by EPA.

As of August 1992, all states and territories had approved nonpoint source assessments and management programs or portions of management programs. Congress appropriated $40 million in section 319 FY 1990 and $51 million in FY 1991 funds to assist States in implementing their management program.

2. Clean Water Act Section 320 - National Estuary Program

EPA also administers the National Estuary Program under section 320 of the Clean Water Act. This program focuses on point and nonpoint pollution in geographically targeted, high-priority estuarine waters. Under this program, EPA assists state, regional and local governments in developing estuary-specific comprehensive conservation and management plans that recommend corrective actions to restore and maintain estuarine water quality and to protect fish populations and other designated uses of these targeted waters. To date, seventeen estuaries have been designated as part of the National Estuary Program.

3. **Near Coastal Waters Program**

The Near Coastal Waters (NCW) Program serves as a primary vehicle for implementing environmental protection in coastal areas under a variety of programs and authorities. It is also the framework for coastal regions for carrying out Agency directives, strategic themes, and other initiatives not specifically related to distinct program issues. Examples of these cross-cutting themes include geographic targeting for management attention; pollution prevention; and setting priorities based on the expected efficacy of preventive measures as well as the magnitude of ecological or human health risks. Specific objectives include:

- directing and focusing EPA's coastal activities within priority geographic areas;
- promoting linkages among programs;
- encouraging a comprehensive approach to problem assessment and management; and
- maximizing environmental results.

The NCW Program is implemented through two basic components: specific national activities which provide direction, support, and oversight; and Regional development of NCW Strategies that serve to implement the Program within EPA's Regions and that are carried out through activities described in annual work-plans.

4. **Ground Water Protection Programs**

EPA has a number of programs, in addition to section 319, to control nonpoint source pollution of ground water. Since at least 1984, ground water protection programs have provided technical and financial assistance to states for the development of state ground-water strategies and, more recently, Ground Water Protection Programs. Under the Safe Drinking Water Act, EPA may designate sole source aquifers. These are aquifers that are the sole or principal of drinking water source for an area. At EPA's discretion, no commitment for federal funds can be made for projects that will contaminate these aquifers. In addition, the 1986 amendments to the Safe Drinking Water Act established a Wellhead Protection program. This program was created to protect ground waters that supply wells and wellfields that contribute to public drinking water supply systems. USDA and EPA are also cooperating under a program to assess private drinking water wells on farmsteads.

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5. **Pesticides Program**

EPA's pesticides program under the Federal Insecticide, Fungicide, and Rodenticide Act addresses some forms of nonpoint pollution. Among other things, this statute authorizes EPA to control pesticides that may threaten ground water and surface waters. In determining the appropriate regulatory approach for specific pesticides, EPA uses the following step-by-step approach:

1) EPA determines the pesticide's potential for leaching into ground and surface water; 2) if there is such potential, EPA considers whether establishing national label restrictions (enforceable under FIFRA) would adequately address leaching concerns (included in these restrictions can be classification of the pesticide as "restricted-use," which requires application by a trained, certified applicator; requirements for certain methods of application, safe handling, storage, and disposal; etc); 3) if these restrictions are not adequate to address the potential problem, EPA will determine whether providing states with the opportunity to develop Pesticide State Management Plans for the chemical will effectively address the unreasonable risk from pesticide contamination. In the event that Pesticide State Management Plans could not sufficiently reduce the risks to human health and the environment (i.e., an unreasonable risk remains), then EPA would resort to national cancellation of the pesticide.

Pesticide State Management Plans will be developed by state agriculture, water/environment, and health agencies and will prescribe pesticide application measures to protect ground water that is vulnerable to pesticide contamination. Required components of these Plans will include: state philosophy and goals, state roles and responsibilities, legal authority, resources, assessment and planning, monitoring, prevention, response, enforcement, public awareness and participation, information dissemination, and records and reporting.

Since areas to be managed under State Pesticides Management programs and coastal nonpoint programs may overlap in developing the coastal nonpoint programs' management measures for agricultural pesticides, state coastal zone and nonpoint source agencies should work with the State Lead Agency for Pesticides (or the state agency that has a lead role in developing and implementing the State Management Plan). Such coordination is necessary to ensure that program efforts and pesticide management measures and practices to protect ground and surface water, complement and are not in conflict with the pesticide label and with requirements in the Pesticide State Management Plans. (For instance, if a Pesticide State Management Plan prescribes a moratorium on pesticide use in one are, the coastal nonpoint program should not allow pesticide use in that area). In states where Pesticide State Management Plans have not been developed, planning efforts for the two programs should be closely coordinated.

6. Wetlands Protection Program

EPA's wetlands program also has undertaken a number of projects to increase awareness of the relationship between the protection and restoration of wetlands and nonpoint source control. In 1990, the agency developed guidance to encourage coordination of nonpoint sources and wetlands programs, both within EPA and the states, to attain water quality goals shared by the two programs. In addition, EPA has released guidance on how to ensure effective application of water quality standards to wetlands. Projects in this area include:

Efforts with other Federal Agencies: The Wetlands Division is working with several agencies to develop methods and transfer information on protecting and restoring wetlands in ways which can be expected to provide nonpoint source abatement benefits:

- The Wetlands Division is working with members of the Interagency Task Force on Floodplain Management and the Association of State Floodplain Managers to better protect and enhance the natural and beneficial values of the Nation's floodplain by promoting the concept of comprehensive or multi-objective river corridor management. Managing river corridors for multiple uses provides the opportunity for communities to simultaneously address nonpoint source pollution, water quality, flooding, recreation, habitat and any number of needs and challenges.

- The Wetlands Division is initiating a pilot project with USDA, the Fish and Wildlife Service, and non-profit groups to encourage landowner participation in USDA's Wetland Reserve Program. By working cooperatively, these groups will help landowners identify wetland restoration sites that will improve water quality as well as enhance other wetland values.

Development of technical and outreach materials: The Wetlands Division has worked with a number of other EPA offices and regions to develop materials that can increase awareness of the important role wetlands play in improving water quality.

- Publications include: "Livestock Grazing on Western Riparian Areas"; "Summary of Section 319(h) Wetlands and Riparian Projects for Fiscal Years 1990 and 1991"; and "Beyond the Estuary: The Importance of Upstream Wetlands to Estuarine Processes" which focuses on the beneficial effects that upstream wetlands have on the downstream water quality in estuaries.

- EPA has released technical guidance to States on how to ensure effective application of water quality standards to wetlands. The development of standards provides the foundation of a broad range of water quality management activities including, but not limited to, monitoring under Section 305(b), permitting under

Sections 402 and 404, water quality certification under Section 401, and control of nonpoint pollution under Section 319.

- The Wetlands Division is developing a manual on best management practices to protect wetlands from excessive stormwater runoff and to avoid overloading their water quality improvement functions.

Criteria to address nonpoint source pollution: EPA is providing support for the development of criteria to address the many types of nonpoint source pollutants including nutrients, clean sediment, and organic contaminants (e.g., pesticides). The Wetlands Division is assisting in the development of wildlife criteria applicable to all waterbody types and biological criteria for wetlands.

Wetlands Regional Contacts: For more information regarding regional or state initiatives, contact the EPA regional wetlands coordinator.

Region I	(617) 565-4422
Region II	(212) 264-5170
Region III	(215) 597-9302
Region IV	(404) 347-2126
Region V	(312) 886-0243
Region VI	(214) 655-2263
Region VII	(913) 551-7573
Region VIII	(303) 293-1570
Region IX	(415) 744-1971
Region X	(206) 553-1412

NOAA Programs

Coastal Zone Management Program

The Coastal Zone Management Act of 1972 established a program for states and territories to voluntarily develop comprehensive programs to protect and manage coastal resources. In order to receive Federal approval and implementation funding, states and territories must demonstrate that they have programs, including enforceable policies that are sufficiently comprehensive and specific to regulate land uses, water uses, and coastal development; and to resolve conflicts among competing uses. In addition, they must have the authority to implement the enforceable policies. The programs operates within a coastal zone bound any which includes coastal waters and those which have a direct one significant impact on coastal waters.

There are currently 29 federally approved state and territorial programs. Despite institutional differences, each program must protect and manage important coastal resources, including: wetlands, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitats. Resource management and protection is accomplished in a number of ways through state laws, regulations, permits, and local plans and zoning ordinances.

While water quality protection is integral to the management of many coastal resources, it was not specifically cited as a purpose or policy of the original statute. The Coastal Zone Act Reauthorization Amendments of 1990 specifically charged state coastal programs, as well as state nonpoint source programs, with addressing nonpoint source pollution affecting coastal water quality.

USDA Programs

The U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service (ASCS), Soil Conservation Service (SCS) and Extension Service administer a number of programs that contribute to reducing nonpoint pollution from agricultural production.

Agricultural Conservation Program

The Agricultural Conservation Program, administered by ASCS, provides cost-share funds to farmers and ranchers to install conservation practices. The program has several goals including: conserving soil and water, improving water quality, protecting and maintaining productive farm and ranch land, and preserving and developing wildlife habitat.

ASCS also administers the Conservation Reserve Program (CRP), designed to protect the nation's most highly erodible land and to protect and improve water quality. Under the CRP, farmers are reimbursed for retiring highly erodible and environmentally sensitive croplands from production under ten year contracts. Water quality improvements occur as lands are taken out of production because of lower fertilizer and pesticide applications and because reductions in soil erosion decrease sediment loadings to water. Land enrolled in the reserve program also provides habitat and other environmental benefits.

Criteria for the conservation reserve program have been expanded to include environmentally sensitive lands such as filter strips, wetlands and wellhead protection areas.

Soil Conservation Service

The Soil Conservation Services (SCS) is the technical arm of USDA. SCS provides technical assistance to conservation districts throughout the U.S. Under the President's Water Quality Initiative, started in 1989, SCS is focusing some of its technical assistance on a number of demonstration projects to address water quality problems. SCS staff are also located in many of EPA's Regional Offices to provide technical assistance and support to the States and EPA. SCS is also providing accelerated technical assistance to multi-state, regional projects such as the Chesapeake Bay Program, the Gulf of Mexico, the Great Lakes National Program, Land and Water 201, and the National Estuary Program.

Nonpoint Source Hydrologic Unit Areas

In selected agricultural watersheds and aquifer recharge areas, SCS, Extension Service, and cooperating federal, state and local agencies will provide technical assistance and conservation planning to help farmers and ranchers meet state water quality goals without undue economic hardship. These hydrologic units are selected based on: significance of the agricultural sources of pollution, relative predominance of pollutants such as pesticides, nutrients, and animal wastes, and conformance with other water quality efforts. Findings on the water quality effects of selected conservation practices will provide a basis for expanding applications of such practices to other areas with similar water quality problems.

Forest Service

The Forest Service managers 191 million acres of public forest and range land for multiple use purposes. These lands comprise the National Forest System. EPA and the Forest Service held a joint technical workshop in Oregon this past winter on sediment and water quality. This meeting reflects the increased concern regarding the potential impacts of sediment production from forest management activities on water quality and aquatic life.

President's Water Quality Initiative

In 1989, President Bush launched an initiative to protect ground and surface water from contamination of fertilizers and pesticides. Congress has funded the initiative in the past several years. USDA, EPA, USGS, and NOAA are all working together on this initiative through a series of work groups. Through this initiative, a number of watershed projects have begun to address fertilizer and pesticides problems. The agencies are tracking the implementation progress in these watersheds.

U.S. Geological Survey

EPA and the U.S. Geological Survey have signed a memorandum of understanding (MOU) pledging cooperation and collaboration on water quality monitoring and assessment activities. Both agencies expend much effort on monitoring and assessment activities and the MOU is a tool to coordinate these efforts.

APPENDIX F: Designated Uses and Support Levels

DESIGNATED USES

Wildlife	Fish and wildlife
Fishery	Warmwater Fishery Coldwater Fishery
Shellfishery	Shellfish protection
Drinking water	Domestic water supply
Agriculture	Agriculture Irrigation Livestock watering
Industry	Industrial
Recreation	Recreation Primary contact Secondary contact Noncontact
Navigation	Navigation
High Quality	High Quality Nondegradation

SUPPORT LEVELS

Fully Supported	= all uses supported
Partial Support	= one use not supported
Non-support	= 2 or more uses not supported
Threatened	= all uses supported, but one or more uses may not be fully supported in the future (unless additional management measures are implemented) because of anticipated new or expanded sources

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APPENDIX G: State Coastal Nonpoint Program Submission

1. DESCRIBE PROGRAM GOALS AND OBJECTIVES

The introduction should include a description of the magnitude and distribution of sources of nonpoint pollution in the 6217 management area.

2. DESCRIBE OVERALL PROGRAM COMPONENTS

a. **§6217 Management Area**
Respond to NOAA's boundary recommendation.
[§6217(b)(7); Program Guidance, p.9]

b. **Coordination Mechanisms**
Describe the mechanisms which have been established to coordinate among the state, regional, and local agencies responsible for implementing portions of the program. [§6217(b)(6); Program Guidance, p.33]

c. **Public Participation**
Describe the process used to ensure full public participation in the development and implementation of the program. [§6217(b)(5); Program Guidance, p.32]

d. **Technical Assistance**
Describe the state program for technical assistance to localities and the public. [§6217(b)(4); Program Guidance, p.31]

e. **Water Quality Monitoring**
Describe activities to monitor the effectiveness of management measures (see Chapter 8 of the (g) Guidance). States may choose to design specific monitoring programs for individual source categories.

3. DESCRIBE MANAGEMENT MEASURES "in conformity with" (g) GUIDANCE

State programs should address each management measure identified in the (g) Guidance for the six source categories: agriculture, forestry, urban, marinas, hydromodification, wetlands and riparian areas. The following information should cover each management measure, but may be provided by source category, subcategory, or individual management measure.

a. **Covered Sources**
Identify nonpoint source categories and subcategories in the 6217 management area. Identify the categories or subcategories specified in the (g) Guidance which 1) do not exist in the 6217 management area or 2) may be excluded based on Program Guidance criteria, p.13.

b. **Management Measures**
Identify the (g) Guidance measure or alternative measure to be implemented. Alternative measure must include technical documentation. [Program Guidance, p.15]

c. **Management Practices**
Describe state practices to implement measure or the process for selecting practices to meet site-specific conditions. Include operation and maintenance practices where appropriate.

d. **Lead Agency**
Identify the lead agency and cooperating agencies responsible for implementation of the management measure. Identify available resources (staff, funding, etc.)

e. **Enforceable Policies and Mechanisms**
Cite state and local authority to ensure implementation of the management measure, including inspection and monitoring provisions. If the program relies on local or regional authorities, cite state oversight authority to ensure implementation. [§306(d)(16); Program Guidance, p.34]

f. **Schedule**
Describe schedule, including milestones, to ensure implementation of management measures for existing sources within three years of program approval or conditional approval. New sources are subject to management measures at time of program approval. [Program Guidance, p.44]

4. DESCRIBE ADDITIONAL MANAGEMENT MEASURES

Describe the implementation of additional management measures including the following information:

a. **Impaired and Threatened Coastal Waters**
Identify impaired and threatened coastal waters using existing water quality assessments. [§6217(b)(1)(a); Program Guidance, p.23]

b. **Land Uses**
Identify land uses in the 6217 management area which individually or cumulatively may cause or contribute to a degradation of coastal waters. Use(g) Guidance source categories as a starting point and add others appropriate to state conditions. [§6217(b)(1); Program Guidance, p.24]

c. **Critical Coastal Areas**
Identify and map, critical areas adjacent to impaired and threatened coastal waters. [§6217(b)(2); Program Guidance, p.25]

d. **Additional Management Measures**
Describe measures that will be implemented at time of program approval 1) in critical areas and 2) in cases where (g) Guidance measures (or their equivalent) are fully implemented for certain source categories or subcategories, but water quality threats or impairments persist.

Describe process for determining the need for additional measures to meet water quality standards even after implementation of (g) Guidance measures. Describe process for revising measures.

e. **Enforceable Policies and Mechanisms**
Cite state and local authority to ensure implementation of the management measure, including inspection and monitoring provisions. [§306(d)(16); Program Guidance, p.34]

f. **Schedule**
Describe schedule, including milestones, to ensure implementation of management measures for existing sources within three years of program approval or conditional approval. [Program Guidance, p.44]

Appendix H: Demonstrated Benefits of Trading

I. SIGNIFICANT TECHNICAL DOCUMENTS

A. Emissions Trading: An Exercise in Reforming Pollution Policy, 1985. T.H. Tietenberg.

In Emissions Trading: An Exercise in Reforming Pollution Policy, Tietenberg references studies that show that trading may be used in lieu of command-and-control approaches to limit biological oxygen demand in water. The studies demonstrate that trading can lower costs by factors of 1.12 to 3.13 without affecting benefits. Tietenberg also discusses a variety of air emission studies that illustrate that trading can lower the costs of achieving environmental objectives by factors ranging from 1.07 to 22.

B. "Financial Cost Effectiveness of Point and Nonpoint Source Nutrient Reduction Technologies in the Chesapeake Bay Basin," 1991. R. Camacho.

Trading can offer very large cost savings to sources while achieving quality goals. In order to offer gains to all market participants, incremental costs of pollution control must differ between sources. Camacho demonstrates this in "Financial Cost Effectiveness of Point and Nonpoint Source Nutrient Reduction Technologies in the Chesapeake Bay Basin." The article states that for nitrogen and phosphorus, the cost effectiveness of controls differs by as much as a factor ten. This differential provides the necessary economic incentive for trading to be effective.

C. The Private Use of Public Interest, 1975. C. Schultze

Schultze presents trading programs as a means of harnessing the private incentives of polluters for public purpose in The Private Use of Public Interest. Trading programs allow sources with low control costs to undertake additional abatement efforts in exchange for compensation from high-cost sources. More pollution abatement is therefore undertaken where it is cheapest, and less is undertaken where it is costly. Such a trading scheme minimizes the total cost of achieving loading reductions.

D. "Incentive Analysis for Clean Water Act Reauthorization: Point Source/Nonpoint Source Trading For Nutrient Discharge Reductions," 1992. USEPA.

"Incentive Analysis for Clean Water Act Reauthorization: Point Source/Nonpoint Source Trading For Nutrient Discharge Reductions" provides an assessment of trading potential for nutrient discharges to surface waters. The report states that

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over 900 water quality-limited waterbodies could potentially benefit from trading under current conditions, and that the best opportunities are for trading nutrient allocations.

E. "Point Nonpoint Source Trading of Pollution Abatement: Choosing the Right Trading Ratio," 1992. A. Malik.

The question of the right trading ratio for trades between point sources and nonpoint sources has been addressed by Malik et. al. in "Point Nonpoint Source Trading of Pollution Abatement: Choosing the Right Trading Ratio." Two types of uncertainty are recognized: the effectiveness of nonpoint source controls, and NPS loadings reductions attributable to weather. Uncertainty in the effectiveness of nonpoint source controls would justify higher trading ratios, which imply expected net reductions in loadings. The uncertainty attributable to weather, however, may justify lower ratios.

II. NOTABLE CASE STUDIES

A. Dillon Reservoir, Colorado

The Dillon Water Quality Management Plan established the nation's first point/nonpoint source phosphorus trading program. The program is driven by the reservoir's phosphorus limit and a perceived need to offset new nonpoint sources of phosphorus with phosphorus removals elsewhere in the watershed. A 2:1 trading ratio was established in which point sources received a credit of one additional pound of phosphorus above their allocation for every 2 pounds of phosphorus removed from a nonpoint source that existed before 1984. This ratio establishes a safety margin and has also been used in two trades to offset increased loadings from new nonpoint source discharges to the reservoir.

B. Tar-Pamlico, North Carolina

A point/nonpoint source trading program was developed as part of the overall nutrient management strategy of the Tar-Pamlico River Basin. Under the established rules of this trading program, it is anticipated that trading will achieve equivalent or better water quality than would have been achieved under originally proposed effluent limits. The trading program allows a coalition of point source discharges (the Basin Association) to fund less expensive nonpoint source controls, thus avoiding high compliance costs associated with major facility upgrades. Monies generated by trading go into a fund where they are subsequently allocated by the Division of Soil and Water Conservation for nonpoint source control implementation.

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C. Cherry Creek, Colorado

Several years ago, the citizens of Cherry Creek Reservoir in Colorado anticipated a significant population increase as a result of development pressure. It was determined that this growth would result in an exceedance of the reservoir's phosphorus budget by 1990. The Cherry Creek trading program will allow the reservoir to accommodate growth by permitting municipal wastewater treatment plants to gain waste load allocation credits in exchange for the implementation of nonpoint source controls. Because the greatest amount of phosphorus loading comes from nonpoint sources, the trading program will go into effect only after urban nonpoint sources reduce their loading by 50 percent.

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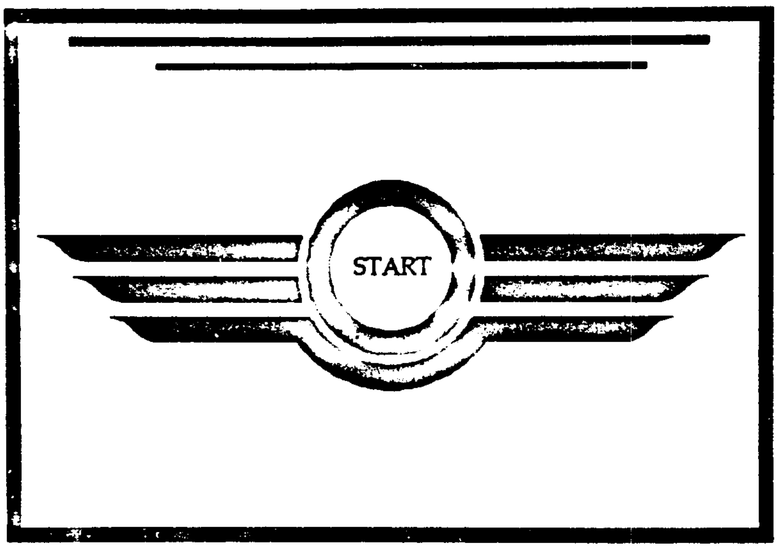

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in cooperation with

U.S. Environmental Protection Agency

August 1994

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Fundamentals of Urban Runoff Management:

Technical and Institutional Issues

By
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Joseph J. Skupien
and
Eric H. Livingston and H. Earl Shaver
Watershed Management Institute

Produced by
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The authors also acknowledge the support of Tom Davenport, U.S. Environmental Protection Agency, Region 5, whose continuing dedication to solving urban runoff management problems led to the Chicago conference and this manual.

Finally, the authors thank Bobbi Shulman for editing this manual and converting the technical writing into a readable and understandable format.

Produced under the direction of Lura T. Svestka, edited by Roberta F. Shulman, and designed and typeset by Jessica A. Johnson.

Dedication

This manual is dedicated to the memory of an individual who, for many years, carried the banner of resource protection through scientific study and analysis. D. Earl Jones, who passed away in 1991, was a leader in water resources research and a friend. We need more such individuals if our efforts to protect and maintain water quality are to be successful.

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Introduction

This manual departs from the traditional urban runoff management design manual—in addition to providing technical information, the manual offers an in-depth discussion of institutional issues.

Traditional urban runoff management design manuals from states, regional authorities, and local governments present best management practices (BMPs) or pollution prevention practices. However, they normally offer little guidance on the institutional structure or framework necessary to ensure that BMPs are implemented and continue to function. In this manual—designed for program managers, engineers, technical staff, biologists, and others who have urban runoff management responsibility—even the technical chapters stress the program aspects of urban runoff management.

To engender support from elected officials, industry, and the general public, professionals need background information on urban runoff quantity, pollutant sources, and their associated impacts. Professionals need to ensure that decisionmakers understand the serious nature of the urban runoff problem so that the problem receives the priority and attention it deserves.

Historically, our society has lived and worked in a narrowly defined environment, only aware of relationships affecting us individually. In today's era of global communication and travel and with our increased understanding of the impacts of our activities, we can no longer ignore our effects on aquatic and terrestrial resources. Our awareness obligates—or should obligate—us to address the problems our actions cause. Information in this manual is intended to explain the impacts that urban land uses have on our receiving systems.

After presenting the fundamentals of urban runoff hydrology and the impacts of urban land use in Part I, Part II presents guidance on the various types of runoff control measures and practices available. In addition to the more traditional structural measures, the manual also presents nonstructural strategies and practices. These nonstructural practices, based largely on ordinary common sense, can both enhance the performance and longevity of more complex structural measures and, at times, even replace them. This integrated presentation of structural and nonstructural practices is only one example of the dynamic, interactive approach to urban runoff management the manual encourages.

But all these practices and best intentions will not succeed unless we work to establish an infrastructure that provides the overall framework to implement programs. Because the programmatic considerations are as important as the actual urban runoff management practices themselves, half of this manual is devoted to program-related issues.

The manual's recommendations are based on the authors' experience in the technical and programmatic aspects of urban runoff management, with a strong interaction between research and program implementation.

The manual is a summary of materials distributed at a workshop in Chicago in June 1992. This information is valuable for individuals who implement runoff requirements under the National Pollutant Discharge Elimination System, Coastal Zone Act Reauthorization Amendments, or section 319 of the Clean Water Act. Any opinions rendered are those of the authors and do not necessarily reflect the opinions of either the U.S. Environmental Protection Agency or the Terrene Institute.

Since *all* of us contribute to the decline in our natural resources, all will need to alter our daily habits if we are to significantly improve our resource values. Native Americans demonstrate a reverence for the land worthy of emulation if true resource protection efforts are to be successful. In Delaware, the Nanticoke Indians demonstrate this reverence in their daily lives. The following quote shows how our attitudes must change if we are to succeed in addressing our environmental problems:

To the Native American people, Mother Earth is a living, breathing entity.
The rocks and coal in the soil are her bones.
The rivers and oceans are her blood.
The trees and plants are her hair, and the wind is her breath.
All living creatures are her children, they are our brothers and sisters.
If we fail to protect our brothers and sisters, we do not respect our Mother Earth.
Each step upon the Earth is a sacred dance.

Charles C. "Little Owl" Clark, IV
Nanticoke Native American
Millsboro, Delaware

Richard R. Horner
Eric H. Livingston
H. Earl Shaver
Joseph J. Skupien

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PART I

Technical Issues

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CHAPTER 1

Hydrologic Impacts of Land Use Change

Urban runoff is a by-product of the land's interaction with rainfall. Since, by definition, urban runoff remains on and moves along the land's surface, it is the most visible of the many forms into which rainfall is converted. This chapter provides the technical fundamentals of the rainfall-runoff and soil erosion processes. It also describes ways that land development alters these processes and quantifies some of the adverse impacts.

The amount or volume of runoff produced by a rain event and the rates, depths, and velocities at which it flows during and after the event depend on several factors. They include the amount and rate of the rainfall and the amount of other forms into which rain is converted. These "conversions" are related to several land characteristics, including depth, slope, and permeability of both the surface and subsurface soils; the extent and character of any surface vegetation; and the degree of moisture already present in the soil. Other important factors typically encountered when the land undergoes a use change, or development, include the extent of impermeable surfaces covering the soil and the presence and efficiency of any conveyance system created through natural processes or constructed through human processes to drain runoff from the land.

Runoff directly affects the surface it flows within and across. These effects are most readily seen as erosion and sediment, as the forces created by runoff moving along the ground surface—as well as the initial impact of the raindrops themselves—dislodge and transport surface particles downstream to slower velocity areas. When runoff velocities can no longer transport the heavy particles, they drop out of the flow and back onto the surface.

Similar to the rainfall-to-runoff process, the amount of erosion and the character of the eroded material depend on several factors, including the flow volume, rate, duration, and the character of the surface material. Soil erosion has several major consequences:

- The original sites of the eroded material are degraded, therefore, potential productivity is lessened;
- The sites of soil particle deposition are altered physically, chemically, and hydrologically; and
- The chemical and physical nature of the transporting water system is affected.

From this information, three key aspects of urban runoff now come into focus:

- Since the amount and rate of urban runoff from a given storm event depend not only on the rainfall but also on the characteristics of the land on which runoff falls, changing the land characteristics can increase the runoff amount and/or rate, sometimes with disastrous results.
- An increase in runoff amount and rate can also increase the erosion of land surfaces and stream channels and change the quality of the runoff.
- The fundamental characteristics of the rainfall-runoff and erosion-sedimentation processes are not mysterious. With the information and references presented in this chapter and some logical thinking, those involved in developing urban runoff management programs at *all levels* can base their efforts on a sound understanding of the hydrologic processes at the core of the program.

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This first chapter will provide all readers—from novices to veterans of urban runoff management—fundamental technical information on urban runoff, soil and channel erosion, and the quantitative impacts of land development. The chapter also highlights some of the unknowns and uncertainties of both processes, to the extent of our current understanding. It also discusses various computational methods and models typically used to supply quantitative answers. The chapter concludes with advice and insights into the technical aspects of developing a runoff management program.

This broad approach will not only help the reader understand the technically complex urban runoff management topics presented in later chapters, it will also help ensure that decisions on a specific runoff management program will be founded on an informed understanding of runoff fundamentals. The chapter also provides a list of recommended textbooks and other references from a large body of technical material currently available. Because of the chapter's broad scope and focus on "learning the fundamentals first," readers should use the reference material to expand their knowledge beyond the manual's pages.

Throughout this chapter, the technical information regarding urban runoff hydrology is presented not as an end in itself but to assist in developing urban runoff management programs. This style, which varies somewhat from more traditional textbooks, should make the technical information more understandable to readers unaccustomed to a traditional approach. In addition, the style also allows the more experienced reader to view the technical aspects of urban runoff hydrology from a different perspective.

Finally, while melting snowfall also produces runoff, the complexities of the melting process are beyond the technical scope of this chapter. Therefore, discussion of runoff will be limited to rain events.

Real Versus Design Conditions

In technical subject matter, important differences exist between "real" and "design" conditions. This distinction is important when establishing a technology-based regulatory program. The "real" process that actually occurs during a storm event can be extremely complex, not only in its physical or mechanical behavior, but also in the numerous and highly variable external factors and conditions influencing it.

In the case of urban runoff hydrology, for example, the mechanics of evapotranspiration are extremely complex. They are strongly influenced by numerous external factors such as rainfall amount and intensity, antecedent moisture conditions, the character and condition of the vegetation, ambient air temperature, humidity, and wind speed—all of which can vary greatly from storm to storm. This inherent complexity of the mechanical processes—and the conditions under which they function—makes it difficult to precisely compute the runoff volume from a real storm event. Determining the exact level or value of all the influencing factors that exist when a storm event occurs is overwhelming.

On the surface, this inability to precisely analyze real storm events does not bode well for a regulatory program intended to manage the resulting runoff. Fortunately, differences can be predicted using simplifications between real and "design" events—i.e., hypothetical or future events. To deal with hypothetical events, we can preset all the external factors and conditions that will exist when the future storm event occurs. We can even decide that certain factors have no significant effect. We can also assume that the actual mechanical process will not be as complicated in our design world as in the real world. These simplifications will certainly make our analysis easier. But how can we be sure that it remains accurate and workable?

To achieve simplicity, accuracy, and usable design parameters, we must be able to make simplifying assumptions that are conservative or safe. This means that the predicted results of these assumptions will be on the safe side of the real answer, if we could compute it. For example, suppose our regulatory program required temporary storage of increased runoff from a land development site, as many do. A safe assumption for the value of any influencing factor would be one that would compute a runoff volume greater than what would actually occur. This will ensure that the constructed runoff storage facility will be larger and presumably safer than what will be required.

To consistently make safe assumptions, we must understand, at least qualitatively, how the real process works and what factors influence it. If dense vegetation covering the ground results in less runoff volume, then to be safe, our analysis might assume that only a thin stand of vegetation exists. Or if the degree of soil moisture before the storm event affects runoff volume, for safety we might assume that this moisture level is greater than average conditions.

We cannot be sure that our assumptions—and, therefore, our programs—are safe unless we understand the technical aspects of urban runoff hydrology well enough to identify all pertinent factors and understand their effect. This is a sound argument for learning the fundamentals first.

To gain a firm understanding of the fundamentals of urban runoff hydrology, we might ask, "How safe is safe?" and, perhaps more importantly, "How safe is too safe?" As our theoretical knowledge and analytical abilities improve, we may learn that the safe assumptions that simplified our computations have resulted in conservative program measures whose size, cost, or management needs are impractical and/or unaffordable. Therefore, the urban runoff management benefits they provide may simply not be worth the expense.

Those with a cursory knowledge of urban runoff hydrology can, in time, learn to make unquestionably safe analytical assumptions. However, only those with an in-depth understanding can consistently make program assumptions and decisions with the right combination of safety, cost, and practicality. To be truly effective, an urban runoff management program must possess large doses of all three.

The Rainfall-Runoff Process

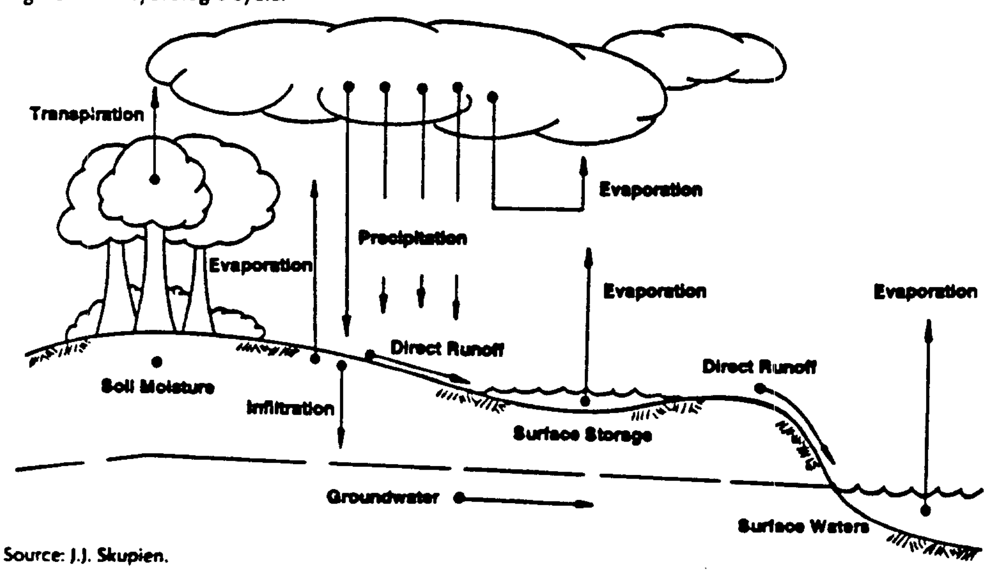
The Hydrologic Cycle

As previously explained, runoff represents a byproduct of the land's interaction with rainfall. While appropriately describing an individual storm event, this conversion process is only one of many that water goes through as it continually moves over, through, or above the land. Therefore, the rainfall-runoff process is an integral part of a cyclical process—the hydrologic cycle—that the earth's water supply continually experiences.

The hydrologic cycle shows the primary components or forms that water can take (Figure 1.1). The figure represents the earth's entire surface and atmosphere, including various forms of water that exist in the atmosphere such as water vapor measured as humidity near the ground surface, clouds comprised of tiny droplets of water condensed from that vapor, and forms of precipitation—created by large droplets too heavy to remain suspended in the clouds.

After arriving on the earth's surface, water follows one of several possible routes. It is absorbed by surface soils, intercepted by vegetation, directly impounded in numerous surface features from small depressions to large lakes and oceans, or infiltrated through the surface and subsurface soils into the groundwater. Another route taken by some water falling as precipitation is runoff.

Figure 1.1—Hydrologic cycle.



Source: J.J. Skupien.

The hydrologic cycle has two important aspects. First, the path of water movement is only half the story. Water also moves from the earth to the atmosphere, primarily through evaporation from surface waterbodies such as the oceans and evapotranspiration by vegetation. In fact, the rates of both movements over time are exactly equal. If they were not, the skies would get *very* cloudy or inland property owners would eventually have ocean or lakeside views. Although we can, and will in coming sections, focus on a single rain storm as a localized, temporary imbalance in this water transfer between the earth and its atmosphere, such a storm event is only one component of a much larger and complex process continually occurring around the planet.

Second, the hydrologic cycle is not easily broken into separate, discrete components. The cyclical process demands that the places water can be and the routes it takes between them are interrelated. Depending on conditions, the water that becomes part of the surface runoff from a parking lot may join the elevated flow in a nearby stream, or the moisture in the soil surrounding the lot, or—if it moves vertically through the soil—the groundwater moving below the lot. In fact, the water that was originally parking lot runoff and then became groundwater beneath it may eventually become streamflow, although well after the initial flooding has passed.

How do we make enough sense of this very common but complex cycle to develop a regulatory process to manage it? By defining the process by (1) the location on the ground that we may affect; (2) the land size and characteristics from which runoff will flow (or drain) to that location; and (3) the time period for which we analyze the continuously operating hydrologic cycle. To assist us, we rely on simplified design conditions to overcome unknowns or uncertainties in the real process that we must quantify in some manner. Finally, we rely on our knowledge of hydrologic fundamentals to ensure that our assumptions are safe, reasonable, and affordable. The following sections present details of these steps.

Runoff Estimation—Typical Parameters

In the previous description of routes that rainfall may follow, runoff was listed last. That is because runoff is the last form or by-product of precipitation used in most runoff estimation techniques for ungaged drainage areas after all the other processes—infiltration by soil, interception by vegetation—have been quantified. That is, we often estimate runoff produced by a given amount of rainfall by subtracting from the total rainfall those portions or percentages likely to become something other than runoff. The remainder is the estimated runoff.

The preceding paragraph uses the term "ungaged drainage area" to qualify the statement concerning runoff estimating techniques. If we were fortunate enough to have some type of gage or metering device to measure the actual runoff over an extended time period, our computations would be more direct and our interest in other aspects of the rainfall-runoff process, including rainfall itself, would be incidental at best. Using this flow data and the knowledge that runoff, like rainfall, is a random event, we could use standardized statistical and probability techniques to estimate the runoff volume, peak rate, duration, and other characteristics for runoff events of various frequencies.

For example, individuals concerned with flooding and flood plain delineation and management could choose a 100-year flood frequency event, technically defined as an event with a 1 percent chance of being equaled or exceeded in any given year. Others concerned with erosion could develop estimates of the two- or five-year flood—having a 50 or 20 percent chance, respectively. While the magnitudes are not as great as the 100-year event, they possess the right combination of frequency and magnitude to define natural channel banks and cause considerable erosion. Finally, individuals concerned with urban runoff quality and the impacts of nonpoint source pollution would probably be most interested in one-year and even more frequent events, since these have the most severe, acute, and chronic water quality effects. A 2.5 year, 24-hour flood is the most frequently used design.

However, while many streams and rivers have been equipped with flow gages by local, state, or federal agencies—including the U.S. Geological Survey (USGS)—gages are primarily meant to address flooding and water supply on a large scale. In contrast, urban runoff management must address localized issues such as construction site runoff and small stream erosion. Even if flow gages were practical on a small scale, we would need several years of actual runoff measurements before we could accurately predict future possibilities.

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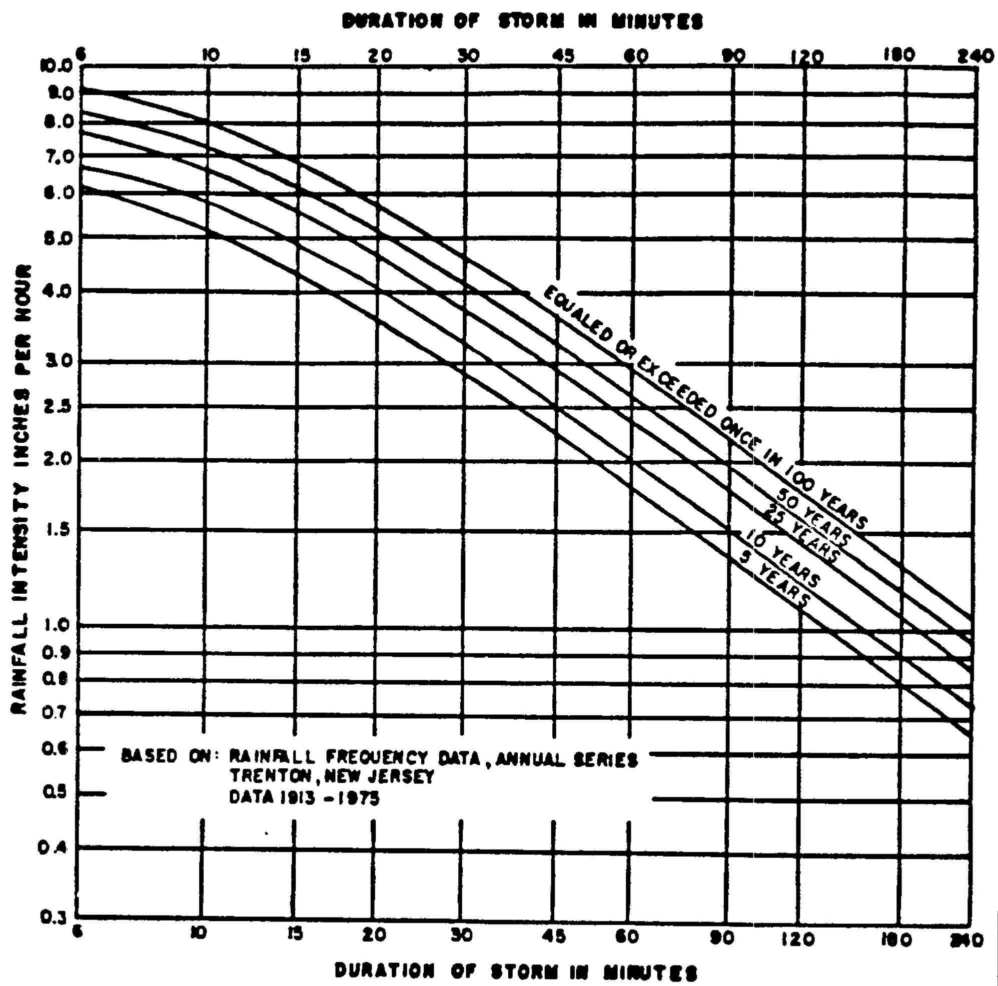
The shear impracticality of installing, operating, and analyzing runoff gages at the scale required for urban runoff management, in addition to some inherent limitations of gaged flow analysis, means that instead of focusing on runoff directly, we must focus on it indirectly by analyzing the rainfall that creates it. We must study the rainfall-runoff process closely and use the runoff byproduct approach previously described.

Most runoff estimation methods use some of the following factors or parameters. They each, therefore, require at least some quantitative estimate of their effects on the final product—runoff.

Rainfall. As the most significant parameter in any runoff estimation process, rainfall is the primary input value. Actual rainfall amounts measured at gages in or near the drainage area are used to analyze real or historic rainfall events. Hypothetical rainfall amounts and intensities are typically used for design or regulatory purposes. Data collected from an actual storm event of appropriate magnitude, if available, can be used to check the design or even serve as the design storm itself. Finally, as computer and data resources increase, real, long-term data—considered the most accurate approach to estimating runoff—is increas-

Figure 1.2—Rainfall intensity-duration-frequency curves for New Jersey.



Source: New Jersey Dep. Environ. Prot. Energy, 1988.

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ingly being used and accepted in continuous rainfall-runoff simulation models.

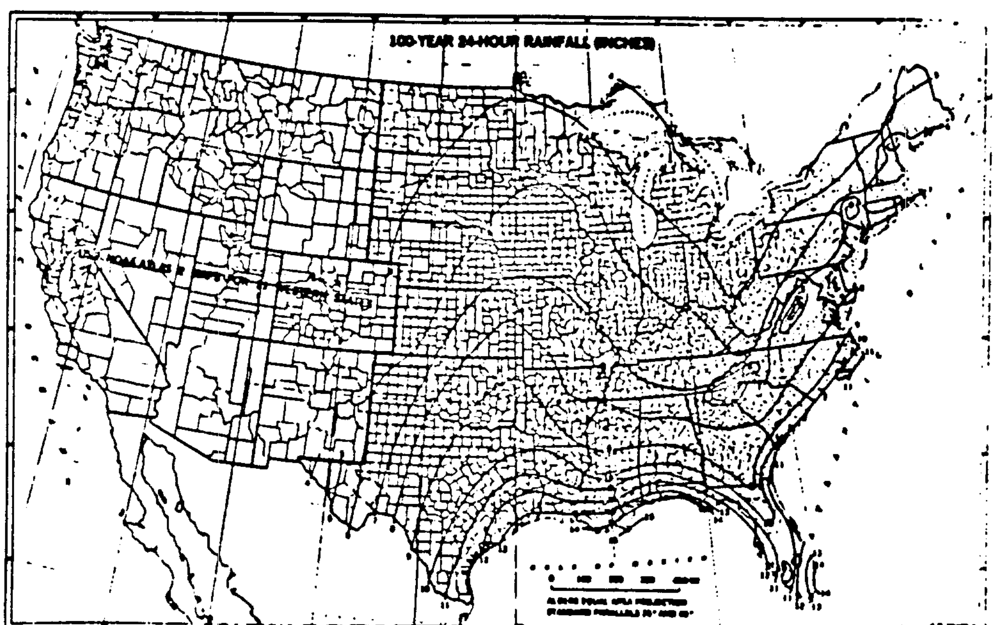
Rainfall data for hypothetical or design events is obtained from statistical compilations and extrapolations of real data collected over a statistically significant time period. Figures 1.2 and 1.3 present two such compilations. Figure 1.2 shows rainfall intensity-duration-frequency curves developed from data collected over a 62-year period at the rainfall gage in Trenton, New Jersey. The curves predict the expected average rainfall intensity for a given frequency storm event over a user-selected time period. For example, the expected five-year average rainfall intensity for a hypothetical rainfall period lasting 30 minutes is approximately 2.8 in (7.1 cm)* per hour. Thus, the total rainfall during the half-hour period will be 1.4 in (3.6 cm).

The curves in Figure 1.3 also show rainfall intensity-duration-frequency relationships, but with some significant differences. Data is presented for the entire United States east of the Rocky Mountains and is expressed for only one duration (24 hours) and frequency (100 years). The rainfall is expressed as a total amount over the time period, rather than as an intensity or rate. Using simple arithmetic, we can compute the average rainfall intensity over 24 hours. The curves in Figure 1.3 are part of a larger set for numerous storm frequencies and durations originally published in *Rainfall-Frequency Atlas of the United States (TP-40)* by the (then) U.S. Weather Bureau. Although TP-40 is out of print, the curves are reproduced in *Urban Hydrology for Small Watersheds (TR-55)*, published by the USDA Soil Conservation Service (USDA SCS). This publication has become a current standard for estimating runoff. This chapter will provide additional information on TR-55 and the USDA SCS hydrologic methodology on which it is based.

To use rainfall data such as that shown in Figures 1.2 and 1.3, the user must select not only the

* Note: Throughout this manual, English measurements are presented first with SI (metric) conversions in parenthesis, except where dual measurements would be confusing, inaccurate, or redundant or where no comparable measurement exists.

Figure 1.3—100-year 24-hour rainfall (inches).



Source: U.S. Dep. Agric. 1986.

rainfall frequency pertinent to the analysis but also the rainfall duration. The element of time or duration is vital to any rainfall-runoff analysis and will be discussed in greater detail later. But for now, the time runoff takes to collect and flow to the point of concern on the ground surface—located at the lowest end of the area draining to that point—is key to selecting the appropriate rainfall duration.

Regarding the element of time, while the data in the figures and in similar charts are based on real storm events, they are not meant to imply any total storm duration or amount. For example, while Figure 1.2 indicates that the five-year rainfall intensity of 2.8 in (7.1 cm) per hour will last for 30 minutes, it gives no indication of the actual storm length. Instead, Figure 1.2 shows a 20 percent chance (the probability of a five-year event) exists that any rain event of at least 30 minutes will contain a 30-minute period that will produce 1.4 in (3.6 cm) of rain—i.e., rain falling at an average rate of 2.8 in (7.1 cm) per hour over a half-hour period. The figures indicate nothing about how the rain fell during the selected time period—they only indicate the total amount that fell. That is why we use the word "average" whenever we discuss rainfall rates.

As analysts, we may be required to select critical rainfall intensities and durations within an overall storm event. The specific runoff characteristic we seek (e.g., peak flow rate versus total volume) will help determine whether or not we need to select a total storm event duration.

Our rainfall discussion would not be complete without mentioning the rain that has fallen during prior storms. While the runoff from this rain may have long since drained from the watershed, some may still be present as soil moisture or stored in surface depressions. Referred to as antecedent rainfall, runoff, or moisture condition, this helps characterize a watershed's potential to produce runoff from a new storm event by describing how wet conditions are from previous storms.

Antecedent runoff conditions are particularly critical when recreating real or historic storm events and when analyzing real or hypothetical storms involving fairly small amounts of total rainfall. For simplicity, many runoff estimating techniques assume that average antecedent conditions are present in the watershed prior to the start of the storm in question. The more sophisticated techniques allow the analyst to vary the input data to reflect some other antecedent condition. Readers should keep antecedent conditions in mind when reviewing discussions of initial abstraction, surface depressions, and soil infiltration.

▌*Time.* The time element plays a critical role in both the real rainfall-runoff process and the methods used to estimate the runoff. This is not surprising, since gravitational, thermodynamic, and other natural forces involved in producing both precipitation and runoff are intrinsically dynamic and constantly changing with, and therefore influenced by, time. This chapter presents a simplified description of how time affects runoff estimates. The reader should further explore the time element through the publications referenced here and the many other excellent ones available.

Two fundamental measures or lengths of time are important when performing runoff estimates, whether for an existing or future condition. The first measure is the response time of a drainage area to a rainfall input. This response time indicates how quickly runoff drains to the bottom of the watershed and how quickly the runoff rate, created by a certain rainfall, will change as the rainfall rate changes. To a lesser degree, this response time may also help determine the runoff volume produced by the rainfall.

Several terms and definitions quantify this response time; most are applicable to a particular runoff estimating technique or method. The most common definition of watershed response is time of concentration (TC), which the USDA SCS and others define as the time runoff—once it has begun—takes to flow from the most distant point in the watershed to the point of interest at the bottom. Numerous procedures, equations, charts, and graphs can help estimate TC, including those presented in Chapter 3 of TR-55.

Remember that TC or any other watershed response time definitions are only conceptual values. A watershed's actual response time is not only affected by numerous and complex factors, it is also constantly changing in length throughout a storm. Therefore, any computed TC estimate is *only* an estimate. The reason is not only because we use simplified data and equations to compute the TC, but also because we assume that a single time represents the watershed throughout the entire storm event. This assumption is critical to remember when computing entire runoff hydrographs.

Regardless of the definition or estimating technique adopted, the most important aspect of the watershed response time is its direct effect on the rate of runoff flow. Since response time determines how quickly the runoff produced throughout a watershed can flow to the bottom or outlet, it determines how much *time* runoff will take to *concentrate* at the bottom. Therefore, whether we seek just the peak runoff rate from a storm event or an estimate of all the various runoff rates during and after a storm period—known as a hydrograph—we must compute a reasonable time estimate. In addition, the shorter the response time, the greater the flow rate for a given runoff volume amount. Or, we can analyze further to determine how an existing runoff rate will be changed if the watershed's response time is altered. More information regarding the impacts of such alterations from land development is presented later.

Since watershed response time also indicates how quickly the runoff rate will change due to changes in rainfall rate or intensity, response time helps us determine the length of rainfall increments needed in a runoff analysis to assure accurate results. Or, stated differently, we learn how short a time period is needed to safely assume an average rainfall rate. For example, a watershed whose outlet takes several hours to respond to the rainfall within it will show little change in runoff rate from a change in rainfall intensity lasting only a few minutes. As a result, we would waste time and effort if we based our analysis on rainfall increments of less than 15 minutes. This aspect of watershed response time helps determine the appropriate time increment for other time-dependent runoff computations such as detention basin, reservoir, and channel/flood plain routings. It can also help us select appropriate sampling and recording intervals required for runoff field studies.

The second fundamental measure or length of time in rainfall-runoff analyses is the total event time. It not only includes the total time for rain to fall, but it frequently includes the time required after the rainfall for a watershed to fully respond. For example, if we wished to compute the total runoff volume from a certain frequency rainfall, we would need to know both the average intensity and total duration. This differs from the peak rate example given in the preceding paragraph. There, we only needed to know the rainfall that fell during the time period, equal to the watershed response time, that produced the peak rate. In addition, if we need this estimate of total runoff volume to design an urban runoff detention or other storage facility at the watershed outlet, then we must extend the total event time to include the additional time the facility prolongs or delays the watershed's response time. This additional time, known as the "interevent dry period" between rain events (Wanielista and Yousef, 1993), has become increasingly important as the use of extended runoff storage times for urban runoff quality grows in popularity and the storage times increase in length.

▌*Drainage Area.* The drainage area or watershed concept is fundamental to any rainfall-runoff analysis. As such, we must determine and evaluate several key drainage area characteristics to perform runoff estimates. The first and most obvious characteristic is the drainage area size. This is usually determined by using topographic or other area maps upstream from the point of interest and actual field reconnaissance to verify available map data and supplement missing data.

Most runoff estimating techniques assume a linear relationship between drainage area size and runoff volume. Therefore, a 20 percent error in estimating the drainage area size will, among other impacts, result in a similar error in estimating runoff volume. This relationship is important when determining the required accuracy of drainage area computations and the amount of time and effort to spend achieving it. The percent of a particular drainage area that contributes runoff during a storm event will vary by antecedent moisture content, size of the storm event, and duration.

Two important drainage area characteristics, particularly for estimating runoff rates, are the shape of the drainage area and its various slopes. The previous discussion of watershed response time shows that a watershed with steep surfaces and channels allows runoff to drain to its outlet more quickly. This creates a greater peak flow than a flat watershed of similar total area. Similarly, an elongated drainage area with a longer distance from its upper reaches to its outlet may have a longer response time than a rounded one of equal size and, therefore, a lower peak runoff rate.

The term "may" conveys reservations about over-generalizing drainage area shape and slope and their effects on runoff rate, particularly for complex watersheds with major branches or tributaries. Each drainage area or watershed has its own unique shape, slope, and complexity, and each factor has a direct effect on response time and resultant runoff. Therefore, the representative response time required by the selected runoff estimating method should be computed as accurately as possible for each watershed under study and should consider all these unique characteristics.

The slope of localized areas within a watershed, particularly those that create surface depressions and other low areas, can have a direct effect on the watershed's response time and volume of runoff, especially at the rainfall onset. If the surface depressions are large relative to the rainfall volume, they can capture and store the beginning runoff, delaying its flow downstream.

This delay, combined with such effects as soil infiltration and interception by vegetation, helps produce the "initial abstraction"—the amount of rainfall converted into something other than runoff during the earliest part of the storm event. In estimating runoff, the initial abstraction is the amount of rain that must fall before runoff begins. Depending on the watershed's surface, soils, and vegetation, and the amount of rainfall analyzed, the initial abstraction can significantly affect the results. It should not be overlooked, particularly when analyzing small, frequent storm events in largely pervious watersheds.

■ *Soils*. Since several soil characteristics in a watershed have a direct effect on the rainfall-runoff process, they are included in most runoff estimating techniques. These include soil layer thickness, permeability or infiltration rate, and the degree of moisture in the soil before the rain event. The greater the soil permeability—the ability to infiltrate rainfall to its lower strata—the less remains to become runoff. The same can be said for soil thickness, particularly above bedrock or an impermeable subsurface layer, and the degree of moisture present in the voids between the individual soil particles.

If a storm occurs in an undeveloped watershed whose soil is saturated from previous rainfalls and incapable of storing additional water, the runoff amount could be the same as that produced in a watershed completely covered with impervious surfaces such as roofs, parking lots, and roadways. This fact is particularly critical in many parts of the country in spring, when extended wet weather and prolonged snowmelt keep soil levels nearly or completely saturated. This saturation causes a high threat of flooding, since extreme flow rates and flood levels can even be caused by small storms with high probabilities or frequencies.

Soil infiltration rate and thickness data is found in numerous sources, including laboratory tests of soil samples taken from various watershed locations, borings, and other subsurface samples. USDA SCS county soil surveys are reliable sources for general soil information. Depending on drainage area size, degree of accuracy required, and importance of soil characteristics to the runoff estimating method, the data may need some degree of field verification.

As in surface depressions, the delaying effects of initial soil wetting and infiltration help to produce initial abstraction. This can significantly affect the rainfall-runoff analysis result and should be considered, when analyzing small, frequent storm events in pervious watersheds.

■ *Vegetative Cover.* The vegetative cover directly affects the rainfall-runoff process and is an important parameter in many runoff estimating techniques. Vegetation characteristics include various types, canopies, and densities; extent of coverage; degree of residue or natural litter at the base; and degree of surface roughness. These characteristics affect the amount of rainfall that becomes runoff and the length of time the watershed takes to fully respond. For example, according to data in TR-55, sheet flow—runoff that occurs during the critical first stages of runoff movement—has an average velocity 10 times slower across a wooded area than it does across a comparable bare soil or asphalt-paved area. These effects must be considered in estimating peak runoff rates.

Vegetation data sources, frequently used in combination, include field reconnaissance and aerial photographs and satellite imagery, particularly to study large watersheds using computerized geographic information systems (GIS).

Vegetation's delaying effects of rainfall interception also help produce initial abstraction, which can significantly affect the results of a rainfall-runoff analysis in largely pervious watersheds.

■ *Impervious Cover.* Impervious cover means that virtually all rain will become runoff. Under most conditions, impervious cover is the last factor created in a watershed. As mentioned previously, the sheet flow velocity of runoff over a smooth, impervious surface such as a road or parking lot is about 10 times faster than over a vegetated surface. These strong impacts on runoff volume and rate make impervious cover the most critical characteristic in most runoff estimating techniques. In fact, the British Road Research Laboratory (BRRL) Method considers only the impervious portions of a watershed or drainage area.

Sources of impervious cover data required for rainfall-runoff analyses range from field reconnaissance to aerial photographs to satellite imagery, particular for GIS-based studies.

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Runoff Estimation—Common Methods

In this manual, most techniques used to analyze the rainfall-runoff process and estimate runoff volumes, peak rates, and hydrographs are classified into two general types, distinguished by how each uses time in its computations.

▮ *Steady State Methods.* These methods assume that key parameters remain steady or constant throughout the rainfall duration. Therefore, these methods use uniform rainfall intensities, soil infiltration rates, and representative watershed response times. Rather than merely a shortcut, steady state conditions are a reasonably accurate way to estimate peak runoff rates from high to moderate frequency storms in small watersheds with relatively short response times. As a result, steady state techniques, such as the rational method, are widely accepted for such watersheds. This relative accuracy may be caused by the short response time, resulting in a short time period over which steady or constant conditions are assumed (Wanielista and Yousef [1993] recommends limiting rational method use to drainage areas with a maximum TC of 20 minutes). Unfortunately, these same assumptions limit steady state methods, such as the rational method, to computing peak runoff rates. They are less effective in estimating total event runoff volumes and hydrographs.

A modified form of the rational method estimates runoff volumes from a series of hypothetical rainfall events of similar frequency but different duration. The method is primarily used to design smaller runoff detention and other storage facilities. Unfortunately, urban runoff management is expanding beyond traditional flood control and drainage needs to address aspects such as runoff quality, nonpoint source pollution, and aquatic habitat management. These uses require more accurate estimates of total runoff volumes and hydrographs, in particular, than the methods using steady state assumptions can reliably produce. Nevertheless, their simplicity and proven—if limited—accuracy means that steady state estimating still retains a firm position in urban runoff hydrology.

▮ *Variable State Methods.* These methods allow such parameters as rainfall intensity, soil infiltration, and watershed response time to vary with time. As such, these methods can more accurately compute runoff characteristics from rainfalls of varying intensities in single or even multiple storm events. This makes them more suitable to compute event runoff volumes and hydrographs and more capable of accurately recreating runoff from past or historic rainfall events. These methods, then, can be more readily calibrated and verified, further improving their accuracy.

Specific runoff estimating methods based somewhat on variable state assumptions include the USDA SCS runoff equation, which assumes a nonlinear soil infiltration rate to estimate runoff volumes; and methods based on either unit hydrograph theory, originally developed by L.K. Sherman in 1932 (Sherman, 1940), or the more recent kinematic wave theory to distribute runoff volume into runoff hydrographs.

In general, to consider variations in parameters, the methods divide the rainfall event into small time periods and use separate estimates of each parameter sequentially during each time period. To be accurate, a variable state method should consider the effects of previous parameter values from preceding time periods in each current time period. Most standard methods currently available do so, at least for some parameters.

In using variable state methods, the closer resemblance to the "real" rainfall-runoff process and, consequently, the greater accuracy, broader applicability, and potentially greater benefits do not come without additional cost. These methods need more input data (e.g., an initial value for each parameter and a technique for varying it throughout the event) and more computations. This normally requires appropriate computer programs and more user knowledge and experience to maintain an acceptable level of accuracy and safety. These requirements can limit the use of some methods and the effectiveness of the regulatory programs based on them.

In developing or expanding an urban runoff management program, we must balance regulatory effectiveness and technical accuracy. But because of the current demands to manage runoff and the continued growth of hydrologic tools and techniques, all urban runoff management programs should encourage technical growth and be capable of updating their own regulations.

Runoff Estimation—Computer Models

The amount and complexity of the data and computations are overwhelming. And as the scope and complexity of urban runoff management grows, linking data and computed hydrologic results with hydraulic, structural, economic, and even demographic analyses is increasingly important. As a result, we must have quick computerized runoff models and other enhanced computational tools, particularly to study large, complex watersheds. Fortunately, numerous urban runoff management programs are available.

The terms computer "program" and "model" can be confusing. The runoff models described here are computer programs since they are written in a computer language and are run (or executed) on a computer. However, the term "model" implies a specialized type of computer program that simulates or models a physical process. The user must both provide input data and make informed decisions about data values, such as soil infiltration rates or extent of vegetative cover.

The model differs, then, from a simple computer program, which may perform complex arithmetic, but uses input data requiring little or no user discretion; for example, a program that computes the mean or standard deviation or that computes the closure error on a land survey. According to this definition, various estimating techniques used in urban runoff management analyses and labeled "methods" are also considered models in scientific and engineering terms. We will, therefore, refer to the computerized versions of these methods as computer models.

▌*Single Event Models.* These models allow the user to analyze or simulate the rainfall-runoff process during a single event. The user must not only select the rainfall to analyze but also the conditions and factors in the watershed immediately prior to its onset. The models then estimate the resulting runoff characteristics such as volumes, peak rates, and entire hydrographs.

To develop and use a single event model, the user need only know the initial values of the factors in the runoff estimating method and how they will change over time in response to the selected rainfall. The user does not need to know how the factors will continue to change during any drying period following the selected rainfall and preceding the next one, since the model is only intended to analyze a single event. This makes these computer models ideally suited to analyze individual historic storm events and design urban runoff detention and other short-term urban runoff storage facilities primarily influenced by individual storms.

Some popular single event computer models available include HEC-1 Flood Hydrograph Package, developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (1990); USDA Technical Release 20 (TR-20), developed by the USDA SCS (1992); and the U.S. EPA Stormwater Management Model (SWMM) (Huber and Dickinson, 1988); along with numerous others. The first two models can only be used for estimating quantitative aspects of runoff such as volumes, rates, and hydrographs. SWMM can also be used to estimate runoff quality characteristics such as pollutant concentrations and masses. References at the end of the chapter provide detailed descriptions of the models.

▌*Continuous Models.* Unlike single rainfall-runoff models, these models analyze the rainfall-runoff process for a series of storm events over an extended time period—several years or even decades. Models must account for changes in watershed factors and parameters during the time *between* storms (interevent dry periods) as well as *during* storms. Such factors as temperature, relative humidity, surface evaporation and evapotranspiration, and groundwater levels and movement, all of which may significantly affect runoff response to the next rainfall in the analysis or simulation, must be considered. These factors require a similar increase in data needs and user knowledge and experience.

The additional effort and expense are often well spent, particularly to analyze or design agricultural, urban runoff management, or water supply facilities that respond slowly to rainfall and, therefore, are influenced by a long series of storm events. Single event analyses are of limited value for these facilities, since they are part of a larger, more complex picture. Also of limited value are such problems as long-term, cumulative pollutant loadings and their effects on streams, lakes, and estuaries. These phenomena occur slowly and are continuously influenced by rainfall events. Using continuous models may not only be justified, but in many instances mandatory.

One of the most familiar continuous models is Storage, Treatment, Overflow, and Runoff Model (STORM), originally developed by the U.S. Army Corps of Engineers in 1974.

Runoff Estimation—An Example

To highlight the rainfall-runoff concepts, parameters, and methods previously discussed, we have selected a sample method of a single event presented in TR-55 to estimate runoff volumes, peak rates, and entire hydrographs. The methodology first uses the USDA SCS runoff equation—a mathematical model of the real rainfall-runoff process—to estimate the runoff volume, expressed as a uniform depth in inches over the watershed, that would result from a specified rainfall depth. We assume that this rainfall depth falls over a 24-hour period in a hypothetical pattern developed by USDA SCS from the rainfall depth-frequency-duration data originally published in TP-40 (U.S. Dep. Commerce, 1961). The resultant runoff volume is then distributed over time using a synthetic unit hydrograph for the watershed to estimate the peak runoff rate. If we desire, we can estimate the entire hydrograph that would result from the day-long rainfall. The synthetic unit hydrograph is based on the principles and assumptions of unit hydrograph theory and, in part, on an estimate of the watershed's TC.

This is a complicated mix of theories, assumptions, and calculations. However, the USDA SCS runoff equation, synthetic storm distributions, and synthetic unit hydrographs included in the methodology are based on extensive field data, research, and experience. They are, therefore, consistent with the concepts and cautions discussed earlier for real versus design conditions. As a result, the USDA SCS hydrologic methods, including those in TR-55, have gained widespread acceptance among engineers, planners, and regulators. Details regarding USDA SCS methodology in the following example are in TR-55 as well as USDA SCS's National Engineering Handbook Section Four— Hydrology (NEH-4) (U.S. Dep. Agric. 1972).

As described in these publications, the USDA SCS runoff equation is

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S} \qquad [1]$$

where:
- Q = Runoff depth (inches)
- P = Rainfall depth (inches)
- S = Potential maximum retention once runoff begins (inches)
- Ia = Initial abstraction (inches)

As previously explained, the initial abstraction is the amount of rainfall that must fall before runoff begins and represents all other routes rain can take (e.g., infiltration into the soil) or forms it will assume (e.g., depression storage) during the earliest part of the storm. While the actual initial abstraction can be highly variable, USDA SCS has developed the empirical equation $Ia = 0.2S$. This eliminates Ia as an independent variable in equation 1 and results in the following:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad [2]$$

The parameter S is a measure of how much rainfall the watershed soils and the materials covering them can potentially hold once the initial abstraction is overcome and runoff begins. No mention is made of the rainfall amount required to reach this limit because S is related to the actual soils and covers through a runoff curve number (CN) by the equation

$$S = \frac{1000}{CN} - 10 \qquad [3]$$

TR-55 and NEH-4 have several tables of CNs for numerous ground covers and land uses in various hydrologic conditions, including lawns, meadows, woodland, impervious surfaces such as roads and roofs, and even bare soil. These tables present four CNs for each cover/use/condition. USDA SCS has classified most soils into hydrologic soil groups (HSG) based on their minimum infiltration capabilities. Soils in HSG A have the highest infiltration rates, while HSG D soils have the lowest. Conversely, HSG A soils have the lowest runoff potential while HSG D soils have the highest. The recommended CNs in the TR-55 and NEH-4 tables are also based on the assumption of average antecedent runoff conditions at the start of rainfall.

Graphic solutions to equation 2 (i.e., the USDA SCS runoff equation for $Ia = 0.2S$) for a range of CNs is presented from TR-55 in Figure 1.4. A summary of recommended CNs for various land uses/covers, conditions, and hydrologic soil groups taken from the extensive listings in TR-55 (Tables 2-2a and 2-2c) is presented in Table 1.1. TR-55 also contains rainfall depth-frequency-duration maps originally published in TP-40 to allow the user to select the appropriate 24-hour rainfall amount.

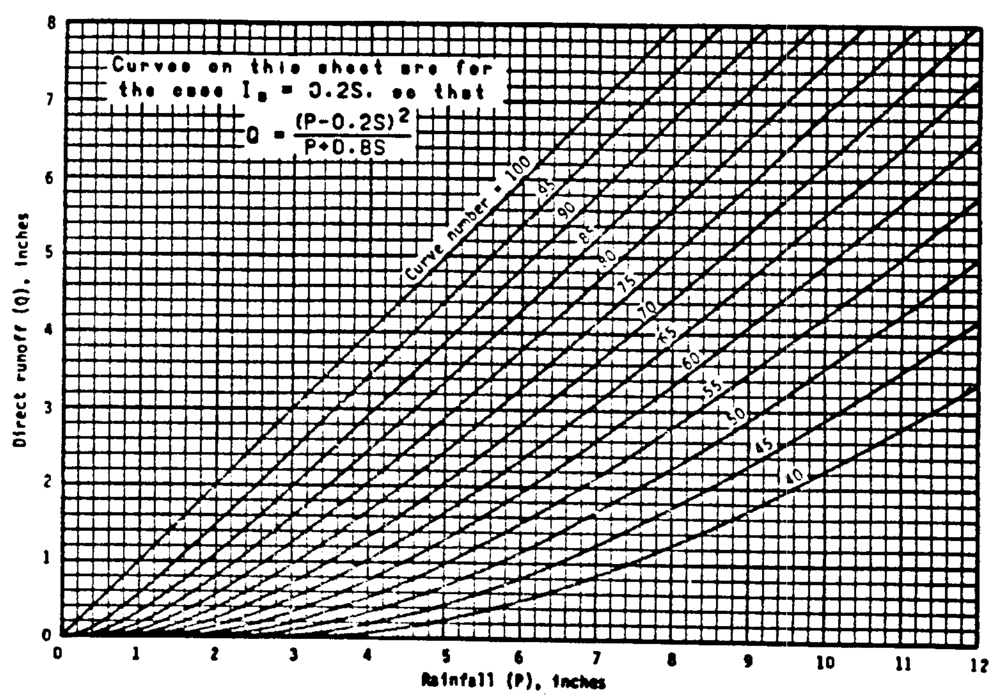
For example, assume a wooded, 20-acre (8.1-ha) drainage area around Chicago with good leaf cover and other natural litter on the ground. Using the previous equations and the CNs from Table 1.1, we can estimate the volume of runoff expected for a 2-year, 10-year, and 100-year storm event lasting 24 hours. We will base the computations on two alternative soil types—HSG B and D—and compare the results.

Table 1.1—Summary of recommended SCS runoff curve number for average antecedent runoff conditions.

COVER TYPE/LAND USE	HYDROLOGIC CONDITION	HYDROLOGIC SOIL GROUP A	B	C	D
Woods	Poor–no forest litter Good–litter and brush	45 30	65 55	77 70	83 77
Meadow	—	30	58	71	78
Lawns/open space	Good–full grass cover	39	61	74	80
Bare soil	—	77	86	91	94
½ acre residential (25% impervious)	—	54	70	80	85
Commercial/business (85% impervious)	—	89	92	94	95
Roofs/paved roads, drives, and parking	—	98	98	98	98

Note: Summary values are presented for example only. Refer to complete SCS tables and texts for actual CN use.
Source: U.S. Dep. Agric. 1986.

Figure 1.4—Graphic solution of Soil Conservation Service runoff equation.



Source: U.S. Dep. Agric. 1986.

From the description and information from Table 1.1, we can safely assume that the wooded area is in "good" hydrologic condition and a CN of 55 can be used if the soils belong to HSG B. Similarly, a CN of 77 is recommended if the soils belong to HSG D. We can now perform some preliminary computations using these values, equation 3, and the USDA SCS assumption that Ia is equal to 20 percent of S:

PARAMETER	SOIL GROUP B	SOIL GROUP D
CN	55	77
S (inches)	8.18	2.99
Ia (inches)	1.64	0.60

From these computations, we can make some comparisons between the two soils right away, even before the rain begins. For instance, we have estimated that a drainage area comprised of HSG B soils can potentially retain 8.18 in (20.8 cm) of rainfall, once the initial abstraction of 1.64 in (4.2 cm) is used up and runoff begins. This is almost three times greater than if the drainage area were comprised of HSG D soils. In addition, the HSG B drainage area requires a greater amount of rainfall to overcome the initial abstraction and for runoff to begin than the HSG D drainage area.

To complete the computations, we use 24-hour rainfall values for the general Chicago area for 2-year, 10-year, and 100-year storm events from Figure 1.3 (from TR-55, Appendix B: Figures B-3, B-5, and B-8). Using these values, the preliminary computations, and equation 2, we can compute the following estimates of runoff volume:

STORM FREQ. (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)	
		B SOIL	D SOIL
2	2.8	0.14	0.93
10	4.0	0.53	1.81
100	5.8	1.40	3.30

The estimated runoff volumes from equation 2 are expressed in inches, which does not exactly meet the mathematical definition of volume. Actually, these volumes are meant to represent average runoff depths over the entire drainage area where the CN has been computed (the USDA SCS runoff equation does not have an explicit term for drainage-area size). To compute the various runoff volumes in more traditional measurement units, we can multiply the average runoff depths produced by equation 2 by the 20-acre drainage area (making sure of our units) to produce several different versions of estimated volumes:

STORM FREQ. (years)	ESTIMATED RUNOFF (inches)		ESTIMATED RUNOFF (cubic feet)		ESTIMATED RUNOFF (acre-feet)	
	B SOIL	D SOIL	B SOIL	D SOIL	B SOIL	D SOIL
2	0.14	0.93	10,019	67,518	0.23	1.55
10	0.53	1.81	38,333	131,551	0.88	3.02
100	1.40	3.30	101,495	239,580	2.33	5.50

All previous estimates for each storm frequency and HSG represent the same runoff volume—they only represent different units. Referring to runoff volumes in inches of average depth over the entire watershed or in units of acre-feet is often easier than in cubic feet.

In comparing the two HSGs, the HSG D drainage area would produce 2-year, 10-year, and 100-year runoff volumes that are 6.6, 3.4, and 2.4 times greater than those from the HSG B drainage area. This confirms our suspicions from the preliminary computations. While the HSG D runoff volumes are greater than those for HSG B in all storm frequencies analyzed, the percentage difference decreases as the storm frequency—or, more precisely, the rainfall amounts—increases. However, the USDA SCS runoff equation uses both a fixed initial abstraction value for a given CN (i.e., it does not vary with rainfall) and an exponential infiltration rate (note the squared numerator in equations 1 and 2). We will explore this important aspect of urban runoff hydrology later.

Some interesting relationships exist within each HSG. For example, in the HSG B drainage area, the estimated 2-year runoff volume represents only 5 percent of the total 2-year rainfall. This percentage increases first to 13 percent and then to 24 percent for the HSG B drainage area as the storm frequency/rainfall amount increases to the 10-year and 100-year levels. A similar relationship between event frequencies exists for the HSG D drainage area.

The following is a summary of the percentages for both HSGs:

STORM FREQ.	24-HOUR RAINFALL	ESTIMATED RUNOFF (inches)		RUNOFF AS PERCENT OF RAINFALL	
(years)	(inches)	B SOIL	D SOIL	B SOIL	D SOIL
2	2.8	0.14	0.93	5%	33%
10	4.0	0.53	1.81	13%	45%
100	5.8	1.40	3.30	24%	57%

These relationships show the effects of both the initial abstraction and nonlinear (i.e., exponential) infiltration rate assumptions from the USDA SCS runoff equation. The percentages also show the strong effect of soil characteristics on runoff volume from a given amount of rainfall. The data show that a much greater percentage of rain falling on the HSG D drainage area will likely become runoff than the percentage on the HSG B drainage area. For example, while we estimate that only 5 percent of the 2-year rainfall on the HSG B drainage area will become runoff, 33 percent of the same rain falling on the HSG D drainage area (with the same ground cover) will become runoff. Therefore, this hypothetical switching of HSGs clearly shows why soil characteristics are such an important parameter in runoff computations. The remaining percentage of rain that does not become runoff in either drainage area represents the sum of all the other rainfall by-products.

We can extend this example to include estimates and comparisons of peak rates at which the various runoff volumes might flow from each drainage area. We will assume that the 24-hour rainfall will fall throughout that 24-hour period in accordance with a hypothetical USDA SCS storm distribution known as Type II. This hypothetical or "design" storm is one of four 24-hour distributions that USDA SCS has developed for various parts of the United States, with Type II recommended for the Chicago area, the location of the 20-acre drainage area in our example (TR-55, Appendix B, contains a detailed description of these distributions).

Assuming a Type II storm and an estimated TC of 0.5 hours, we use Figure 1.5 to estimate the various peak runoff rates for the different storm frequencies and soil groups (TR-55, Chapter 3, contains one of the most complete and concise presentations of both the concept and computation of TC presently available).

Figure 1.5 presents various values of the parameter, unit peak discharge (qu), expressed in units of cubic feet per second per square mile of drainage area per inch of runoff (csm/in), for various drainage area TCs and Type II storm distribution. Multiplying the appropriate unit peak discharge value by the drainage-area size (expressed in square miles) and the estimated runoff volume (expressed in inches) will yield an estimate of peak runoff rate in units of cubic feet per second (cfs). Figure 1.5 also contains one additional value, Ia/P—the ratio of the drainage area's initial abstraction to the total storm rainfall—that must be determined before estimating a peak rate (TR-55, Chapter 4, contains more instruction and insight into estimating peak runoff rates).

Summaries of the resulting computations for the 20-acre (8.1 ha; 0.03 mi^2) drainage area with a 0.5 hour TC for both HSGs follow:

FOR HYDROLOGIC SOIL GROUP B

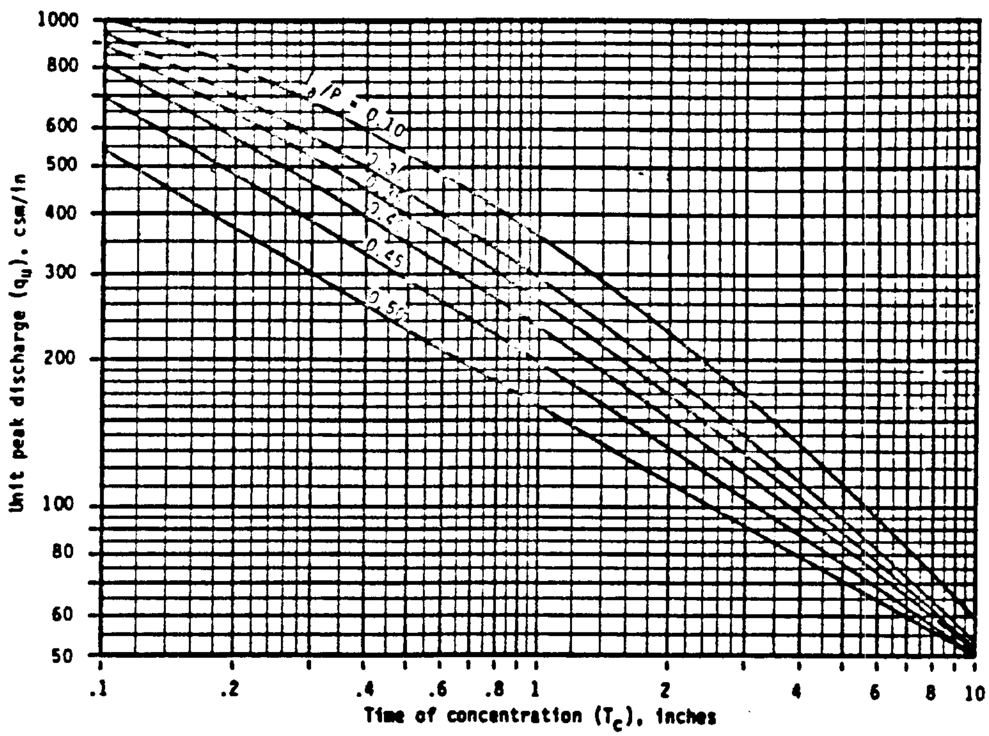
STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.14	0.59	230	1.0
10	0.53	0.41	340	5.6
100	1.40	0.28	450	19.7

FOR HYDROLOGIC SOIL GROUP D

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.93	0.21	470	13.7
10	1.81	0.15	505	28.6
100	3.30	0.10	530	54.7

In the HSG B and D tables, we note that while the estimated peak runoff rates for the HSG D drainage area are greater than those for the

Figure 1.5—Unit peak discharge (qu) for Soil Conservation Service Type II storm.



Source: U.S. Dep. Agric. 1986.

HSG B, the ratio or percentage difference between the peak rates is greater than between the volumes. For example, the HSG D volume estimate for the 10-year frequency storm is 3.4 times greater (1.81 inches divided by 0.53 inches) than the HSG B volume. However, the HSG D peak rate estimate for the same 10-year frequency storm is 5.1 times greater (28.6 cfs divided by 5.6 cfs) than the HSG B peak rate. Similar increases for the 2-year and 100-year events show the same decreasing trend for increasing rainfall amounts. This further difference between the two HSGs is the result of several factors. These include the HSG D soil's lower initial abstraction, which results in an earlier start of runoff and has a lower Ia/P ratio and higher qu value; the variable shape of the Type II storm distribution, in which the most intense rainfalls occurs near the middle of the 24-hour duration; and the exponential character of the USDA SCS runoff equation.

The examples confirm the following points. First, the amount of runoff produced by rainfall varies nonlinearly. Consequently, as the rainfall amount increases, the amount of runoff volume will increase even more. This relationship is also true for peak runoff rates. Second, a change in drainage area or watershed runoff characteristics, as demonstrated by hypothetically varying the soils from HSG B to HSG D, can complicate both the runoff volume and rate. Finally, while we can generalize on a drainage area's rainfall/runoff relationship, we can only determine specific estimates of resultant runoff through mathematical analysis based on sound assumptions and the appropriate amount and quality of data. We will explore these relationships and the effects of drainage area changes in discussing hydrologic impacts of land development.

The Soil Erosion Process

Concepts and Theories

As previously stated, both rainfall and the runoff it produces—or is converted into—affect and are affected by the land surfaces they contact. For rainfall, this contact occurs only at the instant the raindrops strike the ground. For runoff, the contact period normally lasts considerably longer. Nevertheless, the forces exerted briefly by raindrops and longer by runoff combine to dislodge and transport soil particles, commonly known as sediment.

Chapter 2 discusses in detail the impacts of sediment on surface water quality, biota, and habitat, presenting the theoretical and technical fundamentals of the soil erosion process. A sound understanding of these fundamentals will prepare readers for the more detailed presentations to follow and will enable them to better develop and manage a comprehensive urban runoff management program. The soil erosion fundamentals are largely based on Appendix A1 of the *Standards for Soil Erosion and Sediment Control in New Jersey* (1987). The publication is one of many excellent sources for theoretical and practical information on soil erosion and its control.

Soil erosion is a three-part process, beginning the instant raindrops strike the ground surface, sometimes at velocities up to 30 mi (48.3 km) an hour. The impact force is often sufficient to dislodge soil particles from bare ground surface and begin their movement down slope. This initial stage of the soil erosion process primarily from raindrop impact is known as sheet erosion. In the sheet erosion stage, significant quantities of soil particles are mobilized from the enormous number of raindrop impacts over an area.

The exact amount of sediment produced during sheet erosion depends on several factors, including the size, mass, and texture of the soil particles; the size and slope of the ground surface; the type and degree of surface cover; and the intensity and duration of the rainfall. The shear forces created by runoff flowing across the impacted area from upslope portions of the drainage area can also dislodge soil particles from the ground surface. This increases the total quantity of sediment produced during sheet erosion.

Once the soil particles are detached from the surface, runoff primarily keeps them mobilized during the next stage of soil erosion—downslope transport. During this stage, runoff transports the sediment across the ground surface, along small rills and gullies, and through larger swales and channels. The extent of the sediment movement also depends on a large number of factors, including the volume, rate, and duration of the runoff; the size, mass, and shape of the displaced soil; and the shape, slope, and roughness of the various surfaces over which the runoff-borne sediment is moving. As previously explained, runoff moving across the ground surface also further displaces soil particles by mobilizing previously attached material. This runoff movement can create enormous amounts of additional sediment, particularly in highly erodible stream channels.

The final stage of the soil erosion process is the deposition stage, when the runoff can no longer carry the sediment and deposits it back on the ground some distance from where it originated. This can occur anywhere in the watershed—from upland surfaces, to channels, to lake bottoms. The watershed is then left with depleted upper soil layers in some portions and new soil layers in others.

The soil erosion process is extremely complex and dynamic. All three stages can and do occur continually, to varying degrees, throughout the rainfall/runoff event—which is also complex and dynamic. Since sediment produced by the soil erosion process can come from anywhere in the watershed, we must carefully manage and protect each portion and component.

Estimating Sheet and Rill Erosion

Despite the complexities of measuring sediment, research and experience have developed various methods and techniques to estimate the amount of soil loss from sheet and rill erosion. The Universal Soil Loss Equation (USLE) is generally accepted as the standard technique to estimate the effectiveness of various erosion control practices and measures. Appendix A of the *Standards for Soil Erosion and Sediment Control in New Jersey* (1987) contains a detailed presentation.

The USLE is an empirical equation used to estimate the annual amount of soil lost by sheet and rill erosion on a given parcel of land:

$$E = (R)(K)(L)(C)(P) \qquad [4]$$

where:

E = Estimated Annual Soil Loss due to sheet erosion (in tons/acre/year).

R = Rainfall Factor or Rainfall Erosion Index—a measure of the erosive force of rainfall occurring over the study area during a normal year. Figure 1.6 presents typical values of R for various portions of New Jersey.

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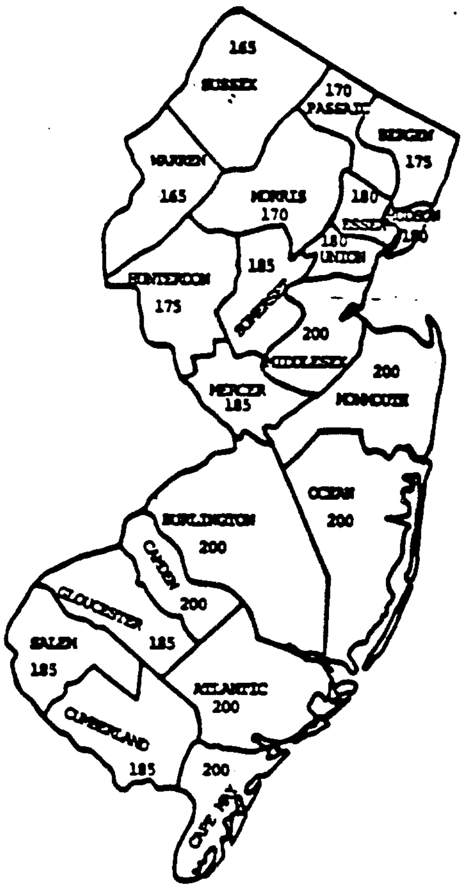
Figure 1.6—Rainfall erosion index (R) for New Jersey counties.



Source: New Jersey Dep. Agric. 1987.

TABLE 1.2—Universal Soil Loss Equation soil erodibility (K) classes and ranges.

ERODIBILITY CLASS	RANGE OF K
Low	0.17 – 0.24
Medium	0.28 – 0.37
High	0.43 – 0.49

Source: New Jersey Dep. Agric. 1987.

K = Soil Erodibility Factor—a measure of the erodibility of soils in the study area based on field tests of fallow ground with standardized slope and length. Table 1.2 presents ranges of K for various soil erodibility classes.

L = Slope Length Factor—allows adjustments to be made to K to account for the actual slopes and lengths in the study area that vary from the standardized test values.

C = Cover Index—allows adjustments to be made to K to account for the actual ground cover in the study area other than the standard fallow condition. Table 1.3 present typical values of C for various ground covers.

P = Erosion Control Practice Factor—a relative measure of the effects of various surface conditions in the study area. Table 1.4 presents typical values of P for various surface conditions found particularly at construction sites.

The USLE uses additional factors to produce estimates for periods of time less than one year and for individual storm events of specified frequency.

The USLE is a fairly simple mathematical equation. The estimated soil loss is a function of the erosive properties of a given soil (K), as determined through standardized tests, which are then modified by a number of pertinent factors—such as rainfall and ground slope, cover, and surface character—to reflect the actual conditions in which the soil exists. In addition, the mathematical relationship between all input factors and the final result are linear—a certain percentage change in any input variable results in an identical change in the result.

The actual sheet and rill erosion process, however, is not simple and the various input factors do not behave in a simple, linear fashion. The USLE's apparent simplicity masks the complexity of the actual sheet erosion process and the difficulty of mathematical modeling. Users need to exercise caution when applying the USLE and its estimates.

The most important aspects of the USLE that relate to urban runoff management programs are the cover index (C) and the erosion control practice factor (P). These are the factors that designers, constructors, and regulators can control. For example, placing straw mulch on bare ground at the

Table 1.3—Universal Soil Loss Equation typical cover index (C) values.

GROUND COVER	APPLICATION RATE (tons/acre)	SLOPE (%)	TYPICAL C
None	—	All	1.00
Straw or hay	1.0	0 – 10	0.20
	1.5	0 – 10	0.12
	2.0	0 – 10	0.06
	2.0	11 – 15	0.07
Crushed stone (0.25–1.50")	135	0 – 15	0.05
	240	0 – 15	0.02
Woodchips	7	0 – 15	0.08
	12	0 – 15	0.05
	25	0 – 15	0.02
Temporary seeding and straw mulch (first 6 weeks)	No mulch	—	0.70
	Mulch @ 1.0	—	0.20
	Mulch @ 1.5	—	0.12
	Mulch @ 2.0	—	0.06
	No mulch	—	0.10
	Mulch @ 1.0	—	0.07
	Mulch @ 1.5	—	0.05
	Mulch @ 2.0	—	0.05
Permanent seeding (after 2 years) and sod	—	—	0.01

Source: New Jersey Dep. Agric. 1987.

rate of 1 ton per acre will result in an 80 percent reduction of the C value in the USLE (in Table 1.3, from 1.0 to 0.2). The USLE's linear nature can produce a similar reduction in the estimated soil lost through sheet erosion from those surfaces. Proper surface conditions, demonstrated in the typical P values in Table 1.4, can achieve more limited results.

Table 1.4—Universal Soil Loss Equation typical Practice Factor (P) values.

SURFACE CONDITION WITH NO COVER	TYPICAL P
Compacted and smooth Machine scraped along slope	1.3
Compacted and smooth Machine raked along slope	1.2
Compacted and smooth Machine scraped across slope	1.2
Compacted and smooth Machine raked across slope	0.9
Rough and irregular Random machine tracks	0.9
Loose and smooth Deeper than 12 inches	0.9
Loose and rough Deeper than 12 inches	0.8

Source: New Jersey Dep. Agric. 1987.

The second aspect of the USLE and sheet erosion is the time the erosive condition is allowed to exist in the field. Regardless of the ground cover, surface conditions, or any other USLE sheet erosion factor, limiting erosion to the shortest practical exposure time attains the least soil loss. Chapter 4 recommends techniques and regulations to minimize losses.

USDA is in the process of replacing the USLE with the Water Erosion Prediction Program (WEPP). Currently, the Revised Universal Soil Loss Equation (RUSLE) is being adopted nationwide. RUSLE is based on updated rainfall cover index and erosion control practice factors.

Estimating Channel Erosion

The sediment created by sheet erosion is only part of the soil erosion process. Once the runoff across the ground surface exceeds a certain depth, gravity moves the runoff toward collection in progressively larger conveyance devices. These range from small rills to large gullies and finally to stream and river channels. As gravity forces runoff to flow downslope, it creates further erosion and collects additional sediment from the soils on the banks and bottoms.

Whether runoff causes such erosion and how much sediment it creates depends on a number of interrelated and dynamic factors. These include the velocity and duration of flow; weight, shape, and location of the soil particles; the degree of sediment already suspended in the runoff; and the channel's shape, length, slope, and irregularity.

Although estimating soil losses due to channel erosion is beyond the scope of this and most similar manuals, the rate of channel erosion is partly a function of the channel's flow velocity. While all velocities do not cause erosion, a channel is generally considered to be stable up to some conceptual flow velocity, called the maximum permissible velocity. This flow velocity should be thought of as the channel erosion equivalent of time of concentration—that is, a conceptualization that can be practically used.

Once this maximum permissible velocity is exceeded, erosion of soil particles on the channel banks and bottom will begin and continue as long as the velocity is maintained. As the flow velocity increases, the rate of erosion will also increase. While we cannot determine an upper limit on the erosion rate, the quantity of sediment produced by channel erosion can be enormous, as an inspection of natural stream channels immediately following a major flood event can show.

Impacts of Land Development

Impacts on Urban Runoff

Typically, a land development project in a drainage area or watershed involves replacing or modifying at least some of the existing surface cover with roads, roofs, driveways, and other impervious material. Since the existing cover material is usually more permeable, particularly if it existed naturally, this change will result in a greater percentage of rainfall becoming runoff. We can use the USDA SCS runoff equation (equation 2) and the recommended runoff curve numbers (CNs) from Table 1.1 to quantify this.

We will assume that the 20-acre (8.1-ha) wooded drainage area in the earlier example has

Table 1.5—Comparison of runoff volume between undeveloped and developed conditions.

PARAMETER	UNDEVELOPED CONDITIONS	DEVELOPED CONDITIONS
CN	55	70
S (inches)	8.18	4.29
Ia (inches)[1]	1.64	0.86

STORM FREQUENCY (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)	
		Undeveloped	Developed
2	2.8	0.14	0.60
10	4.0	0.53	1.33
100	5.8	1.40	2.64

STORM FREQUENCY (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)		RUNOFF AS PERCENT OF RAINFALL	
		Undevel.	Devel.	Undevel.	Devel.
2	2.8	0.14	0.60	5%	21%
10	4.0	0.53	1.33	13%	33%
100	5.8	1.40	2.64	24%	46%

now been converted into half-acre residential lots with an average impervious coverage of 25 percent and, for simplification, contains soils in HSG B. According to values from Table 1.1, the CN would increase from 55 in the wooded state to 70 when the homes, lots, and roads are constructed and the lawns and other landscaped areas are fully established. Equations 2 and 3 produce the results shown in Table 1.5.

The increase in impervious coverage has reduced the drainage area's initial abstraction by nearly a half—from 1.64 in (4.2 cm) to 0.86 in (2.2 cm)—and less rainfall is needed to produce runoff from the drainage area. This results in a greater amount of runoff from storms that already produced runoff from the drainage area and an increase in the total number of future runoff-producing storms. Among other impacts, this increase in runoff means decreased amounts of rain infiltrating into the soil. This can produce lower groundwater levels and diminished or totally eliminated dry weather or base flows in streams.

The increased impervious coverage further increases runoff volume by increasing the runoff production rate once the initial abstraction is overcome and runoff begins. We see this clearly by comparing the estimated percentages of rainfall that becomes runoff in undeveloped and developed conditions. The 2-year storm percentage increases fourfold—from 5 percent to 21 percent. The 10-year and 100-year percentages also increase, with the 10-year nearly tripling and the 100-year almost doubling. This indicates, however, that land development impacts on runoff volume will be more acute for the smaller, more frequent storm events—a problem for channels and streams, which are sensitive to these storm events.

Another effect of land development is a decrease in the drainage area's response time or TC. This effect results from the faster flow of runoff across the impervious surfaces and the installation of more efficient (i.e., faster) conveyance measures—gutters, storm sewers, and impermeably lined channels—replacing the natural measures present prior to development. If these measures resulted in a new TC for the 20-acre (8.1-ha) drainage area of 0.25 hours, we can use charts and data from TR-55 to estimate the following changes to the peak runoff rates from the drainage area:

UNDEVELOPED CONDITIONS
Woods in Good Hydrologic Condition

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.14	0.59	230	1.0
10	0.53	0.41	340	5.6
100	1.40	0.28	450	19.7

DEVELOPED CONDITIONS
Half-Acre Residential

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.60	0.31	620	11.6
10	1.33	0.22	660	27.4
100	2.64	0.15	710	58.6

These estimates indicate that the peak runoff rates from the drainage area increase because of development activity, with the estimated 2-year, 10-year, and 100-year peak rates increasing by factors of approximately 10, 5, and 3, respectively. The impacts of these peak flow increases include increased depths in the streams and rivers downstream, which can aggravate existing flood problems and create new ones in previously safe areas.

As shown in the previous chart, land development impacts on the rainfall-runoff process typically include an increase in the volume of urban runoff created by a given amount of rain, a decrease in the time it takes for runoff to drain from the land, and consequently, an increase in peak rate. These increases can produce more frequent and deeper flood depths, threatening the safety and property of those residing and working downstream. In addition, the increased volume of runoff typically means a decrease in groundwater levels and base flows in the streams and rivers, which also threatens aquatic organisms and their habitats and water supply resources.

Impacts on Soil Erosion

The impacts of land development activity on soil erosion can be devastating. Soil erosion can accelerate to levels higher than geologic norms. These impacts begin during the construction phase, primarily in the form of sheet erosion, and often persist after construction. Increases in sheet erosion during construction are caused by removing natural vegetation during site clearing, exposing surface soils to the impacts from raindrops, and the shear forces of the resultant runoff.

For example, a typical C value for grass cover ranges from approximately 0.10 for temporary grass cover after six weeks of growth to 0.01 for established grass cover or sod (Table 1.3). However, the C value for bare ground is 1.00—10 to 100 times larger. Since the USLE considers the average annual soil loss (E) from an area linearly related to C, the soil lost to sheet erosion during construction can be as much as 100 times greater than from the natural, undisturbed area. This makes up to 100 times more sediment available for runoff to transport into downstream waterways.

However, this estimate does not include the effects of bare soil in increasing the volume and rate of runoff that can dislodge and transport even more sediment. In Table 1.1, the CN for bare soil

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in HSG B is 86, greater than the CN of 70 that reflects final developed conditions in the drainage area. Therefore, the construction phase of land development not only increases the quantity of erodible sediment but also the rate and volume of runoff to transport it.

The increased rate and volume of runoff from development activity can also aggravate existing or create new channel erosion, initiating additional sediment loadings. For the more frequent 2-year and 10-year storms, greater impervious coverage and a shorter drainage area response time produce peak runoff rates 5 to 10 times greater after development. These increased peak runoff rates will, in turn, produce higher peak runoff velocities in the downstream waterways. If these increased velocities exceed a certain critical level, channel erosion will likely occur in previously stable, undisturbed channels. For channels already experiencing erosion, these increased velocities will increase the problem.

Sediment is typically deposited in a flatter, slower reach of the waterway or at the bottom of a wetland, lake, or estuary. Sediment recovery in the lower reaches can also have devastating effects. Chapter 2 discusses the qualitative effects of the erosion and sedimentation process.

Summary and Conclusions

The chapter's purpose is to enable those developing urban runoff management programs to make informed decisions about their programs and increase their effectiveness and applicability.

The chapter's key messages are

1. The rainfall-runoff and soil erosion processes are dynamic and complex. No perfect analytical models or methods can exactly reproduce past runoff or erosion events or predict future ones.

2. Because urban runoff management must consider the quantitative impacts of land development on runoff quality, its complexity significantly increases. These impacts exacerbate any weaknesses or inaccuracies in the analytical models and methods.

3. Through research and a sound understanding of the fundamentals, we can make simplifying assumptions about these hydrologic processes that enable us to produce reasonable, practical, and safe runoff and soil erosion estimates.

4. Everyone involved in developing an urban runoff management program must understand the fundamentals of urban runoff hydrology. Experienced professionals in the field must be included in the development process, particularly in selecting technical standards, methodologies, and measures.

5. The growth of computer resources and capabilities has increased the accuracy and applicability of methods and models and the effectiveness of urban runoff management programs. However, the need for more comprehensive data and expanded user knowledge has increased likewise, further highlighting the importance of technical knowledge and experience.

6. While general information can be a useful guide, the complexity of the hydrologic processes demands site-specific data and methods to identify, define, and/or address urban runoff management problems or concerns.

7. The interrelationships of the rainfall-runoff and soil erosion processes emphasize the need for a comprehensive, watershed approach to all aspects of urban runoff management, ranging from individual site designs to comprehensive regulatory programs.

Recommended Reading

The following publications were influential in developing this chapter. We strongly recommend them to readers wishing to expand their knowledge of the rainfall-runoff and soil erosion processes.

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CHAPTER 2

Water Quality Impacts of Urban Land Use

Urban runoff carries with it a wide variety of pollutants from diverse and diffuse sources. Representing all recognized classes of water pollutants, these runoff contaminants originate not only from land activities in the drainage catchment where runoff is collected but also from atmospheric deposition as either "dryfall" or "wetfall." Moreover, surface and groundwaters can exchange. This chapter focuses on water quality by examining the characteristics, sources, and patterns of urban runoff pollutants and discusses assessment techniques.

Contaminants originating below ground (e.g., landfill leachate, effluent from failing septic systems) can enter surface runoff, while runoff can enter groundwater through sinkholes or drainage wells. Pollutants originating on the surface can also percolate through the soil and contaminate groundwater.

These general sources of urban runoff pollution on, above, and below the surface represent a complex set of watershed conditions. They determine the effects that drainage from the watershed will have on a natural receiving water, and represent a challenge for management. Figure 2.1 illustrates the relationships between watershed activity and its consequences in the receiving water. The complex of watershed conditions determines the characteristics of the habitats that will develop in the receiving waterbody. For example, if the base geological material is relatively insoluble and erosion resistant, a stream draining that area will likely have a substrate of relatively large cobbles, or even bedrock, and a low level of nutrition. The aquatic biota evolve in direct response to the types of habitats produced by the watershed conditions. In this example, the biota will likely consist of diatoms at low biomass levels among the attached algae. Populations of invertebrates and fish, though probably quite diverse, are likely to be relatively small in both numbers and sizes of the individual organisms. The dashed arrow at the top of Figure 2.1 shows that living organisms do have some ability to modify their environment.

The lower portion of Figure 2.1 links watersheds in which humans are active to the systems to which they drain. Numerous pollutants in the watershed, here represented by only two, can stress organisms and interact to varying degrees. This interaction can either reinforce or reduce the stress of the participating agents. Water pollution is not the only condition in the watershed that causes stress. Chief among other stresses is modified hydrology from increased wet weather flow volumes and peak rates discharged from altered landscapes. Conversely, stress can come from decreased dry weather base flows resulting from reduced groundwater recharge in urban areas.

In Figure 2.1, water pollutants go through various kinds of processing before they create some effect on an aquatic organism. During their transport on land and in water, losses such as sedimentation can reduce the total stress burden on water column organisms, although the reduction may not be permanent (e.g., sediments can resuspend). Of course, organisms dwelling among the sediments often become more affected by these processes. Physical, chemical, or biological processes can also cause transformations to different physical (particulate versus dissolved) or chemical forms. Transformation can cause enhanced or reduced stress potential.

Finally, the biota, or receptors, are affected by the various stresses in whatever form they ar-

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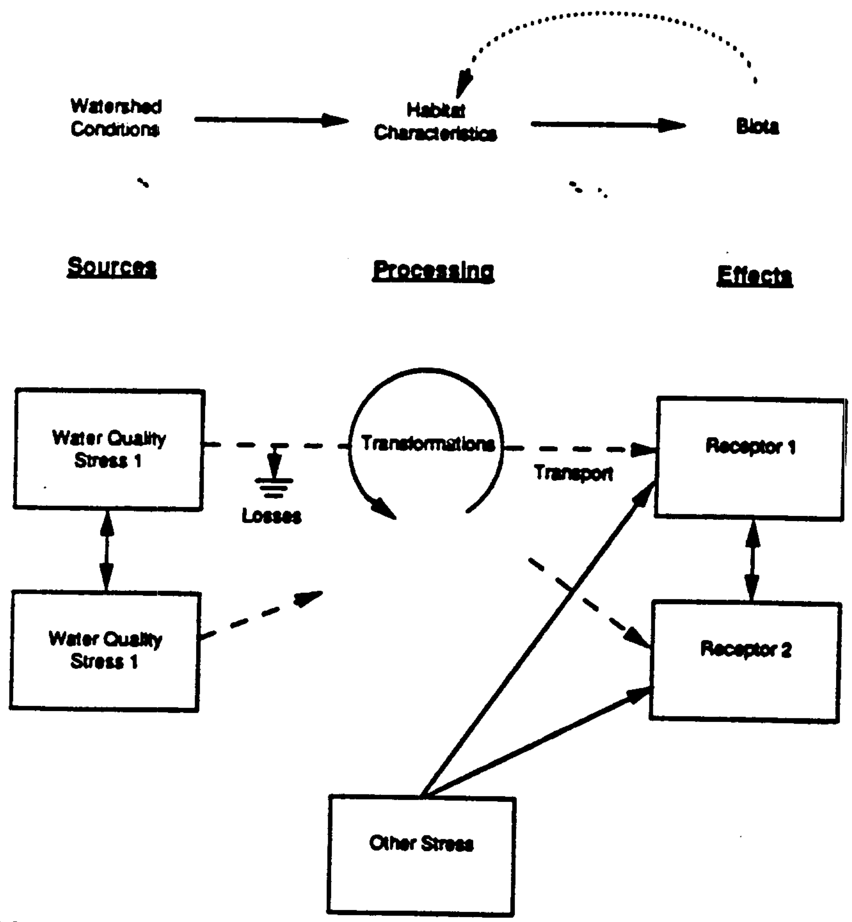
Figure 2.1—Watershed habitat-biological linkages in aquatic ecosystems.



Source: R.R. Horner.

rive. A receptor will have an easier time dealing with a few rather than many stressors, especially when they reinforce each other. Of course, populations of aquatic organisms do not live in isolation but interact with other species, especially in predator-prey relationships. This relationship is represented by the arrow linking the two receptors in the simple system. These interactions have many implications for the ecosystem. For example, the loss of one species from a pollution problem will likely result in the decline or elimination of a major predator of that species.

This illustration sets the stage for discussions in this chapter and in Chapter 3, Aquatic Biological Impacts of Urban Land Use. Substantial complexities exist at every level of the system from pollutant generation to ultimate effects on aquatic ecosystems. Therefore, predicting the result of a particular event or action in the watershed is problematic. However, by carefully tracing the progression of problems and their interrelationships, we can make some judgments to improve our success in ecosystem protection. While this chapter focuses on water quality, Chapter 3 discusses the water quality and hydrologic stresses that disrupt habitats and harm aquatic life.

Characteristics of Urban Runoff Pollutants

Substances In Urban Runoff

Table 2.1 lists pollutant categories commonly found in urban runoff that can harm receiving wa-

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ters and the specific measures that express them. Pollutants other than solids and pathogens are found in either a solid or dissolved state. In urban runoff, most pollutants occur as solids or are associated with soil or other natural particulates. This condition differs among the specific pollutants. For example, depending on overall chemical conditions, each metal differs in solubility. For instance, lead (Pb) is relatively insoluble, while zinc (Zn) is in solution form. The nutrients phosphorus (P) and nitrogen (N) typically differ substantially from one sample to another in dissolved and particulate forms.

Table 2.1—Urban runoff pollutants.

CATEGORY	SPECIFIC MEASURES
Solids	Settleable solids (SS) Total suspended solids (TSS) Turbidity (Turb)
Oxygen-demanding substances	Biochemical oxygen demand (BOD) Chemical oxygen demand (COD) Total organic carbon (TOC)
Phosphorus (P)	Total phosphorus (TP) Soluble reactive phosphorus (SRP) Biologically available phosphorus (BAP)
Nitrogen (N)	Total nitrogen (TN) Total Kjeldahl nitrogen (TKN) (ammonia + organic) Ammonia-nitrogen (NH_3-N) Nitrate + nitrite-nitrogen (NO_3+NO_2-N)
Metals	Copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), arsenic (As), nickel (Ni), chromium (Cr), mercury (Hg), selenium (Se), silver (Ag)
Pathogens	Fecal coliform bacteria (FC) Enterococcus bacteria (Ent) Viruses
Petroleum hydrocarbons	Oil and grease (O + G) Total petroleum hydrocarbons (TPH)
Synthetic organics	Polynuclear aromatic hydrocarbons (PNAs) Phthalates Pesticides Polychlorobiphenols (PCBs) Solvents

Source: R.R. Horner.

Besides these pollutants, other water quality characteristics affect the behavior and fate of materials in water. These characteristics include

- Temperature (Temp);
- pH—an expression of the relative hydrogen ion concentration on a logarithmic scale of 0-14, with 0-6.99 representing a preponderance of hydrogen relative to hydroxyl ions (acidic conditions), 7.00 being neutral, and 7.01-14 representing a preponderance of hydroxyl ions (basic conditions);
- Dissolved oxygen (DO);
- Alkalinity (Alk)—the capacity of a solution to neutralize acid of a standard pH, usually the result of its carbonate and bicarbonate ion content, but conventionally expressed in terms of calcium carbonate equivalents;
- Hardness—an expression of the relative concentration of divalent cations, principally calcium (Ca) and magnesium (Mg), also conventionally expressed in terms of calcium carbonate equivalents; and
- Conductivity (Cond)—a measure of a water's ability to conduct an electrical current as a result of its total content of dissolved substances (often expressed as salinity in estuarine and marine waters).

These characteristics affect pollutant behavior in several ways. Metals generally become more soluble as pH drops below neutral and hence more available—bioavailable—to harm organisms. Depleted dissolved oxygen can also make some metals more soluble. Anaerobic conditions in the bottom of lakes release phosphorus from sediments, as iron changes from the ferric to the ferrous form. Elements creating hardness work against the toxicity of many heavy metals. Water quality standards take this relationship into account by varying the permitted level as a function of hardness.

Quantifying Water Pollutants

Water pollutants are quantified by concentrations and loadings. Concentration is the mass of pollutant per unit volume of water sample, usually expressed as mg/L or µg/L. It is a measure of the pollutant content at the instant the sample is taken. If the pollutant level is higher than an aquatic organism can tolerate, the concentration represents an acute effect that could be lethal or affect the performance of some physiological function as long as the concentration persists. The effects of pollutant concentrations have been established through bioassays exposing test organisms in standard laboratory procedures. However, these simple, static tests completely omit the dynamic patterns and other complexities associated with urban runoff.

Loading is the mass of pollutants delivered to a waterbody over a period of time and is usually given on an annual basis as kg/year (kg/y) or lbs/y. When ascribed to a particular land use, loading—sometimes termed yield or export—is stated per unit area of the land use (kg/ha-y or lbs/acre-y). It represents the cumulative burden over the extended period and hence the potential chronic effects on receptor organisms. With few exceptions (e.g., phosphorus loading to lakes), testing has not established the biological significance of loadings and the way they are delivered to a waterbody. Thus, loading is mainly used to

Table 2.2—Pollutant concentration statistics for general urban and highway runoff.

CONSTITUENTS	GENERAL URBAN RUNOFF		HIGHWAYS RUNOFF		LIMITS FOR PROTECTION OF AQUATIC LIFE**
	MEAN	RANGE*	MEAN	RANGE*	
Suspended Solids (mg/L)	150[2]	2-2,890	220[3]	14-522	10 if background ≤ 100 mg/L 10% of background if background > 100 mg/L
BOD (mg/L)	9[1]	0.41-159	•	•	•
COD (mg/L)	65[1]	< 10-1,031	124[3]	34-1,291	•
Lead (µg/L)	140[1]	3-28,000	550[3]	10-3,775	34
Copper (µg/L)	34[1]	4-560	43[7]	13-288	6.7
Zinc (µg/L)	160[1]	10-5,750	380[3]	40-25,500	30
Cadmium (µg/L)	0.7[8]	0.7-30	•	•	0.2
Chromium (µg/L)	7[8]	< 10-110	•	•	2
Nickel (µg/L)	12[8]	< 2-126	•	•	25
Arsenic (µg/L)	13[8]	10-130	•	•	50
Organic Pesticides (µg/L)	•	0.002-0.35[8]	•	•	•
Phthalate Esters (µg/L)	•	0.06-160[8]	•	•	4-DBP, 0.6-DEHP 0.2-all other PAEs
Phenols (µg/L)	•	8-115[8]	•	•	•
Oil & Grease (mg/L)	7.8[4]	up to 35.7	30[6]	•	•
Total Hydrocarbons (mg/L)	3.7[5]	1.8-43	•	•	•
Polvnuclear Aromatic Hydocarbons (µg/L)	•	< 0.01-12	3.7[6]	•	0.01 BaP
Total Nitrogen (mg/L-N)	1.5[1]	0.34-20	2.72[3]	up to 3.4	•
Total Phosphorus (mg/L)	0.33[1]	0.01-4.3	0.59[3]	up to 0.7	0.005-0.015***
Alkalinity (mg/L)	38.2[4]	5.5-87	•	•	recommend > 20
pH	•	6.2-8.7[4]	•	6.6-8.0[6]	6.5-9.0

• No data reported.
* Range of actual values reported in literature from various studies unless otherwise indicated.
** Maximum concentrations for the protection of freshwater aquatic life as reported in "Approved and Working Criteria for Water Quality," British Columbia Ministry of Environment (1989), when the receiving water hardness is 50 mg/L $CaCO_3$ (average for Fraser River in Lower Mainland).
*** For lakes with salmonids as predominant fish species.
1 U.S. Nationwide Urban Runoff Program database.
2 U.S. EPA database.
3 Median of U.S. Federal Highways Administration database.
4 Light Industrial Catchment in British Columbia.
5 General Urban Catchment in Philadelphia.
6 Highway runoff in England.
7 Highway runoff in Washington State.
8 Data from Metro Seattle.

Source: British Columbia Res. Corp. 1992.

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make relative comparisons, for example, of total pollutant burden before and after development or with and without a certain control strategy.

Table 2.2 presents concentration statistics on several pollutants in general urban and highway runoff and water quality criteria to protect aquatic life. While concentrations generally range widely, the mean values tend to be low. Highway runoff is similar to urban drainage, but means and maximums are generally higher. Urban runoff usually does not exceed water quality criteria with reasonable dilution in the receiving water, but it could. These criteria stem from laboratory testing and represent continuous flow discharges, such as industrial and municipal sewage treatment plant effluents, better than runoff.

Table 2.3 presents typical loadings for a number of pollutants and land uses. Although this table presents no ranges or statistics on the possible dispersion of these numbers when measurements are made, the variation is always substantial from place-to-place in the same land use and from year-to-year at the same place. The general order of loading production, from highest to lowest is

Industrial and commercial > freeway > higher-density residential > lower-density residential > open land.

However, the construction phase can produce far higher loadings of solids and pollutants in soil, like phosphorus, than any finished land use. These data, however, were derived from 10-year-old studies and should be used with caution. For example, substantial evidence indicates that the values for lead have considerably declined in urban runoff with the much reduced use of leaded gasoline.

Metals and synthetic organics are of particular interest because of their potential for toxicity to human consumers of water and to aquatic life. They make up most of EPA's priority pollutants list. Table 2.4 lists the priority pollutants most frequently detected in samples collected during EPA's Nationwide Urban Runoff Program (NURP) in the early 1980s. Three metals (lead, zinc, and copper) were found in almost all samples, and four additional metals were detected in approximately half. Phthalate, the most common synthetic organic, was found in only 22 percent of the samples. Present in 10 to 19 percent were three chlorinated hydrocarbons (two pesticides and a wood preservative) and four polynuclear aromatic hydrocarbons (PNAs).

Table 2.3—Typical pollutant loadings (lbs/acre-y) from urban land uses.

LAND USE	TSS	TP	TKN	NH_3-N	NO_2-N	BOD	COD	Pb	Zn	Cu
Commercial	1,000	1.5	6.7	1.9	3.1	62	420	2.7	2.1	0.4
Parking lot	400	0.7	5.1	2.0	2.9	47	270	0.8	0.8	0.04
High-density residential	420	1.0	4.2	0.8	2.0	27	170	0.8	0.7	0.03
Medium-density residential	190	0.5	2.5	0.5	1.4	13	72	0.2	0.2	0.14
Low-density residential	10	0.04	0.03	0.02	0.1	NA	NA	0.01	0.04	0.01
Freeway	880	0.9	7.9	1.5	4.2	NA	NA	4.5	2.1	0.37
Industrial	860	1.3	3.8	0.2	1.3	NA	NA	2.4	7.3	0.50
Park	3	0.03	1.5	NA	0.3	NA	2	0.005	NA	NA
Construction	60,000	80	NA	NA	NA	NA	NA	NA	NA	NA

NA not available.

Source: Pitt, 1991; Horner and Mar, 1982.

Table 2.4—Most frequently detected priority pollutants in Nationwide Urban Runoff Program samples.

INORGANICS	ORGANICS
DETECTED IN 75% OR MORE	
94% Lead 94% Zinc 91% Copper	None
DETECTED IN 50-74%	
58% Chromium 52% Arsenic	None
DETECTED IN 20-49%	
48% Cadmium 43% Nickel 23% Cyanides	22% Bis(2-ethylhexyl)phthalate 20% α-Hexachloro-cyclohexane
DETECTED IN 10-19%	
13% Antimony 12% Beryllium 11% Selenium	19% α-Endosulfan 19% Pentachlorophenol[a] 17% Chlordane[a] 15% Lindane[a] Pyrene[b] 14% Phenol 12% Phenanthrene[b] 11% Dichloromethane 10% 4-Nitrophenol 10% Chrysene[b] 10% Fluoranthene[b]

[a] Chlorinated hydrocarbon
[b] Polynuclear aromatic hydrocarbon

Source: U.S. Environ. Prot. Agency, 1983.

Sources of Urban Runoff Pollutants

Table 2.5 summarizes urban runoff pollutant sources and shows that most pollutant categories have diverse sources. Likewise, the major sources emit contaminants in most pollutant categories. The atmosphere also contributes some pollution to runoff. Thus, urban runoff is a multifaceted and complex problem to manage.

Synthetic organics represents an exceptionally large and diverse category of chemicals. They include hundreds of specialized products for industrial and commercial uses and compounds produced incidentally through chemical reactions. Examples of the latter group are the PNAs, by-products of fossil fuel combustion, that appear in vehicle exhausts and lubricants and smokestack emissions. New chemicals also form through environmental reactions after the release of a material.

Stormwater management can also be the source of pollutants. During large flows, poorly maintained facilities—like catch basins, conveyance systems, sedimentation ponds, and belowground vaults—can release surges of sediments trapped during small storm events. Galvanized pipes and other parts of drainage systems, commonly used to convey runoff, can also add zinc, a ubiquitous metal in the environment.

Urban Runoff Water Quality Patterns

While pollutant magnitudes in urban runoff follow characteristic patterns over short and long time spans, they vary greatly over space and time. The short term spans a period of hours during one or a sequence of storm events. Measurements at discrete points through such a period often reveal a pattern of pollutant concentration similar to that illustrated in Figure 2.2. During the first minutes, first flush of runoff contains a relatively high concentration of contaminants. The concentration then drops substantially and fluctuates at a lower level for the remainder of the runoff event. The first flush sometimes does not appear, or is less pronounced, when rainfall is not intense or follows soon after an earlier storm that cleans the surfaces. A secondary spike can appear if a sudden burst of intense rain drives material off surfaces not completely cleaned by the initial runoff. Runoff concentrations assume an almost infinite variety of patterns depending on rainfall intensity, antecedent period length and conditions, deposition during the antecedent period, and surface characteristics.

The event concentration-time graph (Figure 2.2) shows the stress created by a single pollutant on a receptor organism. The concentrations represent a series of acute stresses, the most significant of which is the maximum concentration often reached during the first flush. Experts do not fully understand the consequences of a short-duration elevated concentration, even one above water quality criteria, and of the fluctuating stress-filled environment of runoff receiving waters on their resident organisms.

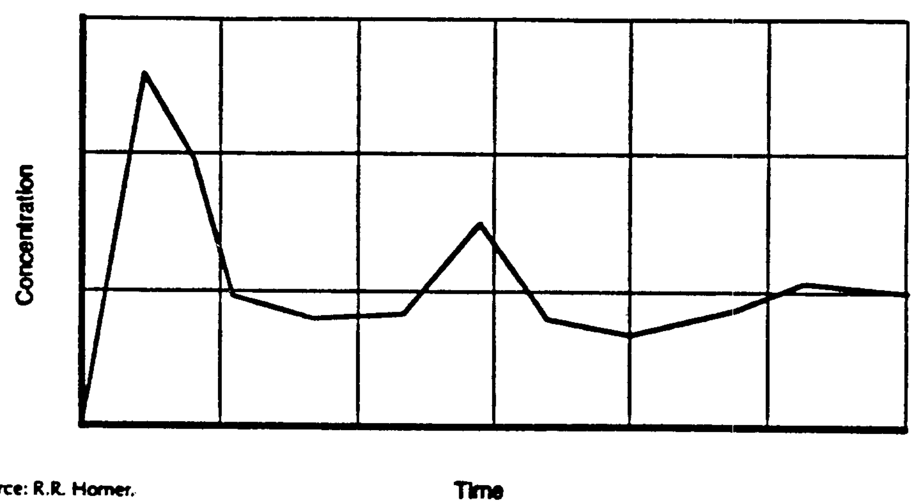
Because of the difficulty in characterizing pollutant concentrations during dynamic flow

Table 2.5—Urban runoff pollutant sources.

POLLUTANT CATEGORY SOURCE	SOLIDS	NUTRIENTS	PATHOGENS	DO DEMANDS	METALS	OILS	SYNTHETIC ORGANICS
Soil erosion	X	X		X	X		
Cleared vegetation	X	X		X			
Fertilizers		X					
Human waste	X	X	X	X			
Animal waste	X	X	X	X			
Vehicle fuels and fluids	X		X	X	X	X	
Fuel combustion						X	
Vehicle wear	X			X	X		
Industrial and household chemicals	X	X		X	X	X	X
Industrial processes	X	X		X	X	X	X
Paints and preservatives					X	X	
Pesticides				X	X	X	
Stormwater facilities	X				X		

Source: R.R. Horner.

Figure 2.2—Typical pollutant concentration pattern during a storm event.



Source: R.R. Horner.

conditions, the expense of sampling, and the analysis required to produce even a partial picture, the accepted practice is to determine an event-mean concentration (EMC). This value is found by analyzing a single sample composited from a series of samples taken at points throughout the runoff event and combined in proportion to the flow rate existing at the time of sampling (termed a flow-proportional composite sample). In addition to its expediency, basing impact assessment on the EMC is justified from a biological standpoint. This will be further explored in Chapter 3.

The flow pattern of an event is customarily pictured on a hydrograph—a graph of flow rate (water volume per unit time) versus time. The integrated area under the curve is the total event runoff volume; the product of volume and EMC is the pollutant loading for the event. The sum of loadings for all events in an interval (e.g., a year) represents the cumulative pollutant burden during that time.

Analysis of climatological data in a number of U.S. locations reveals that most of the total annual runoff is produced by numerous small storms and the initial runoff from large storms. For example, Livingston and Roesner (in press) used Cincinnati data to show that the first 0.5 in (1.27 cm) of runoff from all storms represents more than 90 percent of the total annual runoff volume and encompasses all but four or five events in an average year. Theoretical reasons and some empirical demonstrations indicate that the majority of pollutant loadings is also generated by these smaller flow volumes. Hydrologic criteria for runoff treatment system design are based on these patterns. For example, a pond needs sufficient volume to treat the first 0.5 or 1 in (1.27 or 2.54 cm) of runoff, or the runoff associated with the six-month return frequency, 24-hour duration precipitation event.

Urban Runoff Water Quality Estimation

We need a quantitative estimate of water quality to assess impacts from development actions or to predict the benefits of a management plan. This estimation process is called water quality modeling, although this term is sometimes restricted to the more sophisticated approaches. Assessments are based on annual pollutant loading estimates, although short-term loadings or concentrations are sometimes needed. Long-term loadings tend to diminish the large fluctuations to which short-term phenomena, like instantaneous or event-mean concentrations, are subject. Therefore, we can estimate long-term loading with more assurance than concentrations.

Estimating Concentrations

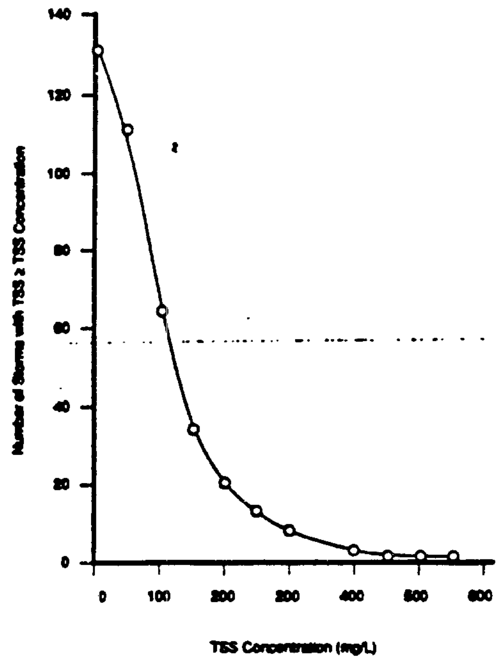
Since concentrations have a high variation level, they must be estimated based on probability—i.e., the ability to state the probability of exceeding any selected concentration. Estimating the probability of concentrations can theoretically be used to estimate maximum (or any other level), but it is usually restricted to the EMC. To estimate even the EMC, we need a large data set to establish the underlying probability distribution for the locale or an assumption of the distribution and a smaller local data set to fit the distribution.

NURP and other data conclusively demonstrated that urban runoff pollutant concentrations fit a log-normal probability distribution—i.e., their logarithms are normally distributed. This is the characteristic distribution of data like those in Table 2.2, where the distribution range is much higher than the mean, and most values are in the lower portion. Figure 2.3, taken from highway runoff data in Washington State, illustrates such a distribution. It shows that the concentration of total suspended solids (TSS EMC) reached as high as 550 mg/L, but exceeded 300 mg/L in less than 10 of more than 130 storms.

Figure 2.4 graphs a highway runoff lead distribution (untreated) on a log-probability plot. The horizontal probability axis expresses the chance of exceeding any concentration selected from the vertical axis. For example, the probability of exceeding 0.12 mg/L in untreated, undiluted runoff is 50 percent, and the chance of surpassing 0.24 mg/L is 10 percent. Treatment or dilution capable of reducing the concentration by 50 percent would decrease the probability of exceeding 0.12 mg/L to 10 percent. Adding the water quality criteria permits performing the analysis from a regulatory perspective. For example, if the receiving water is a drinking water source, the concentration must be reduced by 90 percent to have no more than a 0.5 percent chance of violating the then current standard (the standard is lower now).

NURP produced graphs like Figure 2.4 for each pollutant to determine the EMCs at each site and the EMC medians from all sites nationwide (U.S. Environ. Prot. Agency, 1983). These plots

Figure 2.3—Cumulative frequency distribution of TSS concentrations in runoff from a Washington State interstate highway site.



Source: Little et al. 1983.

can help estimate concentration exceedance probabilities at other locations. Such estimates are best made with data from a site with climatological, land use, geological, and other characteristics similar to those of the location of interest. Using the nationwide plot of median values is less satisfactory.

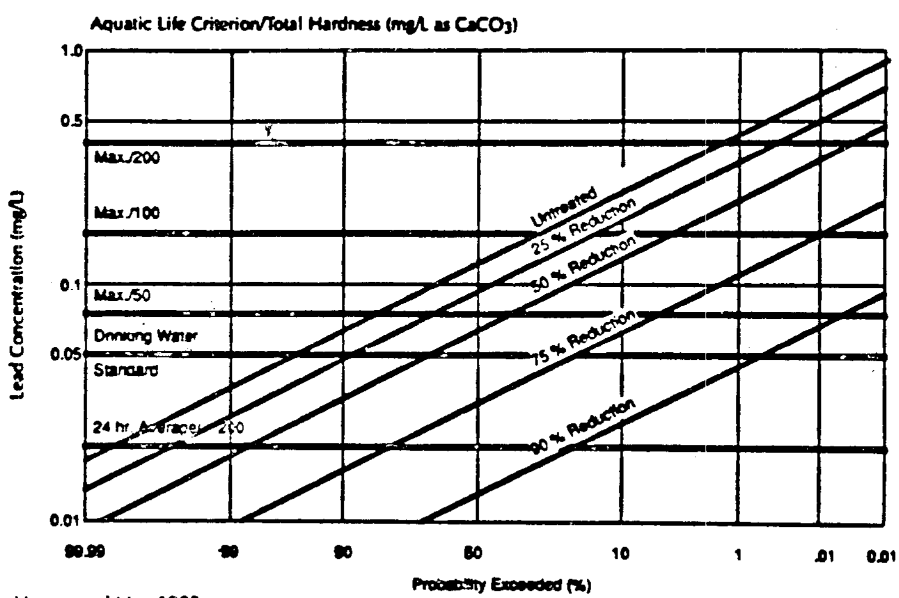
Estimating Loadings

We can estimate cumulative (usually annual) pollutant loadings for a catchment in five ways, from the least to the most complex method:

1. Using published yield values;
2. Using a simple empirical model;
3. Using published regression equations;
4. Computing from site-specific or modeled flow data and either local or published concentrations; and
5. Using a computerized, mechanistic model.

▮ *Method 1—Published Yield Values.* This simple method is least likely to give accurate results because of the general lack of fit between the catchment of interest and the data collection lo-

Figure 2.4—Lead concentration-probability distribution graph.



Source: Horner and Mar, 1982.

cation(s). To apply this method, consult a reference like Table 2.3, select the areal loading rate for each land use, multiply by the areas in each use, and sum:

$$L = \sum a_i \cdot l_i \quad [1]$$

where: L = Total loading;
a_i = Area in land use i;
l_i = Areal loading from land use i.

We can improve this method by producing some measure of uncertainty or error in the estimates. To do so, we establish ranges of areal loadings from the literature, estimate maximum and minimum and mean or median values of L, and then evaluate to determine if uncertainty or error could change the conclusions. For example, uncertainty makes little difference in managing a watershed if we are assessing to identify critical pollutant source areas, and one or more clearly stand out in magnitude.

Table 2.6 presents loading rate ranges compiled by Horner (1992). The author drew values from the general literature and data collected in the Pacific Northwest. The regional data provided values for total phosphorus and total nitrogen for most land uses and all pollutants in road runoff, except fecal coliforms. Accordingly, the regional data have narrower ranges than the remainder. This table should be as discriminately used as others, especially since most pollutants are generally lower in Pacific Northwest runoff than elsewhere. Horner found that ranges estimated from this table

Table 2.6—Pollutant loading ranges[a] for various land uses.

LAND USE	TSS	TP	TN	Pb	Zn	Cu	FC	COD
Road	281	0.59	1.3	0.49	0.18	0.03	7.1E+07	112
	723	1.50	3.5	1.10	0.45	0.09	2.8E+08	289
	502	1.10	2.4	0.78	0.31	0.06	1.8E+08	201
Commercial	242	0.69	1.6	1.60	1.70	1.10	1.7E+09	306
	1,369	0.91	8.8	4.70	4.90	3.20	9.5E+09	1,728
	805	0.80	5.2	3.10	3.30	2.10	5.6E+09	1,017
Single family low density	60	0.46	3.3	0.03	0.07	0.09	2.8E+09	NA
	340	0.64	4.7	0.09	0.20	0.27	1.6E+10	NA
	200	0.55	4.0	0.06	0.13	0.18	9.3E+09	NA
Single family high density	97	0.54	4.0	0.05	0.11	0.15	4.5E+09	NA
	547	0.76	5.6	0.15	0.33	0.45	2.6E+10	NA
	322	0.65	5.8	0.10	0.22	0.30	1.5E+10	NA
Multifamily residential	133	0.59	4.7	0.35	0.17	0.17	6.3E+09	100
	755	0.81	6.6	1.05	0.51	0.34	3.6E+10	566
	444	0.70	5.6	0.70	0.34	0.51	2.1E+10	333
Forest	26	0.10	1.1	0.01	0.01	0.02	1.2E+09	NA
	146	0.13	2.8	0.03	0.03	0.03	6.8E+09	NA
	86	0.11	2.0	0.02	0.02	0.03	4.0E+09	NA
Grass	80	0.01	1.2	0.03	0.02	0.02	4.8E+09	NA
	588	0.25	7.1	0.10	0.17	0.04	2.7E+10	NA
	346	0.13	4.2	0.07	0.10	0.03	1.6E+10	NA
Pasture	103	0.01	1.2	0.004	0.02	0.02	4.8E+09	NA
	583	0.25	7.1	0.015	0.17	0.04	2.7E+10	NA
	343	0.13	4.2	0.010	0.10	0.03	1.6E+10	NA

[a] For each pollutant and land use, loadings are listed as kg/ha-y (except no./ha-y for FC) in the order minimum, maximum, median.

NA Not available.

Multiply loadings in kg/ha by 0.89 to get lbs/acre.

Source: Horner, 1992.

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almost always bound estimates made independently by Hydrologic Simulation Program-Fortran (HSPF) computer modeling (see Method 5).

▮ *Method 2—Simple Empirical Model.* The best example of this method is Schueler's Simple Model (1987):

$$L = 0.23 \cdot P \cdot Pj \cdot Rv \cdot C \cdot A \qquad [2]$$

where:
- L = Loading (lbs);
- 0.23 = Conversion factor;
- P = Precipitation depth (inch) over the desired time interval;
- Pj = Factor that corrects for storms that produce no runoff;
- Rv = Runoff coefficient;
- C = Pollutant EMC;
- A = Area of the contributing catchment (acres).

For annual loading estimation, P is the area's average annual precipitation. Schueler recommends using 0.9 for Pj for annual and seasonal loading calculations. He uses NURP and Washington, D.C., area data to derive a regression equation ($r^2 = 0.71$) for Rv:

$$Rv = 0.05 + 0.009 \cdot I \qquad [3]$$

where: I = Percentage of the catchment area that is impervious.

Relative to C, Schueler notes that NURP data analysis finds no statistically significant differences in EMCs among sites and no correlations between EMCs and storm volume or intensity. Therefore, for rough estimates, these national NURP average EMCs can be used:

Total phosphorus	0.46 mg/L
Total soluble phosphorus	0.16 mg/L
Total nitrogen	3.31 mg/L
Total Kjeldahl nitrogen	2.35 mg/L
Nitrate-nitrogen	0.96 mg/L
Chemical oxygen demand	90.8 mg/L
Biochemical oxygen demand	11.9 mg/L
Zinc	0.176 mg/L
Lead	0.180 mg/L
Copper	0.047 mg/L

Of course, EMCs from local measurements should yield superior estimates. Data from other sources (like Table 2.2) can supplement this listing. A recent comparison of several West Coast watersheds found that Simple Model loading estimates usually agreed, within a factor of two, with estimates made by much more involved and expensive modeling procedures. Either approach will produce the same management conclusions (Chandler, 1993).

▮ *Method 3—Published Regression Equations.* The regression method is best represented by an extensive compilation made by the USGS using its own and NURP data (Driver and Tasker, 1990). This analysis produced multiple regression equations for three national regions for runoff volume and pollutant loadings and concentrations as functions of several independent variables. Independent variables include various meteorological, land use, and other characteristics. Standard errors for the equations were provided as a measure of uncertainty. For a detailed reference, refer to Driver and Tasker's large and complex tables.

▮ *Method 4—Site-Specific or Modeled Flow Data.* To use this method conveniently, arrange the calculations on computerized spreadsheets. Depending on local data, calculations can be performed in several ways. The best situation is to have continuously recorded local flow data and a series of representative local EMC readings. Assuming a log-normal distribution of EMCs, calculate the mean of the EMCs (a) using a statistical equation appropriate for the distribution (Marsalek, 1990). First, take the natural logs (ln) of the EMC values and compute the mean (μ) and variance (s^2) of the natural logs. Then

$$a = e^{(\mu + s^2/2)} \qquad [4]$$

where: e = Base of natural logarithms.

Calculate the confidence interval (C.I.) of the mean EMC estimate using the following equation:

$$C.I. = a \cdot e^{\pm \theta \cdot [s^2/n + 2 \cdot (s^2)^2/(n-1)]^{0.5}} \qquad [5]$$

where:
- + Is used for upper confidence limit;
- − Is used for lower confidence limit;
- θ = 1.96 for 95% confidence interval and 1.69 for 90%;
- n = Number of EMC values used to find μ.

Consult a flow record to obtain the total flow volume for the loading estimate period. Multiply that volume by the mean EMC to get the loading; then multiply it by the upper and lower confidence limits to get the estimate bounds.

Lacking a flow record, use a hydrologic model to estimate (see Chapter 1). One option is to use Schueler's formula for the runoff coefficient, $P_j = 0.9$, and the average precipitation for the period, demonstrated in Method 2. This method can also be used with a flow record but no local concentration data by using NURP or other published average EMC values.

■ *Method 5—Mechanistic Model.* This method includes comprehensive computerized models like the Storage, Treatment, Overflow, and Runoff Model (STORM) created by the U.S. Army Corps of Engineers; Storm Water Management Model (SWMM) and Hydrologic Simulation Program—Fortran (HSPF), both sponsored by U.S. EPA; and Illinois Urban Drainage Area Simulation (ILLUDAS) developed by the Illinois State Water Survey. Detailed coverage of these models is beyond this manual's scope, but the manual does describe their general elements. The models contain hydrologic and water quality components and have mathematical algorithms that represent the mechanisms generating and transporting runoff and contaminants. The hydrologic components of both SWMM and HSPF stem from the Stanford Watershed Model, first introduced almost 25 years ago, and produce continuous hydrograph simulations.

The models structure the water quality components on a mass balance framework that represents the rate of change in pollutant mass as the difference between pollutant additions and losses. Additions, considered to be pollutant deposition, are computed as a linear function of time. Soil erosion is usually calculated according to the Universal Soil Loss Equation (see Chapter 1). Losses are represented by a first-order washoff function (i.e., loss rate is considered to be a function of pollutant mass present); other losses are modeled in mathematically similar ways. For example, both organic matter decomposition and bacterial die-off are considered first-order reactions.

Some models, like SWMM, have both a receiving water and runoff component. These models treat some of the transformation processes that can occur in water (e.g., dissolved oxygen depletion according to the Streeter-Phelps equation). However, no model can comprehensively represent these numerous and complex processes.

These models require substantial local data to set variable parameters in the calibration step and to verify them for the intended application. They also require considerable skill and commitment from personnel. Therefore, only agencies prepared to commit the resources for database development and expertise should embark on using these models. Agencies that need to estimate urban runoff water quality should determine their objectives and select the most appropriate method.

Aquatic Sediment Impacts

At some point in their life cycle, many aquatic organisms have their principal habitat in, on, or near sediment. Sediments also hold pollutants introduced by urban runoff. Pollutants enter sediments in several ways. The most direct path is the settling of solids—this physically changes sediment quality and carries along other pollutants that change sediment chemistry or biology. Dissolved pollutants also move out of solution and into sediments by such mechanisms as adsorption of metals and organics at the sediment surface; ion exchange of heavy metals in water with native calcium, magnesium, and other minerals in sediments; and precipitation of phosphorus.

Most aquatic sediments have a large capacity to receive such contaminants through these processes. Also, many of the pollutants are conservative—once in sediments, they do not decompose or significantly change form. These conservative pollutants include refractory organic chemicals relatively resistant to biodegradation and all metals. Consequently, these types of pollutants progressively accumulate in sediments. Over the long term, discharge of even modest quantities of pollutants can result in sediment concentrations several orders of magnitude higher than in the overlying water. These contaminant reservoirs can be toxic to aquatic life to which they come in direct contact, and can also contaminate reservoirs far beyond the benthic (bottom-dwelling) organisms by biomagnification through the food web.

Historically, water quality has received more attention than sediment contamination. In the past 10 to 15 years, this view has changed because of mounting evidence of environmental degradation in areas that meet water quality criteria. However, sediment toxicity investigations are limited because we do not understand the factors that control contaminant bioavailability and we lack accepted testing methods. The result is an approach that emphasizes bioassay exposure techniques either in situ or in the laboratory along-with chemical analysis of the sediments, overlying water, and/or sediment interstitial water (see Chapter 5).

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CHAPTER 3

Aquatic Biological Impacts of Urban Land Use

A wide array of pollutants entering aquatic ecosystems along with urban runoff causes numerous potential biological effects. These substances often change in transport. Other stresses often associated with hydrologic changes also accompany urbanization. These different stressors interact, and the receptor organisms under stress can interact with one another. How an urban runoff discharge might affect the biota in a receiving water is thus very complex, imperfectly understood, and hard to forecast with assurance.

This chapter focuses on the most numerous, complex, and difficult-to-manage aquatic ecosystem impacts. Table 3.1 provides a general summary of impacts and their causes. The table shows that impacts include chemical effects such as degraded water quality; physical effects such as altered hydrology, degraded habitat, and sediment transport; and biological effects such as altered biotic interactions and death of organisms.

Chapter 3 presents illustrations that cover key issues and the complex, interdisciplinary nature of aquatic biological impacts. Subjects covered include hydrologic and related physical impacts, the role of urban runoff in lake eutrophication, metals and their effects on aquatic organisms, thermal impacts of urbanization and urban runoff management, and fish habitat impacts and managing for habitat protection.

Water quality criteria are a regulatory attempt to avoid adverse impacts on aquatic systems by setting limits on concentrations of specific chemical pollutants that can reach receiving waters. However, relying on these criteria to manage urban runoff is often not an effective strategy, because biological damage can occur even when chemical water quality criteria have been met.

Several factors can explain this dilemma. Based in conventional toxicity, criteria do not represent the variable exposure pattern related to urban runoff or the cumulative effects of pollutant loadings over time. They also cannot account for transformations between release and the point of impact or for the many potential interactions in an ecosystem.

As previously noted, pollutant concentrations are often not high enough in urban runoff, which is diluted in receiving waterbodies, to directly or rapidly harm aquatic organisms. However, continued runoff drainage with relatively low contaminant levels can eventually cause biological damage in two ways:

- Cumulative water quality stress can result in chronic effects; and
- Pollutant accumulations in aquatic sediment can especially affect organisms that inhabit or spend considerable time in or on the streambed or lake bottom.

While this chapter does not cover sediment toxicity and its effects, Chapter 5 discusses both sediment monitoring and using monitoring results to assess biological effects. In addition, Burton (1991) has published an extensive review of information on assessing toxicity of freshwater sediments.

Hydrologic and Related Physical Impacts

Although water quality deterioration from urban runoff is often considered the leading cause of ecological damage, this is not always true.

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Table 3.1—Environmental concerns and impacts associated with urban runoff.

RESOURCE/ WATER USE	CONCERN	POTENTIAL NEGATIVE IMPACT ON RESOURCE/WATER USE	CAUSE
Groundwater	Lower dry-season reserves	Lower dry-season base flow in watercourses Lower drinking water reserves	Increased impervious catchment surface area
Aquatic Habitat	Erosion	Physical destruction of habitat	Peak discharge, high runoff volume
	Fluctuating water levels and velocities	Altered thermal and mixing characteristics Reduced habitat diversity Erosion	High peak discharges and runoff volumes Low dry-season groundwater reserves
	Low dry-season base flow	Elimination of spawning beds Reduced habitat Reduced dilution capacity	Low dry-season groundwater reserves
	Sedimentation	Smothering of bottom communities and spawning beds Filling of stormwater impoundments Transport of particulate-associated pollutants	Erosion Suspended solids
	Turbidity	Lower dissolved oxygen, reduced prey capture, clogging of fish gills	Suspended solids
	Low dissolved oxygen	Lethal and nonlethal stress to aquatic organisms	Biodegradable organic material
	Metals, organic contaminants, chlorides	Lethal and nonlethal stress to fish and other aquatic organisms in water column and bottom sediments Bioaccumulation of contaminants and related food chain effects Osmotic stress Groundwater pollution	Urban pollution
	Increased water temperature	Lethal and nonlethal stress to sensitive cold water aquatic organisms Increased metal toxicity and hydrocarbon solubility	Solar heating of urban surfaces and stored runoff water
	Bacteria	Diseases of aquatic organisms Shellfish contamination	Fecal contamination
	Eutrophication	Algae blooms and nuisance aquatic plant growth Low dissolved oxygen Odors	Nutrient enrichment
Public Water Supply	Lower dry-season reserves	Reduced water supply	Lower dry-season groundwater reserves
	Turbidity	Taste, appearance	Suspended solids
	Metals, organic contaminants, nitrates, chloride	Taste, odor, public health	Urban pollution
	Bacteria	Public health	Fecal contamination
Wildlife Habitat	Flooding and erosion	Physical destruction of environment Dewatering and flooding of key habitat areas at critical times Reduction in streambank cover vegetation	High peak discharges and runoff volumes Sedimentation
Recreation and Aesthetics	Nature enjoyment	See Aquatic Habitat and Wildlife Habitat	See Aquatic Habitat and Wildlife Habitat
	Bacteria	Public health in body contact waters Degradation of fisheries and shellfish beds	Fecal contamination
Agricultural, Residential, and Industrial Land Use	Flooding and erosion	Public safety Damages to crops and farmland Damages to buildings and contents Reduction of useable land area	High peak discharges and runoff volumes Sedimentation

Source: British Columbia Res. Corp. 1992.

Urbanization alters the hydrologic regime of surface waters by changing the way water cycles through a drainage basin. In a natural setting, precipitation is intercepted or delayed by the forest canopy and ground cover. Vegetation, depressions on the land, and soils provide extensive storage capacity for precipitation. Water exceeding this capacity travels via shallow subsurface flow and groundwater and eventually discharges gradually to surface waterbodies. In a forested, undisturbed watershed, direct surface runoff occurs rarely or not at all because precipitation intensities do not exceed soil infiltration rates.

Urbanization effects are multifaceted. Tree removal reduces or eliminates interception storage and the water reservoir in soils. Loss of vegetation and duff from the understory takes away another storage reservoir. Regrading eliminates natural depressions. Impervious surfaces, of course, stop any infiltration and produce surface runoff. Even when surfaces remain pervious, building often removes, erodes, or compacts topsoil. The exposed soil retards infiltration and offers much less storage capacity. Development replaces natural drainage systems with hydraulically efficient pipe or ditch networks that shorten the travel time of runoff to the receiving water.

Adjacent to waterbodies, floodplain encroachment eliminates another storage zone needed to diminish high flows. Clearing bank vegetation removes the wood supply that helps slow down the flow and often helps prevent bed and bank erosion. Clearing also eliminates shade, refuge, and food supply. Urban residents and high stream flows remove remaining wood, further decreasing the stream's opportunity to dissipate energy without flooding or damaging the channel.

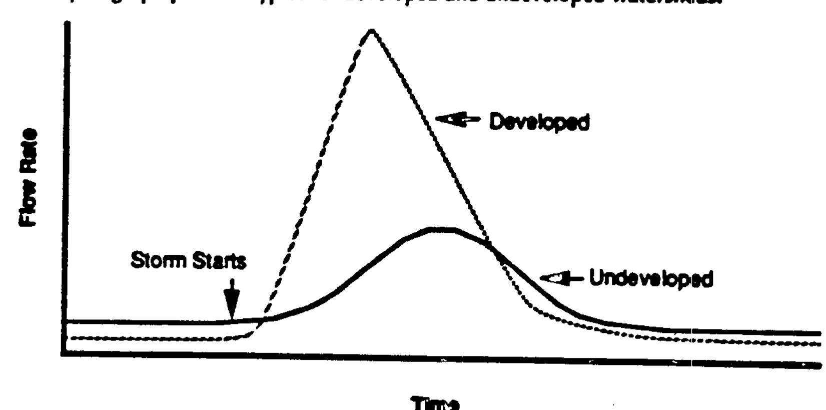
An extensive study comparing an urban and a nonurban stream in western Washington State found that hydrologic changes from urbanization were the principal reasons that the urban stream failed to match its nonurban counterpart in diversity and size of salmonid fish populations and other biological indices (Richey, 1982).

In the Pacific Northwest, the importance of hydrologic alteration and its effects on stream habitats and the salmonid resource is widely recognized. A significant share of the urban runoff management effort goes into controlling runoff water quantity to retain predevelopment hydrologic patterns. In most other U.S. urbanized areas, with respect to resource protection, less attention is paid to controlling quantity to maintain stream channel integrity and more is paid to quality control. Yet, the same hydrologic modification problems have been noted elsewhere; e.g., Mississippi (Wilson, 1967), Long Island (Seaburn, 1969), and Maryland (Hammer, 1972).

The many changes brought on by urbanization tend to alter stream flow patterns in characteristic ways. Figure 3.1 illustrates typical hydrographs (flow rate versus time) for a stream before and after watershed urbanization. The hydrograph emphasizes the higher peak flow rate of urbanized settings compared to preurban conditions. A two-to-five-fold increase is common (Leopold, 1968), although some streams show even greater rises, especially in arid areas.

When the channel cannot contain the greater flow, flooding results. If the flow is largely

Figure 3.1—Hydrograph patterns typical of developed and undeveloped watersheds.



Source: R.R. Horner.

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contained, high flow rates within the same area increase velocities. This can cause large shear stresses that erode streambeds and banks. Shear stress roughly increases proportionately to the square of the velocity (Hynes, 1970). The doubling of velocity could, for example, increase the erosion potential by approximately four. Loss of the stabilizing wood previously in the channel magnifies the effect of flow magnitude.

The hydrograph also indicates the urban stream's faster response to precipitation. Less obvious is the greater total volume, represented by the integrated area under the urban stream curve. When watersheds urbanize, a common runoff volume increase for any given storm is at least 50 percent (Leopold, 1968). Thus, changes in watershed hydrology not only create more friction on the stream channel materials at any instant in time, but that stress also exists for a longer period while the greater volume passes downstream. Runoff quantity control efforts to hold total volumes within predevelopment levels can only be achieved with infiltration equivalent to that in the undeveloped watershed. If storage volume and outlet are sized properly, detention can restrict peak flow rates to those levels, but it will not maintain lower volumes without the needed infiltration. Therefore, even the best quantity control programs often cannot avoid stream channel damage.

The left side of Figure 3.1 shows that while urban streams usually have higher flows during and following rain storms, they also commonly have lower baseflows between storm events. In urban landscapes, baseflow decrease is a consequence of water's rapid transport downstream before it can recharge the groundwater that supplements streams in dry periods. During droughts, baseflow deficit can have an especially severe ecological impact.

These are short-term hydrologic patterns. Urbanization impacts with longer time frames are even more evident. The frequency of recorded high flows increases even more than the flow levels. In one Washington State stream, the flow rate that had been reached only once in 10 years on average before development increased in frequency to about every two years after urbanization (Scott, 1982).

A computer model capable of continuous simulation was applied to another western Washington basin (Booth, 1991). It compared a fully forested basin with a developed 40 percent impervious area. The model predicted that the predevelopment discharge, which occurs only once in five years, would occur in 39 of 40 years after development. Moreover, the model forecasted that in an average year, this discharge level could be reached five times, separated by less than one month in the wet season. The model estimated that the predevelopment five-year discharge could occur bimonthly following development. This 60-fold frequency increase dwarfs the 3.5 times increase predicted for 10-year peak flow rates.

A Long Island study revealed the extent of seasonal hydrologic shifts in urban streams. In several predevelopment streams, baseflow constituted 95 percent of the annual discharge; that proportion dropped to 20 percent after development (Simmons and Richard, 1982).

Some studies have measured urbanization levels that cause significant hydrologic changes. In a study of several Maryland watersheds, Klein (1979) found hydrologic alteration evident with 12 percent impervious area and severe with 30 percent.

Ecological Consequences of Hydrologic Changes

Along with extensive hydrologic modifications, the ecological effects of urbanization on water quantity are also significant. These effects come mostly from habitat damage accompanying hydrologic alteration.

The most basic change is from erosion of the stream channel that sweeps away various habitats and expands the channel, increasing both width and depth. While these increases can be steady and gradual, they frequently occur abruptly in response to particular storms (Hammer, 1972; Leopold, 1973; Booth, 1991). Even in areas where the stream has been stable for years, massive changes in channel dimensions can occur in the first large storm after urbanization, affecting the stream's entire course and profile. The regular meander and pool-riffle patterns of streams not in highly confining substrates will be modified as erosion and deposition increase in magnitude and speed.

Rapid, nearly uncontrolled downcutting, known as incision, can be especially dramatic (Booth, 1990). Incision results when increased flow and loss of the woody debris that dissipates energy occur in relatively steep channels with an easily erodible substrate. While all channel damage is ecologically harmful, incision is especially problematic because it removes virtually all habitat and supplies great quantities of sediment that do further damage downstream.

Research in several humid locations suggests that flows larger than the five-year frequency discharge are sufficient to create large-scale channel disruption (Carling, 1988; Sidle, 1988). More than anything else, the greatly increased incidence of these flows explains the ecological vulnerability of urban streams.

Even without the spectacular phenomenon of incision, habitats are still damaged by complex physical effects from elevated urban stream flows. Impacts can include the following:

- Sediment deposits on gravel substrates where fish spawn and rear young and where algal and invertebrate food sources live;
- Sediment that fills pools where fish feed, take refuge from predators, and rest;
- Direct effects of suspended sediment on aquatic organisms, like abrading gills and other sensitive tissues, reducing light for photosynthesis, reducing visibility for catching food and avoiding predators, and transporting metallic, organic, oxygen-demanding, bacterial, and nutrient pollutants;
- Loss of riparian vegetation, as banks erode, along with the loss of shade and refuge it provides; and
- Loss of the protective qualities of the large woody debris.

Reduced baseflow produces its own set of impacts. Summer temperatures increase because less water absorbs heat, and dissolved oxygen declines from the lower oxygen solubility of warmer water. Less dilution of pollutants results in higher concentrations, and shallower flow can interfere with fish migrations and localized movements.

In the Washington State comparison of urban and nonurban streams, Kelsey Creek, an urban stream, experienced twice the bed scour of its nonurban counterpart, Bear Creek (Scott, 1982). As a consequence, sediment transport was three times as great in Kelsey Creek (Richey, 1982), and fines were twice as prevalent in its substrates (Scott, 1982). The invertebrate communities in different benthic locations produced 14 to 24 taxa in Bear Creek but only six to 14 in Kelsey Creek (Pedersen, 1981; Richey, 1982).

Salmonid fish diversity also differed. Bear Creek had four salmonid species of different age classes, whereas Kelsey Creek had only one non-anadromous species mainly represented by the 0- to 1-year age class (Scott, 1982; Steward, 1983). While both creeks generally met water quality criteria that protect aquatic life from toxicity, differences still occurred. Although we cannot explicitly determine the relative roles of hydrology and water quality, much evidence shows that hydrologic alteration and the related sediment transport were most responsible for the biological effects (Richey, 1982).

King County (Washington) Surface Water Management Division (unpublished data) has examined various aspects of urban hydrology's influence on the valued salmon. Data show a significant decrease in young salmon survival in both large and small streams when events occur that are equal to or larger than the five-year frequency discharge. Since the frequency of events increases tremendously after urbanization, salmonids experience great difficulty even in relatively clean urban streams.

The King County investigations also pointed out the relationship between urbanization level and biological integrity. The study rated channel stability along numerous stream reaches and related it to the proportion of the watershed's impervious areas. Stability was significantly lower with more than 10 percent imperviousness (Booth and Reinelt, 1993). The study rated habitat quality along 87 miles (140 km) of streams in two basins according to four standard measures. Marked habitat degradation occurred at 8 to 10 percent impervious area. Population data on cutthroat trout and less tolerant coho salmon from streams draining nine catchments did not show a distinct threshold. They indicated, however, that population shifts are measurable with just a few percent of impervious area and become substantial beyond 10 to 15 percent (Lucchetti and Fuerstenberg, 1993).

King County also studied urbanization impacts on freshwater wetlands. Gage readings determined mean water level fluctuations (WLF), and a geographic information system related them to various watershed variables. Biological measures were analyzed using mean WLF. The richness (species representation) of both plants and amphibians significantly decreased when mean WLF exceeded 20 cm (7.8 in). WLF depends on various watershed and wetland morphological conditions, but typically surpasses 20 cm when impervious areas are around 10 percent (Taylor, 1993).

Information consistently indicates that placing impervious surface on some 10 percent of a watershed creates significantly negative hydrologic, habitat, and ecological responses. To complicate the picture, development located immediately adjacent to rather than away from a waterbody changes the circumstances. Nonetheless, information of this type provides a basis for protective watershed management through planning and zoning.

Urban Runoff in Lake Eutrophication

Eutrophication is the process through which algal biomass increases overall—especially during "bloom" periods—from increased loading of the nutrient that had previously been in shortest supply relative to need (limiting nutrient). The limiting nutrient in lakes around the world is usually either phosphorus or nitrogen, but is most often and most consistently phosphorus (P) in freshwater lakes. In addition to promoting larger quantities of algae, enrichment typically changes the composition of the algal community. One-celled diatoms give way to filamentous green forms, followed by blue-green forms with a larger nutrient supply.

Eutrophication degrades lake ecosystems in several ways. The filamentous algae are poorer food than diatoms to herbivores because of their structure and, sometimes, bad taste and toxicity. Filamentous algae clog water intakes and boat propellers and form odorous masses when they wash up on beaches. They also reduce water clarity, making swimming unpleasant. When a large biomass dies at the end of the bloom, its decomposition by bacteria creates high oxygen demand. In summer, eutrophic lakes that thermally stratify usually have little or no oxygen in the bottom stratum of water.

As discussed in Chapter 2, urban areas have a number of nutrient sources, and nutrient loadings increase with the development level. The following hypothetical case study discusses the potential of urbanization to change the trophic status of a lake. It compares the lake's trophic state at 10, 50, and 75 percent watershed urbanization. The case assumes the following conditions:

Lake area—100 ha (271.1 acres)

Lake mean depth—3 m (9.84 ft)

Lake water residence time—1 year

Watershed area—5 km^2 (12.36 acres)

Walker (1987) developed a regression equation ($r^2 = 0.69$, standard error = 24) from Minnesota watersheds relating P export to urbanization:

$$\text{P export (kg/km}^2) = 1.02 \cdot \text{(percent urban)} + 2.92$$

Although this equation is quite simplified and omits impervious area and other specifics of the urbanization type, it gives a rough indication of urbanization effects. This example refers to a lake originally in an oligotrophic state. Actual lakes differ in their trophic states even without anthropogenic effects.

The export for the different urbanization levels can be estimated and expressed in terms of its distribution over the lake area, as summarized in Table 3.2. Vollenweider and Dillon (1974) categorized trophic status using data from a number of lakes. They found that boundaries between oligotrophic (relatively unenriched) and mesotrophic (moderately enriched) systems, and between mesotrophic and eutrophic systems (highly enriched), could be drawn by considering the relationship between P loading over the lake area and the ratio of mean depth/water residence time (Figure 3.2).

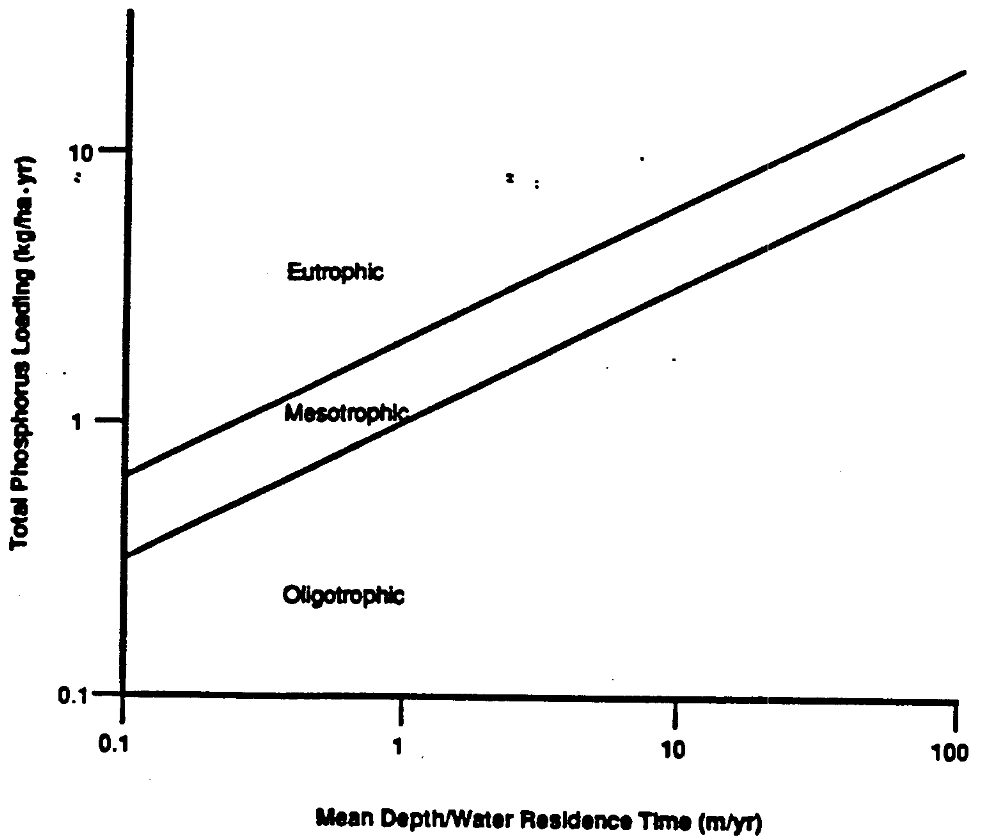
Table 3.2—Phosphorus loadings associated with hypothetical case study conditions.

% URBAN	ANNUAL TOTAL (kg/y)	DISTRIBUTION OVER LAKE AREA (kg/ha · y)
10	50	0.5
50	250	2.5
75	375	3.75

The graph, tabulated data, and mean depth/water residence time ratio of 3 can be used to see that 10 percent urbanization, which would be equivalent to a few percent impervious area, keeps the lake safely in the oligotrophic region. Urbanization at the 50 percent level places the lake in the mesotrophic zone. The highest level of urbanization takes the lake into the eutrophic area.

The exercise can be extended to consider how much P loading control would have to be provided in some way to reach certain lake water quality protection objectives. The typical P loading of a 75 percent urban watershed would need to be reduced 47 percent to keep the lake from passing from its position of 10 percent urban land use into the mesotrophic zone. To keep it more safely in the oligotrophic area—for example, at a loading of 1.5 kg/ha · y—a 60 percent reduction would be needed. This efficiency is very hard to achieve with urban runoff treatment practices (see Chapter 8). Even with this level of control, how-

Figure 3.2—Lake trophic state in response to phosphorus loading.



Source: Vollenweider and Dillon, 1974.

ever, the loading would still be three times the amount at 10 percent urbanization.

A version of this analysis was performed for Lake Sammamish, Washington, using pollutant loading coefficients mostly derived from local data instead of the regression equation. Also, a model was developed to simulate the lake's response to P loading and calibrated with data taken in the lake itself (Welch et al. 1985; Shuster et al. 1986). Planning agencies estimated that urbanization would increase from 16 percent of the watershed in 1975 to 46 percent in 2000, in the form of single- and multiple-family residential and commercial land uses. On the basis of median values of the loading coefficients, P loading per unit area of the lake surface was projected to rise from 4.3 to 7.5 kg/ha · y in that time—a 74 percent increase. These levels are higher than those in the hypothetical case because the watershed of the main tributary to Lake Sammamish has relatively high natural soil sources of P. Nevertheless, the lake's mean depth of 17.7 m (58.1 ft) and water residence time of 1.8 years give it a ratio sufficient to place it low in the mesotrophic zone (Figure 3.2) in 1975. Increased urbanization would send it into the eutrophic area. The projections were used to devise strategies for P source control and runoff treatment.

The Effects of Metals on Aquatic Organisms

Metals are the toxic contaminants most commonly found in urban runoff. Because the exposure patterns of runoff differ from the standard laboratory procedures traditionally used to gage toxicity, metals' role in causing toxic reactions in aquatic organisms is unclear. Different types of experiments are needed to develop a clearer picture and, eventually, more appropriate water quality criteria for waters affected by urban runoff.

For now, clues come from some completed experiments. Davies (1986) summarized a series of experiments with rainbow trout. Although the focus was on mining discharges, results provide some useful insights to consider toxicity in urban runoff. The following account of the findings contains remarks on the significance for urban runoff, which appear in italics.

Note: LC_{50} (96 h) means the concentration lethal to 50 percent of the test organisms in a 96-hour exposure.

Metals Toxicity to Fish

1. Increases in pH, alkalinity, and hardness decrease metal toxicity.

HARDNESS (mg/L as $CaCO_3$)	ALKALINITY (mg/L as $CaCO_3$)	RAINBOW TROUT LC_{50} (96 h) (mg Zn/L)
315	227	7.21
102	81	1.00
23	20	0.56

Hardness (Ca^{+2} and Mg^{+2}) antagonizes toxic metal uptake at the gill surface by competing for uptake sites. Alkalinity plays a role in bioavailability by providing bicarbonate and carbonate ligands under pH control to complex metals in either soluble or insoluble form, removing them from the toxic ionic state. In alkaline waters, metals are not acutely toxic until enough are present to overwhelm the bicarbonate-carbonate buffering system that precipitates lead carbonate complexes. Organic ligands may also form complexes of low toxicity, a subject that has not been well studied. Particulate metals and those adsorbed to particles are relatively nontoxic.

Therefore, runoff discharge to well-buffered waters with most metals in the solid state creates less toxic reactions than dissolved metal discharge to soft waters.

2. Metal toxicity generally increases as temperature increases because of increased chemical activity and metabolism.

TEMPERATURE (°C)	RAINBOW TROUT LC_{50} (96 h) SOFT WATER (mg Zn/L)
6	0.83
10	0.41
15	0.24

Therefore, runoff discharge in the winter and runoff to shaded or groundwater-fed waters in the summer create less toxic reactions than into warm waters.

3. Smaller, younger organisms are more sensitive to metals, and fish are generally more sensitive than macroinvertebrates.

Therefore, runoff discharge during rearing periods creates more toxic reactions than during adult stages.

4. If exposed during the embryonic stage in soft water, fish can acclimate to metals and are less sensitive to higher exposures later. Rainbow trout were approximately four times more sensitive to both cadmium (Cd) and zinc (Zn) when not exposed embryonically, compared to fish that were exposed (chronic effect/no-effect concentrations of approximately 1 μg Cd/L and 50 μg Zn/L for unexposed fish, compared to approximately 4 and 200 for exposed trout). Acclimation ability was confirmed by two-week and one-year experiments in a zinc-contaminated reservoir. However, acclimation does not appear to occur with lead (Pb) and silver (Ag), nor in hard water.

Therefore, relatively low continuous exposures throughout life can somewhat insulate fish from periodic elevated exposures in runoff.

5. Metal toxicity increases as exposure period lengthens.

EXPOSURE (DAYS)	RAINBOW TROUT LC_{50} SOFT WATER (mg Pb/L)
4	1.17
14	0.20

Therefore, fish can better tolerate a high exposure for a short interval than continuous delivery. This observation, however, says nothing about the potential reaction to repeated, periodic exposures, as with urban runoff discharge.

6. The apparent mechanism of acute (one to four days) metal toxicity in fish is gill irritation by the ionic metal, causing mucus secretion and internal destruction of gill epithelium, resulting in suffocation. Chronic (one-week to one-year) toxicity can negatively affect reproduction, growth, physiological and behavioral development, and/or cause death through the breakdown in metabolic or other biochemical functions.

7. "Free" metals include the most toxic ionic forms, as well as other labile forms. Most or all metals present can be free in soft waters but can be a small fraction of total metals in hard waters, thus allowing fish in hard waters to withstand much higher total metals in acute exposure. However, toxicity of free metals is similar in soft and hard water.

HARDNESS (mg/L as $CaCO_3$)	RAINBOW TROUT LC_{50} (96 h) (mg Pb/L) TOTAL	FREE
290	471	1.47
385	542	1.32
32	1.17	1.17

8. Chronic toxicity exhibits trends similar to acute toxicity with respect to free and total metals, but at much lower levels.

WATER	EFFECT/NO-EFFECT PHYSIOLOGICAL ABNORMALITY (µg Pb/L) FREE	TOTAL
Hard	18.2–31.6	120.0–360.0
Soft	7.2–14.6	7.2– 14.6

9. Complexation, which reduces the more toxic free metals, is not instant (e.g., two days for cadmium to come to equilibrium), and mortality increases in tests with unaged water.

   Urban runoff dynamics do not allow time to complete complexation, and therefore buffering is a smaller benefit with intermittent than with continuous releases.

10. "Toxic" concentrations are frequently measured in natural water samples, but fish still live. This contradiction probably stems partly from acclimation and partly from comparing a standard meant for continuous exposure with a condition that is only intermittent. However, the contradiction is also a function of using acid to preserve samples, which frees metals from soils and other particles, and from using the nonselective atomic absorption technique.

11. The use of a dissolved metals measurement can only approximate the toxic forms because some are solubilized over time. "Potentially dissolved" metals can be determined in runoff by waiting to filter for 8 to 96 hours after acidifying the sample, but this method has not been well tested.

   Realistic water quality criteria for waters affected by urban runoff require considering duration and frequency of exposures, chemical forms, and species.

Aquatic Invertebrate Response to Zinc Exposure

Horner (in press) performed experiments with the invertebrate amphipod *Hyalella azteca* that further clarify the observations in points 4 and 5, summarized in Figure 3.3. Organisms were given two types of zinc exposures—continuous and intermittent (three times for 24 hours each)—at the same concentration. Total loadings were close (122 mg with continuous and 90 mg with intermittent). The number of organisms in the continuously exposed community declined gradually at first but stabilized by the end of the 18-day experiment, with a mean survival for individuals of 11.3 days. The concentration was lower than the chronic aquatic life criterion. In contrast, the periodically exposed community declined in steps with each exposure and went extinct by the end (mean survival was 8.5 days).

The same type of experiment was run with a higher loading level (approximately 210 mg) produced by either continuous exposure at 65 µg/L or intermittent exposure in the same pattern as the first experiment at 350 µg/L. The continuously exposed community reacted much as in the first experiment, although the higher concentration caused a more rapid initial die-off that reduced mean survival to 9.6 days. Still, the surviving number was about the same as in the first experiment, despite the higher concentration and loading. The intermittent exposure caused extinction after the second treatment, and mean survival was only 5.0 days.

These results clearly indicate that organisms in the same species tolerate metal toxicity differently. Stronger organisms can survive continuous

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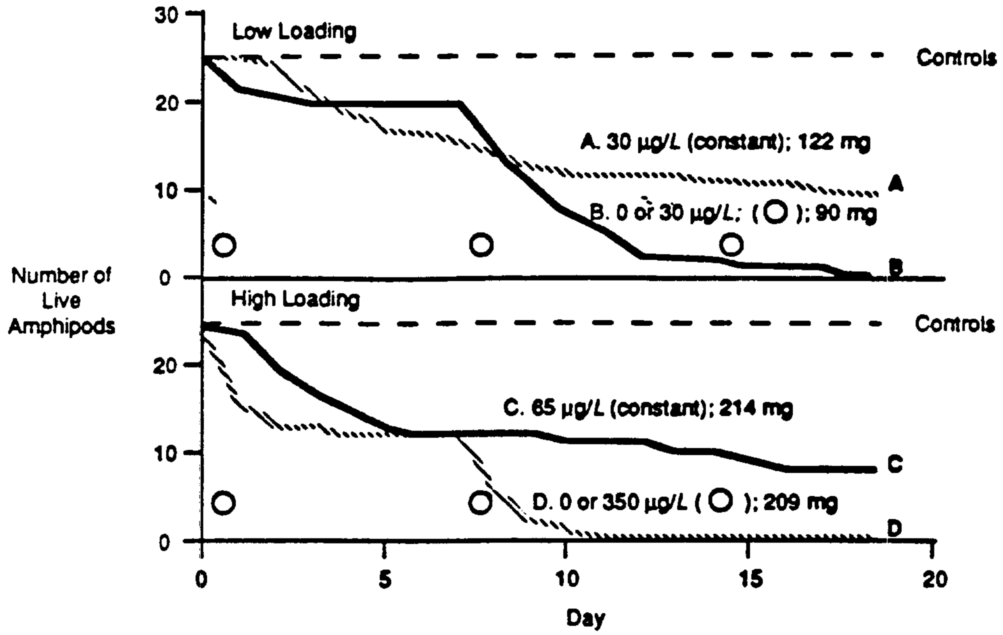
Figure 3.3—Responses of *Hyalella azteca* to constant and intermittent exposures to zinc.



NOTE: Zinc exposures were delivered either at constant concentrations (given in the units µg/L) or intermittently for a 24-hour period on the day, indicated by the circular symbol. The mass values (given in the units mg) represent the total zinc loadings for the entire experimental period.

Source: R.R. Horner.

exposure to concentrations that kill others. In the first experiment, inability to tolerate the same concentration, if intermittent, suggests that, when a threatening condition continues, acclimation defenses may develop over time. Once past the initial period, these defenses probably allow stronger organisms to continue to survive and stabilize the community. Response to the first intermittent exposure in the second experiment shows that, even if the effect to some is severe, the remaining organisms can persist. However, they cannot withstand a second episode of severe shock.

These experiments demonstrate that the important factor is not necessarily pollutant loading but how it is delivered. The findings have substantial implications for urban runoff management—criteria should specify both maximum concentrations for several lengths of exposure, as they do now, and maximum lower concentrations not to be repeated more than once in certain intervals. However, much more work is needed to arrive at the appropriate criteria. A second implication is that the common practice of managing by trying to restrict loading increases may not be successful if we do not develop and incorporate our knowledge of how loading is generated.

Thermal Impacts of Urban Runoff

Aquatic life forms have characteristic temperature preferences and tolerance limits. Fish of interest to humans, like trout and salmon, and their preferred invertebrate food sources have lower ranges and maximums than others. In summer, urban runoff can warm receiving waters to the detriment of these organisms because of lower oxygen concentration in the water. The warmer the water, the less dissolved oxygen can be absorbed by the water and be available to the fish. Urban runoff management facilities can further aggravate the situation when they hold water for an extended time in hot weather. These conditions exist in most of the nation, excluding a narrow band along the Pacific coast west of the Sierra and Cascade Mountains. The Metropolitan Washington Council of Governments (Galli, 1991) investigated the local thermal impacts of urban runoff and its management and reached the following conclusions:

1. Air temperature was the strongest influence on stream water temperature.
2. Average stream temperature increased linearly with impervious area percentage.
3. Some temperature criteria violations occurred with 12 percent impervious area; they increased in severity and frequency with more imperviousness.
4. All structural treatment practices tested that had a surface discharge caused some violations of temperature criteria under both baseflow and storm runoff conditions.
5. The order of the practices in both raising receiving water temperatures and causing violations, from least to most serious, was

   Infiltration basins < extended-detention wetlands < extended-detention dry ponds < wet ponds.
6. Based on the findings from a literature review, the investigators concluded that the thermal conditions produced by urban runoff and treatment facilities could cause algal succession from cold-water (mainly diatoms) to warm-water filamentous green and blue-green species, as well as severe impacts on cold-water invertebrates and fish, where they exist.
7. The findings have important implications for facility selection and design, especially to shade pools and outlets.

Fish Habitat Impacts and Habitat Protection

Effective, comprehensive management of any natural resource has several prerequisites:

1. Setting clear objectives for the effort;
2. Understanding what chemical and physical (including habitat) characteristics organisms need to meet the objectives;
3. Understanding what can disrupt these characteristics; and
4. Understanding what can cause these disruptions and how to overcome the problems.

The following case study illustrates points two and three, summarizing habitat requirements of trout and salmon and citing limits tolerated by various organisms. While salmon are located in only a small area of the nation, trout are prevalent and valued throughout the northern portion and higher altitude, cooler areas farther south. Protecting diversity in aquatic systems requires knowledge of the variation in species requirements. Chapters 2 and 3 discuss causes of reduced diversity; other chapters deal with strategies to overcome these problems (point 4).

Life Cycle Characteristics

Managers must pay attention to organisms' life cycles, which can differ significantly even among closely related species. Table 3.3 summarizes the life-cycle characteristics of six ocean-going Pacific salmon species. Different fish carry out their migrations, reproduction, and rearing at different times and have freshwater stages of various lengths. Management must ensure that the sensitive young fish have the conditions they need at the right time and that barriers to migration do not bar passage of either the returning adults or sea-running young.

Habitat Requirements

Following is a summary of physical and chemical requirements of various salmonid species and life stages that define their habitat requirements, drawn from Bjornn and Reiser (1991), except as noted. As with life cycle characteristics, substantial differences exist among species.

For migration of anadromous adults

Temperature maximum: 15.6°C, except for chinook (dependent on seasonal run—13.3°C spring, 20.0°C summer, 19.4°C fall).

Depth minimum: 0.18 m, except for chinook (0.24 m).

Velocity maximum (sustainable for 5-8 minutes/sustainable in extended cruising, both in meters/seconds) (after Kerr Wood Leidal Associates Ltd. and D. B. Lister and Associates Ltd., 1980):

Coho	3.2/2.7
Chinook (fall)	3.3/2.7
Sockeye	3.1/1.0
Steelhead	4.2/1.4

Dissolved oxygen minimum: Reduced performance when below saturation; sharply reduced when below 6.5-7.0 mg/L; lower limit 5.0 mg/L.

Table 3.3—Life cycle characteristics of anadromous salmonid fish.

SPECIES	ADULT MIGRATION	SPAWNING	EMERGENCE	FRESHWATER STAGE	DIET	JUVENILE MIGRATION
Coho	September–November	October–December	April–May	1 year	Insects Fish fry	May–June
Chinook (fall)	September–October	October–November	March–April	2–3 months	Insects	May–July
Sockeye	August–September	September–October	April–May	1 year (lake)	Zooplankton	April–June
Pink	August–September	September–October	April–May	None	In sea	April–May
Chum	September–December	October–January	April–May	None	In sea	April–May
Steelhead	All months	January–May	June–July	2–3 years	Insects Fish fry	April–June

Source: Kerr Wood Leidal Assoc. and D.B. Lister Assoc. 1980.

Barriers: Ideal falls height to pool depth = 1:1.25; maximum falls height 2.1-2.4 m, except for steelhead (3.4 m) (0.8 m for nonanadromous brown trout).

For spawning adults

Stream flow: Weighted usable (spawning) area (WUA) is a function of depth, velocity, and substrate and is related to discharge by In-stream Flow Incremental Methodology (IFIM) species models.

Dissolved oxygen minimum: 7 mg/L (Welch 1980).

Temperature maximum:
Anadromous: coho and steelhead—9.4°C, sockeye—12.2°C, chum and pink—12.8°C, chinook—13.9°C.
Nonanadromous: brown trout—12.8°C, cutthroat trout—17.2°C, rainbow trout—20.0°C.

Redd area/spawning pair: Dependent on species and space availability; ranges from order 0.1-1.0 m^2 for nonanadromous trout, to 1-10 m^2 for steelhead and smaller salmon, to 10-20 m^2 for chinook.

Depth minimum:
Anadromous: sockeye and pink—15 cm, coho and chum—18 cm, steelhead and chinook—24 cm (except 30 cm for summer chinook).
Nonanadromous: cutthroat trout—6 cm, rainbow trout—18 cm, brown trout—24 cm.

Velocity range:
Anadromous: generally 20-40 cm/s minimum to approximately 1 m/s maximum.
Nonanadromous: cutthroat trout—11-72 cm/s, brown trout—21-64 cm/s, rainbow trout—48-91 cm/s.

Substrate size range:
Anadromous: 1.3-10.2 cm (except 0.6 cm minimum for steelhead).
Nonanadromous: rainbow trout—5.2 cm maximum, brown trout—7.6 cm maximum, cutthroat trout—10.2 cm maximum (0.6 cm minimum in each case).

For egg incubation

Temperature maximum:
Anadromous: 13.3°C, except for chinook (14.4°C) (Welch, 1980, recommended 12.8°C for all salmon and trout).

Substrate size minimum: Data show that embryo survival declines from near 100 percent with near 0 percent fines < 6.35 mm, to approximate 50 percent with 20-40 percent fines (species dependent—order 20 percent for cutthroat, 30 percent for rainbow, 40 percent for chinook and steelhead), to near 0 percent with > 50-60 percent fines.

Dissolved oxygen minimum: Percent survival exhibits a linear relationship with DO for some species (e.g., steelhead); percent survival drops below 50 percent when DO < 8-9 mg/L and low DO reduces size and a threshold relationship for others (e.g., coho, where the threshold is approximately 8-9 mg/L).

For Juvenile rearing

Temperature preferences:
Anadromous: 12-14°C, except for steelhead (10-13°C).
Nonanadromous: 14-16°C for brook trout.

Dissolved oxygen minimum: Data show a threshold relationship generally exists, with the threshold at approximately 4 mg/L and a very rapid decline in survival below that level.

Space minimum: Depends on age and size; anadromous fish with a short freshwater rearing period need 0.01-0.1 m^2/fish and those with an extended freshwater rearing period need 0.5-5 m^2/fish; nonanadromous fish need 5-100 m^2/fish.

Streamflow: IFIM models also exist for rearing.

Depth range: Highly variable; mostly in range 30-75 cm.

Velocity maximum: Variable with few data showing preferences above 40 cm/s.

Substrate size minimum: Embedding large substrate with fines (< 6 mm) reduces juvenile densities (faster in winter than in summer); density decreased to about half of maximum with about 30 percent embeddedness in winter for steelhead and chinook.

Cover: Cutthroat trout biomass exhibited an exponential decline with cover loss in one study; in another study steelhead and chinook biomass was higher with more diversity in cover types and benefited most with increased amounts of side overhang and brush.

Examples of Management Strategies

1. Culverts are a common impediment to fish movements. Considerations are depth, length and velocity in relation to the fish's ability to swim against the velocity long enough to pass through the culvert, and vertical drop at the downstream end. For example, smaller, slower-swimming sockeye salmon adult migrants would need a lower velocity and smaller vertical jump than steelhead. Table 3.3 also shows that favorable conditions would have to be maintained at different times (late summer for sockeye and throughout the year for steelhead).

2. A frequent mistake in protecting and restoring fisheries habitat is to underestimate the space needed for a pair to spawn and each juvenile to rear. Successful spawning for larger fish and those with a longer residency requires that substantial suitable bed space be created or protected. For example, to provide for spawning and rearing of brown trout, 0.1-1.0 m^2 of substrate with 0.6-7.6 cm material must be provided for each spawning pair. The water should be no warmer than 12.8°C, at least 24 cm deep, and have at least 7 mg/L DO and velocity in the range 21-64 cm/s. Each juvenile would need much more space (5-100 m^2), however, at comparable conditions (except lower velocity). Anadromous fish would need more territory for spawning but less for rearing.

Recommended Reading

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CHAPTER 4

Water Quality Monitoring

To obtain conclusive data on urban runoff and its effects on the watershed is difficult and expensive. Therefore, monitoring programs that collect data must be carefully designed to be cost-effective. This chapter suggests a general process for designing water quality monitoring programs, whether the monitoring subject is water quality, sediments, or biological organisms.

This process comes mainly from research to improve monitoring program design in urban runoff and other nonpoint source fields. Consult Reinelt, Horner, and Castensson (1992); Reinelt, Horner, and Mar (1988); Mar et al. (1986); and other references and sources for more details. Guidance on sediment and biological monitoring programs follow in subsequent chapters.

The suggested analytical process has five steps:

1. Specify monitoring program objectives;
2. Determine the level of effort to devote to the analysis;
3. Perform a systematic analysis appropriate to the problem and objectives;
4. Use the analysis results to tentatively specify monitoring program elements; and
5. Evaluate the tentative monitoring program for cost-effectiveness and finalize according to evaluation results.

Monitoring Program Design Steps

1. Specify monitoring program objectives

Establishing objectives is essential, even though they cannot always be specified in great detail. The most thoughtful statements, agreed upon by all stakeholders, should guide the monitoring program design and conduct. Objectives stem from the nature of the problem or decisionmaking need that requires data collection. Urban runoff management problems include the following:

- Defining the water quality status of a discharge or waterbody;
- Identifying problem areas, their sources, or both;
- Selecting locations to apply problem abatement strategies;
- Evaluating alternative abatement strategies both prior to and after implementing control techniques;
- Calibrating and verifying runoff simulation models; and
- Researching (e.g., to identify ways that contaminants affect organisms).

Every monitoring program should, if possible, formulate objectives at two levels—general and specific. General objectives describe what must be accomplished to solve the overall problem or meet the need. For example

- Obtaining a baseline definition of the effect a proposed development will have on water quality in a lake.
- Determining long-term trends in sediment accumulation of metals in a poorly flushed bay.

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- Finding the contamination source that has closed a shellfish bed to harvesting.

Specific objectives relate directly to measurements and produce results to meet the general objectives. Some examples related to the third general objective—finding the contamination source—are

- Determining the annual fecal coliform loadings contributed by agricultural, septic drain field, and urban runoff sources.

- Identifying the three largest sources of fecal coliform loading to the shellfish bed area.

These objectives can be stated in more detail and more specifically, particularly regarding measurements (e.g., zinc and chromium as the specific metals; percent Ephemeroptera [mayflies] + Plecoptera [stoneflies] + Trichoptera [caddisflies] as the macroinvertebrate measure) when step 3 of the general design process is completed. Using this process ensures careful decisionmaking at each step and counters the tendency to use a generic monitoring strategy that may not relate to the program goals. Exercising discipline to make careful assessments is the best way to be cost-effective in monitoring.

2. Determine the level of effort

A monitoring program can range from simple and inexpensive to thorough and costly, depending on the objectives for the particular program. The effort expended depends on the quantity and type of information available, the detail of additional information needed, the resources of the designers, and the urgency to begin monitoring.

Available information can help target new monitoring and substantially reduce costs. Therefore, designers should incorporate this information in their analysis, using techniques in this manual. Some problems may not be worth extensive effort, while others demand it. For example, merely determining whether a problem exists at a particular place is often straightforward and may not need extensive analysis. On the other hand, monitoring to allocate resources for solving problems in a large, complex watershed may require a substantially greater level of analysis.

Even if little guidance information exists, and the designer has limited time and resources, at least the basic analytical process should be applied. After developing a preliminary information base, the designer can always review the systematic analysis of the problem and objectives in more detail later.

3. Perform a systematic analysis

As the core of the process, step 3 represents the most effort. The analyst should give priority to key factors causing the problem.

This systematic analysis is often referred to as a watershed analysis. The term watershed broadly signifies an area, large or small, that drains a land surface to a point of interest. While a watershed can be a small catchment with a simple drainage system, for now we will consider a watershed as a landscape of some size and complexity draining through a network of artificial and natural conveyances to a natural waterbody. Thus, the analysis involves surveying watershed characteristics, identifying the most critical potential problems and sources, and highlighting the most critical places, times, and biological units that manifest the problems.

A watershed inventory involves collecting the appropriate level of data according to the needs of the project. While the level of detail may vary, your inventory should include developing a basin map; identifying such features as land uses, soils, topographic information, and hydrologic data; and identifying potentially critical problem source locations (e.g., earth-moving activity, industrial areas, major traffic concentrations) or areas potentially sensitive to problems (e.g., fisheries and other productive resource areas, rare or endangered resources, stream reaches vulnerable to major channel damage). Obtaining any available data on these features and field reconnaissance are key tasks in a watershed inventory.

Identifying critical problems and sources should be a systematic process of formulating a broad list and then narrowing it by prioritizing items, with the level of effort chosen in step 2 dictating the scale of the analysis. For example, to find the principal sources of water quality deterioration in a river draining a large watershed, we may suspect that certain areas and activities need our attention. However, this judgment should be tested by some quantified, comparative estimates of pollution quantities like those models suggested in Chapter 2. Although such a model may be overly generalized, simplified, and not calibrated locally, its purpose is not to reach a final decision, but to guide the design of a monitoring program. Even with a small effort level, the simplest model can often bring objectivity and rigor to the analysis.

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Identifying critical places, times, and receptor organisms presents a more difficult problem. We must at least conceptualize the relationship between problem occurrence and timing and the potential damage for habitats, species, and life stages. While models can sometimes help, they are usually too simple or inconvenient. Ideally, the specialists (e.g., water quality engineer, hydrologist) will work closely with an ecologist familiar with the waterbody, its ecology, and natural history to judge these critical factors.

Reviewing the original objectives for their continued appropriateness is a good practice. Objectives will likely need to be modified or made more specific with the increased knowledge.

4. Specify monitoring program elements tentatively

If performed properly, the systematic analysis of step 3 will provide sufficient information to give tentative shape to the monitoring program. In designing the program, determine

- What to sample;
- Where to sample;
- When to sample;
- How many samples to take on each occasion (replicates);
- How to sample; and
- What to analyze in samples.

The design should set objectives, identify potentially critical problems, and target the monitoring program, considering cost-effectiveness. Thus, the objectives and analytical findings should dictate the media to be sampled, the locations and times of sampling, and the analyses to be performed. This philosophy rejects working from prescribed sampling scopes and frequencies and standard lists of analytical measures. It advocates tailoring the program to a specific level of effort to meet stated objectives developed from a systematic analysis—all to advance program cost-effectiveness. The tentative decisions on monitoring program design are further evaluated in step 5 before they are finalized.

Deciding when to sample includes planning and scheduling a number of visits to each sampling location. Use careful judgment to select the initial number of visits rather than automatically specifying periodic intervals (e.g., biweekly or monthly). Natural phenomena do not occur at evenly spaced intervals. Most places, for example, have seasonal differences in the type, amount, and/or intensity of precipitation. Accordingly, stratify sampling to consider these events. For instance, visits might be scheduled for times of highest runoff when pollutant delivery is greatest and at lowest flow when pollutants concentrate most. Transitional periods would get less coverage.

How to sample is discussed in the guidance following step 5.

5. Evaluate the tentative monitoring program and finalize

Evaluate the step 4 tentative monitoring program according to its number of samples. The sample numbers and the analyses specified are factors that directly determine the program's cost and probable effectiveness. Monitoring programs frequently fail to provide the desired information, even when performed flawlessly, because the samples are insufficient to achieve an accepted level of statistical assurance. This failure results from the high variability in runoff and natural aquatic systems. For example, variability prevents us from attaining a high level of statistical confidence that an average water quality condition meets a criterion or that a new discharge creates a change in a biological community.

Sources of variability include spatial differences in a landscape or waterbody, differences over time (temporal variability), and measurement error. Measurement errors can be reduced by using better techniques, if they exist. Otherwise, collecting replicate samples quantifies the measurement error component. Increasing sample numbers can overcome natural spatial and temporal variability, unless they are enormous; but that strategy raises cost.

The basic task is to determine the number of samples (stations, occasions, and replicates) needed to meet the objectives, considering variability and budget limits. Using the optimal number of samples to reach a conclusion will produce the maximum confidence level for a set budget, or a minimum cost for a set assurance level. These options, representing two ways to maximize the monitoring program's cost-effectiveness, can only be applied if some data are already available to give statistical measures of central tendency (e.g., mean or median) and variance. In that case, statistical methods can be applied to the optimization

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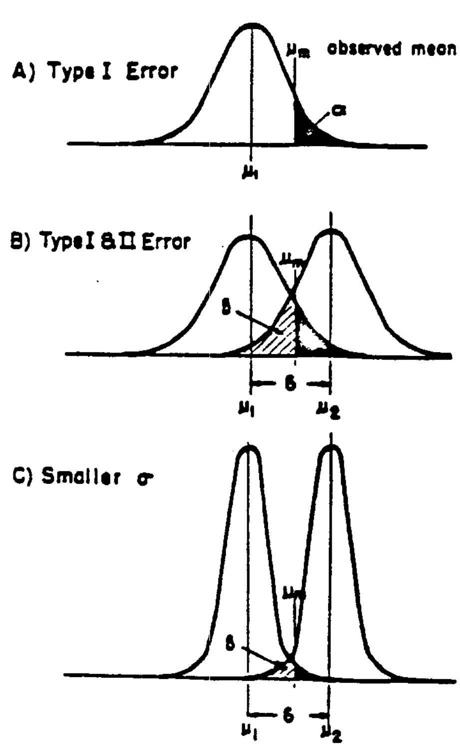
problem. Mar et al. (1986) reviewed the following appropriate methods for common situations in monitoring program designs.

Determining a Mean Value

Determining a mean value applies, for example, when an average water quality condition is compared to a regulatory criterion. In basic statistics, t-distribution defines the confidence interval for the mean of a normal population (set of values) as estimated from a data set. The t-distribution is used to determine sample numbers if the data are demonstrated or assumed to have a normal probability distribution (Figure 4.1A), or if they can be transformed (e.g., by taking their logarithms) to yield a normal distribution.

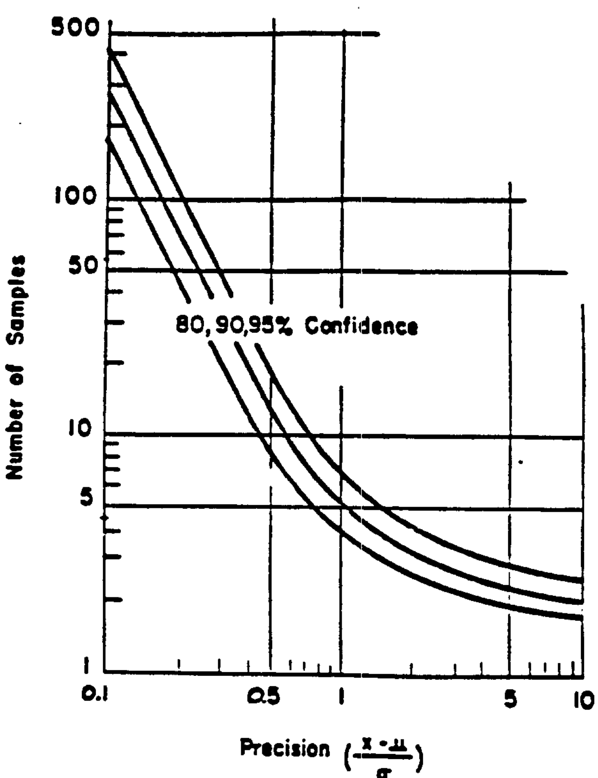
Figure 4.1—Hypothesis-testing fundamentals. μ_1 and μ_2 are the means of two populations of measurements; their difference represents a change—delta. Alpha and beta are the probabilities of the Type I and Type II error, respectively.



Source: Mar et al. 1986.

Figure 4.2 shows an analysis result based on the t-distribution for three confidence levels. The curves show the number of samples required as a function of precision. Precision is the ratio of the difference in the estimated and actual mean (the error that will be accepted) to the standard deviation (the variation or noise in the data). To use the graph, the monitoring program designer consults available data to get estimates of the mean and standard deviation and decides on the acceptable error and confidence level. For the case of an acceptable error equal to the standard deviation (precision = 1) and an 80 percent confidence, four samples are needed. But demanding a precision of 0.1 requires hundreds of samples.

Figure 4.2—Number of samples versus precision for three confidence levels. Precision is the ratio of the allowable error to the standard deviation of the population of measurements.



Source: Mar et al. 1986.

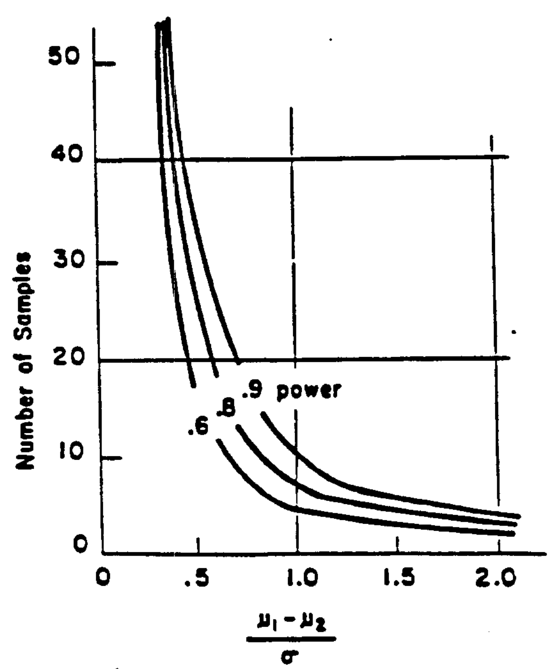
Detecting Change

Detecting change applies, for example, when the size or composition of a biological community is evaluated at two different points in time. Programs designed to detect change require different statistics than those that simply identify means. This type of problem is phrased as a statistical hypothesis test in which the null hypothesis (H_0) is that the populations at the two times are from the same distribution; the alternative hypothesis (H_1) is that they are from different distributions.

Figure 4.1 illustrates terminology needed for this type of evaluation. The shaded area of Figure 4.1(A) represents the probability (alpha) of a Type I error (H_0 was rejected when it was, in fact, true). Figure 4.1(B) shows distributions at both points in time, in which the difference in means represents an apparent change of magnitude (delta). The hatched area represents the probability (beta) of a Type II error (H_0 was accepted when it was, in fact, false). The quantity (1-beta) is termed the power of a statistical hypothesis test. Figure 4.1(C), in comparison to the other two graphs, illustrates the variation effect, as represented by the standard deviation, on power. For a given change, delta, the power increases as the standard deviation decreases.

Figure 4.3 provides a graphic way to establish the number of samples needed to detect change. To use the graph, the monitoring program designer consults any available data to estimate the standard deviation and decides on the magnitude of change to be detected (delta = $\mu_1 - \mu_2$) and the power. This plot shows that to detect changes to less than 50 percent of the standard deviation, the program requires a large number of samples.

Figure 4.3—Power curves relate number of samples to change to be detected. Sigma is standard deviation.



Source: Mar et al. 1986.

Monitoring Costs

The statistical methods previously illustrated show how to measure the program effectiveness value of added information in the form of more samples. However, to optimize the program, cost estimation must accompany these methods. Given the cost and value of added data, a trade-off analysis can be performed to obtain the most cost-effective program within the existing constraints. Costs are accounted as follows:

$$TC = C_o + T \cdot C_t + S \cdot T \cdot C_s + R \cdot S \cdot T \cdot C_r \quad [1]$$

where:
- TC = Total cost;
- C_o = Fixed overhead cost;
- C_t = Fixed cost for each sampling occasion;
- C_s = Cost associated with visiting each sampling station;
- C_r = Cost to collect and analyze each sample;
- T = Number of sampling occasions;
- S = Number of sampling stations; and
- R = Number of replicates on each occasion at each station.

Note that $R \cdot S \cdot T$ = the total number of samples. For a given total, the three quantities can be varied so long as their product remains the same. If measurement error is larger than natural variation, then adding replicates would reduce uncertainty more than adding stations or occasions. However, if spatial or temporal variation dominates, adding stations or occasions, respectively, would be a better strategy.

Optimization Example

Suppose three variables—A, B, and C—are monitored to establish their means with 90 percent confidence. Table 4.1 gives the measurement and variability costs of each. Considering three bases to design the monitoring program illustrates optimizing for a given budget (Designs 1 and 2) and a given level of assurance (Design 3):

▮ *Design 1.* Three samples will be collected for each variable (fixed cost of \$333). What is the minimum error that can be attained in each case?

▮ *Design 2.* Four samples will be collected for each variable (fixed cost of $444). What is the minimum error that can be attained in each case?

▮ *Design 3.* A fixed error of 24 percent of the mean is required for each variable. What design (sample numbers) provides this level of certainty at the minimum cost?

Table 4.1 summarizes the evaluation. Design 2, as compared to Design 1, indicates that an increased but equal number of samples would only slightly improve the estimate of the mean for each variable, and the estimate for variable B would still be uncertain relative to the others. However, as shown by Design 3, allocating more samples to the variable with the greatest variation, and where the most improvement results per dollar spent, provides a more cost-effective design.

In most actual cases, a simple analysis like this is insufficient since uncertainties can result from several factors, including measurement errors and spatial and temporal variability. Then, a sensitivity analysis should be performed to investigate each cost and variance component and its effect on the design in order to allocate the effort among sampling locations, occasions, and replicates. Mar et al. (1986) gives an example of such an analysis.

Table 4.1—Monitoring program optimization example.

INPUT DATA	VARIABLE		
	A	B	C
Cost per sample	$100	$ 1	$10
Standard deviation (percent of mean)	10	100	20

DESIGN 1 (3 samples of each variable)

VARIABLE	COST	PRECISION[a]	ERROR[b] (% OF MEAN)
A	$300	2.4	24
B	3	2.4	240
C	30	2.4	48
TOTAL	$333		

DESIGN 2 (4 samples of each variable)

VARIABLE	COST	PRECISION[a]	ERROR[b] (% OF MEAN)
A	$400	2.2	22
B	4	2.2	22[illegible]
C	40	2.2	44
TOTAL	$444		

DESIGN 3 (fixed allowable error of 24 percent of the mean for each variable)

VARIABLE	ERROR (% OF MEAN)	PRECISION[c]	NO. SAMPLES[a]	COST
A	24	2.4	3	$300
B	24	1.2	5	50
C	24	0.24	56	56
			TOTAL	$406

[a] From Figure 4.2 for 90 percent confidence.
[b] Error = Precision X standard deviation.
[c] Precision = Error/standard deviation.
Source: Mar et al. 1986.

Additional Considerations

Stratification of sampling, as discussed under step 4, can help reduce the variability that complicates monitoring. Values will fit in tighter bounds within a single season if all values are lumped for the entire year. The analysis can be performed separately for the respective seasons and sampling occasions allocated accordingly.

If no data are available, monitoring program designers have several choices. They can conduct a pilot program to obtain a limited data set; however, this would require spending time and money. A second choice is to use data from a similar location or estimate values using professional judgment. Either course has obvious drawbacks in accuracy, but both may be superior to making an educated guess of the sample number with qualitative, but no quantitative, analysis. Even that option is better, though, than blindly choosing the number of sampling occasions without any analysis.

In some cases, uncontrollable natural variability will be too great to achieve confidence in some program element with any feasible budget. The designer must then either delete the element or reduce costs in other areas to direct resources to the element. The options, illustrated by the cost equation, are to reduce the number of sampling stations, the analyses prescribed, the various cost functions representing program elements, or some combination. This decision is often unpalatable because it can demand, for example, cutting geographic coverage or not analyzing for a water quality measure traditionally included. However, the designer must choose and target the program according to objectives and circumstances, rather than conducting a program that gives inconclusive or misleading answers.

Water Quality Monitoring Program Guidance

Flow Measurement

Measuring Flow in Uncontrolled Open Channels

Flow, or discharge, is a basic hydraulic characteristic affecting morphological development of stream channels, flooding behavior, bed and bank erosion, and sediment deposition. A flow measurement is needed to estimate pollutant mass flux—the product of pollutant concentration and flow. Flow is measured manually or by continuously recording automatic instruments. Recording instruments require a controlled section such as a pipe, weir, or flume (see following section).

The common manual methods of flow measurement in uncontrolled channels are current meter surveys, staff gages, and float and tracer surveys (U.S. Dep. Inter. 1977). The current meter technique involves determining flow for a cross section of the channel. Current velocity and depth data from several points along the cross section are summed to obtain total flow. A staff gage provides an instant reading of water stage (i.e., level of water surface relative to a known point or datum). A stage-discharge curve must be developed to estimate flow from the staff gage reading. The curve is developed by correlating flows determined from current meter surveys with stages over a range of flow conditions. Estimating flow from timed float travel measurements can be inaccurate. Using this method should be limited to low or high flow conditions when the current meter cannot be employed. Tracers include biodegradable dyes and salts detectable by photometric and conductometric measurements, respectively. Tracer surveys are less convenient and more time consuming in natural waters than current meter methods.

▮ *Site Selection Criteria.* Select a representative location to establish a station for monitoring flow. Proper site selection improves the accuracy of flow measurements at all discharge levels. Consider the following criteria when establishing a discharge measurement station. However, all criteria listed can rarely be met. Be aware of the site's limitations and possible effects on measurement.

The station should be located in a channel reach (i.e., longitudinal section) with the following characteristics:

- The channel should be straight for 328 ft (100 m) upstream and downstream of the staff gage station.
- Flow should be confined to one channel at all discharge stages (i.e., the channel should contain no surface or subsurface bypasses).
- The bed should be subject to minimal scour and relatively free of plant growth.
- Banks should be stable, high enough to contain maximum flows to be measured, and free of brush.

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- The station should be located a sufficient distance upstream so that flow from tributaries and tides does not affect stage/discharge measurements.
- All discharge stages should be measurable within the reach, but low and high flows at the identical cross section need not be measured.
- The site should be readily and safely accessible.

The cross section in which a station is located within a channel reach should have the following characteristics:

- Banks should be relatively high and stable.
- The channel should be straight with parallel banks.
- Depth and velocity must meet minimum requirements of the method and instruments used.
- The bed should be relatively uniform with minimal boulders and without heavy aquatic growth.
- Flow should be uniform and free of eddies, slack water, and excessive turbulence.
- Sites should not be located downstream of areas with rapid changes in stage or velocity.

Measurement Procedure Using a Current Meter

1. Extend a measuring tape at right angles to the direction of flow and measure the width of the cross section. Record measurements on a data sheet. Leave the tape strung across the stream.
2. Divide the width into segments using at least 20 points of measurement. If previous flow measurements have shown uniform depth and velocity, fewer points may be used; smaller streams may also require fewer points. Measuring points should be closer together where depths or velocities are more variable. Cross sections with uniform depth and velocity can have equal spacing.
3. Record the distance from the initial starting bank and the depth.
4. Record the current velocity at each measuring point. Horizontal (from left to right bank) and vertical (top to bottom) variation of stream velocity may influence streamflow measurements. To correct for vertical differences, hydrologists have determined depths that can yield acceptable estimates of the mean velocity over a vertical profile. If the depth exceeds 0.8 m (2.5 ft), velocities should be measured at 20 percent and 80 percent of full depth and averaged to estimate mean velocity. In the depth range 0.1 to 0.8 m (0.3 to 2.5 ft), take the velocity at 60 percent of the full depth (measured from the surface) as an estimate of the mean over the profile. Measuring velocity in water shallower than 0.1 m (0.3 ft) is difficult with conventional current meters. If much of the reach of interest is very shallow, or flow is too slow for current meter measurement, consider installing a control section and V-notch weir.
5. Calculate flow as a summation of flows in partial areas (Figure 4.4) using the following equation:

$$q_n = v_n d_n \frac{(b_{n+1} - b_{n-1})}{2} \qquad [2]$$

where:

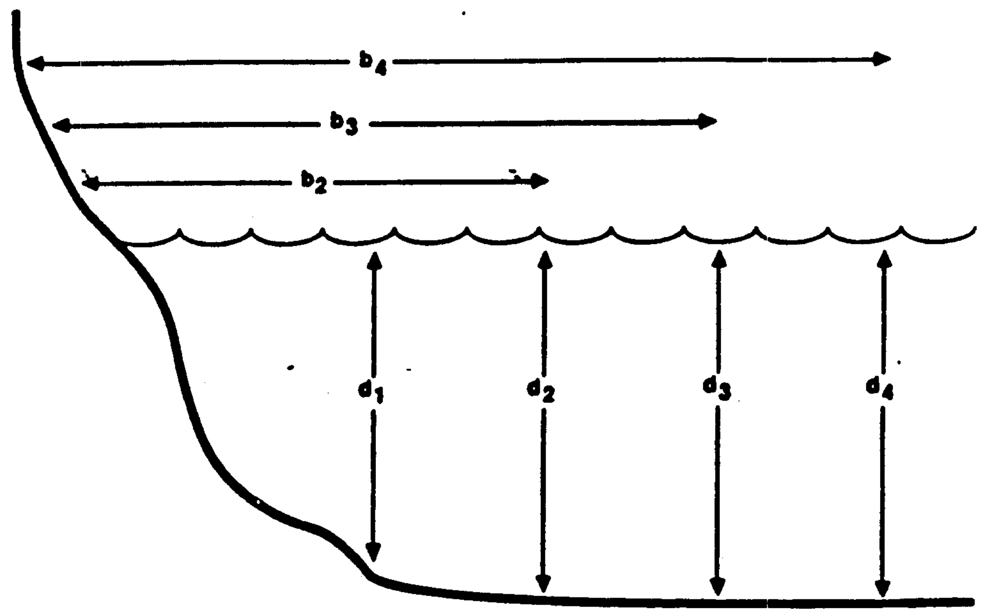
b_{n-1} = Distance from initial point to the preceding point (m [ft]);
b_{n+1} = Distance from initial point to the following point (m [ft]);
d = Mean depth of partial area n (m [ft]);
v = Average current velocity in partial area n (m/sec [ft/sec]); and
q = Discharge in partial area n (m^3/sec [ft^3/sec]).

Measuring Flow in Controlled Open Channels

An open channel is any conveyance where flow is not constrained or under pressure. Therefore, closed pipes and culverts can be open channels if they are not flowing full, a normal situation in runoff conveyance systems. When the channel geometry is regular and absolutely stable, it is termed controlled, as in pipes, culverts, many lined ditches, and channels where a weir or flume can be installed. In those situations, a recording automatic flow meter can be used.

Flow meters measure in several different ways. The most common way to measure runoff is to sense flow depth and convert to flow rate by some known relationship. Other techniques are electronic and ultrasonic.

Figure 4.4—Variables used to calculate stream discharge using the current meter method.



Source: R.R. Horner.

Among the most common means of sensing depth is by releasing a regularly spaced stream of air bubbles at the channel invert and detecting the back pressure resisting the bubble release—a function of depth. The bubble tube must be installed exactly as the manufacturer prescribes to get reliable measurements. How the depth measurement is converted to flow rate depends on the conduit. Standard weirs and flumes have well-established equations to simply compute flow rate from geometry and depth. Without a primary control device such as a weir or flume, flow rate must either be related to depth through a calibration using a current meter or, more commonly, by the standard equation of open channel flow—Manning's equation:

$$Q = A \cdot R^{0.67} \cdot s^{0.5}/n \qquad [3]$$

where:
- Q = Flow rate (m^3/s);
- A = Channel cross-sectional area (m^2);
- R = Hydraulic radius (m) = A/wetted perimeter;
- s = Water surface slope (m/m); and
- n = Manning's roughness coefficient (dimensionless).

In the English system of units, a multiplier of 1.49 on the right side of the equation gives Q in ft^3/s if geometry is in ft and ft^2.

Because of uncertainties in estimating slope, depth, and n—the latter of which comes from tables—the accuracy obtained from using Manning's equation is not as great as with a weir or flume. When using the equation, place the depth sensor in the channel where

- The cross section is uniform;
- The slope and roughness are constant;
- The channel is free of rapids, bends, abrupt falls, contractions, expansions, and backwater; and
- The channel is straight for at least 200 ft (60 m) upstream.

Modern recording automatic flow meters can make depth-to-flow rate conversions, accumulate a continuous flow-rate record, and provide the total flow volume over a period. The operator programs the appropriate flow conversion equation in the meter—using a weir or flume equation, Manning's equation, or a calibration equation derived from empirical data. These flow meters can also control an automatic sampler to collect flow-proportional composite samples.

Water Sampling Guidelines

The essential tasks in sampling natural waters and runoff are to obtain a sample that meets the program requirements and to prevent its deterioration and contamination before and during analysis. Water can be collected either as discrete or composite samples. Discrete samples are collected at a specific point in time and space; composite samples are made by combining a number of samples taken at different locations and/or different times. For flowing water sampling, flow-proportional composited samples better represent average water conditions than discrete samples or multiple samples taken at different times and composited without regard to flow.

Integrated samples refer to spatial composites. While composites can be taken over any dimension, compositing over depth is most common. In variable-depth composites, a series of grab samples are combined in proportion to flow velocities over the depth profile.

Sampling can be performed manually or with automatic collectors that collect a series of discrete samples, time-proportional, or flow-proportional composites. Flow measurements, required to produce flow-proportional composites, can be performed manually or with a continuously recording meter. Simple manual depth-integrating samplers approximately adjust for velocity differences as the sampler is lifted through the water column.

Manual Grab Sampling

The principal problem is obtaining a sample that represents the conditions being investigated. The guidelines for obtaining representative samples differ for flowing and standing water. Further information concerning lake sampling is available in Cooke et al. (1993) and Vollenweider (1974).

Water Sample Handling

To avoid mistakes, label a sample bottle with an indelible marker before going into the field. Sample labels must include station designation, date, collector's name, and any preservative added. The label can also include analyses to be performed and any pertinent remarks.

A tracking record for each sample registers possession as the sample travels from collection through analysis, making misplaced samples easier to find. Samples involved in litigation may require formal sample tracking, or chain-of-custody records.

Samples must be preserved and analyzed within a certain period to avoid deterioration. Recommended preservation methods and holding times, given in Table 4.2 were derived from American Public Health Association (APHA) and U.S. EPA (1983).

Water Quality Analytical Methods

Analytical methods and detection limits for commonly analyzed variables are given in Table 4.3. These methods are covered in both the American Public Health Association (1992) and U.S. EPA (1983) manuals.

Select an analytical laboratory carefully. A good laboratory will advise and help with aspects of the program beyond the analyses, such as sample container preparation and labeling. If an accreditation program is in effect, use a laboratory accredited for water analyses. Write detailed specifications on sample handling procedures, methods, detection limits, and quality assurance/quality control (QA/QC) requirements, using this chapter's recommendations.

Quality Control

The effectiveness of any monitoring effort depends on its quality control (QC) program. The QC program provides quantitative measurements of the "goodness" of the data. For some variables, QC involves calibrating instruments with known standards. To obtain accuracy and precision, QC also further involves analyses of blanks, replicate samples, control samples, and spiked samples. QC definitions of terms are included in this chapter.

Table 4.4 gives QC guidelines. State specific QC requirements explicitly in any contract, and conduct discussions among project managers and field and laboratory personnel concerning the QC project requirements before a contract is signed. Requirements differ among projects — a project involving enforcement actions or litigation can have more stringent QC requirements than one involving routine ambient monitoring. More information is available in U.S. EPA (1979) and American Public Health Association (1992).

Definitions Used in QC Practice

- ***Field replicates.*** Separate samples collected simultaneously at the identical source location and analyzed separately. Field replicates assess total sample variability (i.e., field plus analytical variability).

Table 4.2—Recommended sample sizes, containers, preservation techniques, and holding times for measurement of water quality variables.

VARIABLE	MINIMUM SAMPLE SIZE (mL)[a]	CONTAINER[b]	PRESERVATION	HOLDING TIME[c] RECOMMENDED	HOLDING TIME[c] MAXIMUM
Temperature	1,000[d]	P, G	None	Zero[e]	Zero[e]
Conductivity	100	P, G	Cool, 4°C[f]	28 days	28 days
Dissolved oxygen	300	G (BOD bottle)	Fix with reagents, store in dark	8 hours	8 hours
pH	25[g]	P, G	None	Zero[e]	Zero[e]
Alkalinity	100	P, G	Cool, 4°C[f]	24 hours[h]	14 days
Total hardness	100	P, G	HNO_3 to pH < 2	6 months	6 months
Total suspended solids	1,000[i]	P, G	Cool, 4°C[f]	7 days	7 days
Turbidity	100	P, G	Cool, 4°C[f]	24 hours	48 hours
Ammonia-nitrogen	125	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f]	24 hours	28 days
Nitrate + nitrite - nitrogen	125	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f, j]	24 hours	28 days
Total phosphorus	50	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f]	48 hours	28 days
Orthophosphate-phosphorus	50	P, G	Filter onsite Cool, 4°C[f]	24 hours	48 hours
Fecal coliform bacteria	125	P, G[k]	Cool, 1-4°C[f]	6 hours	30 hours
Metals	1	P[m]	High-purity HNO_3 to pH < 2	6 months	6 months

[a] Recommended field sample size for one laboratory analysis of the given variable.
[b] P = polyethylene, polypropylene, or fluoropolymer; G = glass.
[c] Analyze within the recommended time if possible, but in all cases within the maximum. The holding times given are for routine monitoring work.
[d] Measuring directly in waterbody is preferred.
[e] Analyze immediately.
[f] Holding at 4°C implies holding in the dark.
[g] Increase the volume to rinse the pH electrodes several times, especially in low-alkalinity waters.
[h] Some agencies prefer to analyze low-alkalinity waters in the field, while the greater analytical control available in the laboratory is preferred in other agencies.
[i] Volume given is the maximum needed to filter for analysis of low concentrations. A smaller quantity (100-250 mL) is adequate for most samples.
[j] If nitrate-nitrogen data are needed, a separate, nonacidified sample is required. The nonacidified sample must be analyzed for nitrite-nitrogen within 48 hours. Nitrate-nitrogen is determined by subtracting nitrite-nitrogen from nitrate + nitrite-nitrogen.
[k] Container must be able to withstand autoclaving at 121°C for 20 minutes.
[l] Depends on number of metals to be analyzed and the analytical method. 2 liters is sufficient to analyze all EPA priority metals by atomic absorption (AA), while inductively coupled plasma (ICP) would require less.
[m] Fluoropolymer preferred.

Source: Tetra Tech et al. 1988.

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Table 4.3—Recommended analytical methods and detection limits.

VARIABLE	UNIT	DETECTION LIMIT[a]	METHODS
Temperature	°C	—	Mercury-filled thermometer, digital probe
Conductivity	μmhos/cm[b]	1	Conductivity meter
Dissolved	mg/L	—	Azide-modified Winkler, membrane electrode
pH	pH units	—	Electrometric
Alkalinity	mg/L as $CaCO_3$	1	Titrimetric
Total hardness	mg/L $CaCO_3$	1	EDTA titrimetric
Total suspended solids	mg/L	—	Gravimetric
Turbidity	NTU[c]	1	Nephelometric
Ammonia-nitrogen	μg/L	10	Automated phenate[d]
Nitrate + nitrite - nitrogen	μg/L	10	Automated cadmium reduction Cadmium reduction[d]
Total phosphorus	μg/L	5	Automated ascorbic acid, Heteropoly blue ascorbic acid (following persulfate digestion)[d]
Orthophosphate-phosphorus	μg/L	2	Automated ascorbic acid, Heteropoly blue ascorbic acid[d]
Fecal coliform bacteria	colonies/100 mL	1	Membrane filter
Metals	μg/L	e	Inductively coupled plasma, Inductively coupled plasma-mass spectroscopy, Graphite furnace atomic absorption, Flame atomic absorption

[a] Report results below the detection limit as less than the detection limit.
[b] Microsiemans/cm (μS/cm) are used in the SI system. 1 μmho = 1 μS.
[c] NTU= Nephelometric turbidity units.
[d] Both automated and nonautomated procedures are recommended for nutrient analyses because some laboratories have not been converted to automated techniques.
[e] Depends on metal and method. New inductively coupled plasma-mass spectroscopy methods (ICP-MS) have sub-part per billion detection limits.
Source: Tetra Tech et al. 1988.

■ *Laboratory replicates.* Repeated analyses of a variable performed on the contents of a single sample. Laboratory replicates assess analytical precision. Duplicate analyses usually suffice for well-proven procedures in the laboratory.

■ *Calibration samples.* Samples from distilled-deionized water that contain a known concentration of a specific substance or will produce a known instrument response. Calibration samples analyzed during an analytical run are often re-

Table 4.4.—Calibration and quality control guidelines for water quality variables.

VARIABLE	GUIDELINES[a]
Temperature	Check thermometer against a thermometer certified by American Society for Testing and Materials or National Institute of Standards and Technology.
Conductivity[b]	Calibrate in the laboratory with two standard KCl solutions representing the expected conductivity range of the samples. Check calibration using one standard KCl solution (with conductivity in the sample range) per batch in the laboratory or whenever the meter is set up in the field.
Dissolved oxygen[b]	For the azide-modified Winkler method, run one 100 percent saturated calibration sample/batch. For studies where low DO concentrations are expected, a calibration sample containing zero DO may be used. For the membrane-electrode method, calibrate with a sample of known DO concentration (determined using the azide-modified Winkler method) and with a sample containing zero DO. Calibration is required prior to the start of every series of measurements and whenever the meter is moved or turned off.
pH[b]	Calibrate with two buffers and check with a third every three hours. Use neutral, acid, and basic buffers (e.g., pH 4.0, 7.0, and 10.0) prepared according to National Bureau of Standards Special Publication 260-53.
Alkalinity[b]	Calibrate pH meter as above. Check titrant normality with self-prepared and U.S. EPA standard solutions (one check/batch).
Total hardness[b]	Check titrant molarity with self-prepared and U. S. EPA standard solutions (one check/batch) and run one blank/batch. Run one spiked sample/batch if interference is suspected.
Total suspended solids[b]	Check balance calibration monthly and oven temperature daily. Balances should have annual preventive maintenance checks.
Turbidity[b]	Calibrate with commercial standard in same range as samples. Recalibrate with every range change.
Manual nutrients[b]	Run calibration curve with a blank and standards at 0.2, 0.35, 0.5, 0.75, and 1.0 cu[c]. Entire range of sample concentrations must be included in the calibration curve. Run control samples at 0.2 and 0.9 cu with each batch. Run two blanks/batch and one spiked sample/batch.
Automated nutrients[b]	Run calibration curve with a blank and standards at 0.2, 0.5, and 1.0 cu. Entire range of sample concentrations must be included in the calibration curve. Run control samples at 0.2 and 0.9 cu with each batch. Run two blanks/batch and one spiked sample/batch.
Fecal coliform bacteria	Run a transport blank. Randomly split 10 percent of the samples for analysis at another laboratory. Field and laboratory replicates should both be included at a frequency of 10 percent.

[a] A batch is a group of no more than 20 samples.
[b] Field replicate samples should be collected and analyzed at a frequency of 5 to 10 percent. Laboratory replicates should be analyzed at a frequency of 5 to 10 percent.
[c] cu = Upper limit of expected concentration range.
Source: Tetra Tech et al. 1988.

ferred to as control samples or check standards. The distilled-deionized water used in calibration samples should meet Type 1 water quality criteria specified by American Public Health Association (1992) Method 107.4.

■ *Blanks.* Samples prepared from distilled water, perhaps with reagents added, to represent zero concentration of a specific substance or to produce an instrument response indicating zero concentration.

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A transport blank is required for fecal coliform bacteria studies and may be useful in nutrient studies. A transport blank is transported to the sampling location and treated like a sample thereafter.

- ***Spiked samples.*** Samples prepared by adding known concentrations of a specific substance.

- ***Accuracy.*** The agreement between the measurement of a variable in a sample and its true value. The term "error" is used when the discrepancy between the measured and true values is expressed in the units of the measured variable. Relative error is when the error is expressed by the percentage deviation from the true value.

- ***Precision.*** The agreement among replicate laboratory measurements. Precision is measured by the standard deviation when using the units of the measured variable. Relative standard deviation is when the standard deviation is expressed as a percent of the mean of the replicate values.

Sample Container Cleaning

Avoiding sample contamination requires careful cleaning of sample bottles and laboratory equipment. Some general guidelines for cleaning are presented here. Additional requirements for certain individual variables are covered in the methods sections for those variables. The recommended procedures should be applied to sample containers and all laboratory glassware and implements that will come into direct contact with samples during collection, storage, or analysis.

Laboratory equipment should always be washed with detergent, rinsed with tap water, and rinsed an additional three times with ultrapure deionized water. Detergents must be selected considering the analyses to be performed (e.g., use phosphorus-free detergent when performing phosphorus analysis). An ultrasonic cleaner can minimize the need for hand scrubbing. Following the water rinses, perform acid washing with sulfuric acid on equipment involved with nutrient analyses. After acid washing, rinse equipment completely at least six times with ultrapure deionized water.

If QC criteria are not met, thoroughly review the cleaning operation to determine if inadequate cleaning procedures could be causing contamination.

Criteria for Acceptance of QC Results and Corrective Actions

While this chapter contains general guidelines for accepting QC results and corrective actions, more detailed information is available in U. S. EPA (1979). Control limits for accuracy and precision are established in every laboratory, and these limits may vary among laboratories.

Recommended Reading

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CHAPTER 5

Sediment Monitoring

Traditional point sources of pollution typically discharge effluents of uniform, known quality, at continuous design flow, making them relatively easy to assess, model, and control. Point source assessments have relied on water column chemistry monitoring. However, urban runoff and other nonpoint sources of pollution—because of their intermittent, diffuse, land-use-specific nature—are highly variable in effluent quality and environmental effects. Of greatest environmental concern is the cumulative impact of runoff and nonpoint sources (NPS) of pollution on a waterbody within a watershed.

This chapter discusses sediment monitoring and assessment—an area of monitoring that is typically ignored yet is especially important in the assessment and management of urban runoff and other nonpoint sources. This chapter also reviews and discusses the activities undertaken in Florida to develop and implement coastal sediment sampling, analysis, and environmental assessment techniques.

Water quality managers often do not understand or know how to cope with runoff and NPS pollution. Problems include

- Discriminating anthropogenic loadings from natural watershed loadings of metals and nutrients;
- Assessing intermittent, shock loadings of pollutants;
- Assessing cumulative impacts of multiple sources;
- Comparing waterbodies and establishing priorities for management actions;
- Distinguishing actual or potential problems from perceived problems; and
- Establishing cost-effective ways to assess pollution trends and understand overall watershed pollution.

Most runoff pollutants accumulate over time in sediments, not in the water column. Therefore, assessing cumulative effects of watershed runoff and NPS pollution sources on aquatic systems should include evaluation of sediments and the organisms that reside there. Alternative assessment methods are needed to determine the actual environmental effects of runoff and to assess the effectiveness of control measures. This manual presents two alternative methods. Sediment monitoring is reviewed in this chapter and biological monitoring in Chapter 6.

Assessing Sediments Contamination

Traditionally, concerns about managing aquatic resources have focused on water quality. However, recently we have become more aware of the importance of sediments in determining the fate and effects of numerous contaminants. While evaluations of sediment quality are often used to address site-specific management needs, sediment quality is also a sensitive indicator of overall environmental quality.

Sediments influence the environmental fate of many toxic and bioaccumulative substances in

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aquatic ecosystems. Specifically, sediment quality is important because many toxic contaminants found in only trace amounts in water can accumulate to elevated levels in sediments. As such, sediments serve both as reservoirs and as potential contaminant sources to the water column. Sediments tend to integrate contaminant concentrations over time and may represent long-term sources of contamination. Sediment-associated contaminants can also directly affect benthic and other organisms. In addition to the physical and chemical relationships between sediments and contaminants, sediments provide benthic communities with suitable habitats for essential biological processes (e.g., spawning, incubation, rearing).

Sediments provide an essential link between chemical and biological processes. By understanding this link, environmental scientists can develop assessment tools and conduct monitoring programs to more accurately evaluate the health of aquatic systems. Therefore, sediment quality data provide essential information for evaluating ambient environmental quality conditions in waters. Additionally, information about the amount and quality of sediments within runoff management systems, storm sewers, and other conveyances can help track pollution sources and prioritize areas for implementing control measures.

Assessment of sediments to determine whether urban runoff pollutants are causing or contributing to ecological problems within a waterbody is increasingly performed. Consequently, sediment monitoring and assessment procedures are being developed. Before sediments can be reliably used to assess the effects of contaminants on aquatic systems, three issues must be addressed:

- Accurate, reliable sediment sampling and laboratory analysis techniques;
- Interpretive techniques to determine whether contaminants (especially metals) found in sediments are natural or from human activity; and
- Sediment quality assessment guidelines correlating sediment contaminant concentrations with biological effects. These guidlines assess whether amounts of sediment likely to adversely affect water quality and living resources could recycle to the water column or through food chains.

The Florida Example

Natural versus Anthropogenically Enriched Sediments

Florida has an extensive coastline—approximately 11,000 mi (17,699 km)—and an unusual diversity of estuarine types.* Its many estuary conditions range from nearly pristine to localized severe degradation. Metals are of particular concern in protecting and rehabilitating estuaries because of their potential toxic effects and because high metal concentrations can signal the presence of other pollution. Natural metal concentrations vary widely among Florida estuaries, presenting special difficulties in comparing estuarine systems statewide and in making consistent, scientifically defensible management decisions.

In the past, determining whether estuarine and coastal sediments were anthropogenically enriched with metals was a difficult process requiring comprehensive site-specific assessments. However, a recently developed practical approach for assessing metals contamination in coastal sediments relies on normalization of metal concentrations to a reference element. In Florida, normalization of metal concentrations to aluminum concentrations in estuarine sediments provided the most promising method of comparing metal levels regionally. In Florida and Washington State, early research indicates that other elements (e.g., lithium) may be an appropriate reference element for assessing coastal sediments.

To understand this assessment tool, one must generally understand geochemical processes that govern the behavior and fate of metals in estuaries and marine waters. Natural estuarine sediments are predominantly composed of river-transported debris from continental weathering. Acids formed in the atmosphere or from the breakdown of organic matter (e.g., carbonic, humic, fulvic acids) mix with water and form leaching solutions. These leaching solutions break down rocks and carry away the products in solution or as solid debris. This debris is chiefly composed of chemically resistant minerals, such as quartz and clay minerals, which are the alteration products of other aluminosilicate minerals. The general formula $M\text{-}AlSiO_4$ represents the aluminosilicate clay minerals

** The material in this and the following two sections was adapted from Fla. Dep. Environ. Prot. 1988.*

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where: M = naturally occurring metal that can substitute for aluminum in the aluminosilicate structure
Al = aluminum
Si = silicon
O = oxygen

The metals are tightly bound within the aluminosilicate lattice.

The weathering solution also contains dissolved metals leached from the parent rock. Because of their low solubilities, however, the transporting solution (e.g., rivers) contains low amounts of metals. Most metals transported by rivers are tightly bound in the aluminosilicate solid phases. As a consequence, weathering causes little fractionation between the naturally occurring metals and aluminum.

In general, when dissolved metals from natural or anthropogenic sources come in contact with saline water, they quickly adsorb to particulate matter and go from the water column to bottom sediments. Thus, metals from both natural and anthropogenic sources are ultimately concentrated in estuarine sediments, not the water column. Since much of the natural component of metals in estuarine sediments is chemically bound in the aluminosilicate structure, the metals are generally immobile; however, the adsorbed anthropogenic or pollutant component is more loosely bound. Metals in the anthropogenic fraction, therefore, may be more available to estuarine biota and may be released to the water column in altered forms when sediments are disturbed (e.g., by dredging or storms).

The tool for interpreting metal concentrations in estuarine sediments is based on demonstrated, naturally occurring relationships between metals and aluminum. Specifically, natural metal/aluminum concentration relationships were used to develop guidelines to distinguish natural from contaminated sediments for several metals commonly released to the environment from anthropogenic activities. Aluminum was chosen as a reference element to normalize sediment metals concentrations for several reasons:

- After silicon, aluminum is the most abundant naturally occurring metal;
- Aluminum is highly refractory;
- The proportions of metals and aluminum in crustal materials are relatively constant; and
- Aluminum concentration is rarely influenced by anthropogenic sources.

So that the information used to develop the interpretive tool represented diverse Florida sediments, uncontaminated sediments from around the state were examined for their metal content, and the natural variability of metal/aluminum relationships was statistically assessed (Fla. Dep. Environ. Prot. 1988). Sediment samples from 103 stations in uncontaminated estuarine/coastal areas were collected and analyzed for aluminum and other environmentally and geochemically important metals. The areas sampled encompassed various sediment types ranging from terrigenous, aluminosilicate-rich sediments in northern Florida to biogenic, carbonate-rich sediments in southern Florida. These "clean" sites were selected subjectively, based on their remoteness from known or suspected anthropogenic metal sources.

To ensure that divers retrieved undisturbed sediment samples at each station, they collected sediments in cellulose-acetate-butyrate cores. Sediment for metals analyses was taken from the upper 5 cm (nearly 2 in) of each core. Duplicate samples taken at each station were analyzed for nine metals—aluminum, arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc. Particular care was taken to ensure total digestion of sediment samples as required by the project quality assurance plan.

Simple linear regressions for each metal on aluminum were performed on log-transformed data and 95 percent prediction limits were calculated. Significant correlations were obtained for arsenic, cadmium, copper, lead, nickel, and zinc. The plotted regression lines and prediction limits (Figures 5.1 to 5.7) form the basis for interpreting metal concentrations in sediments. The results indicate that aluminosilicate minerals have a major influence on metal concentrations in Florida's natural sediments. Furthermore, sediment metal/aluminum relationships provide a basis for interpreting metals data from Florida coastal sediments. The effectiveness and utility of this sediment assessment tool has been tested in a variety of regional studies (Hanson and Evans, 1991; Schropp et. al. 1989; Pardue et al. 1992).

To determine whether estuarine sediments are enriched with metals, we calculate a mean value of each metal (derived from replicate or triplicate samples) and plot points representing corresponding metal and aluminum values. The sediment is judged to be natural or metal enriched, depending on where the points lie relative to the regression lines and prediction limits. If a point falls within the prediction limits, then the sediment metal concentration is within the expected natural range. If a point falls above the upper prediction limit, then the sediment is considered to be metal-enriched. Before we determine enrichment, we should confirm the accuracy of the analytical results, since an unusual point can indicate procedural errors. Since the results are interpreted with respect to the 95 percent prediction limit, some points from clean stations will lie outside the prediction limit. The farther from the prediction limit, the greater the likelihood that the sample does indeed come from a metal-enriched sediment. The greater the distance above the prediction limit, the greater the degree of enrichment.

Figures 5.1 through 5.7 show the blank metal/aluminum figures derived from the statistical analyses of sediment samples from 103 stations in Florida's uncontaminated estuarine/coastal areas. Extrapolated portions of the lines are represented by dashed lines. Metals data can be plotted on these figures to assess metals enrichment of estuarine sediments (Fla. Dep. Environ. Prot. 1988).

Figure 5.1.—Arsenic/aluminum regression line with 95 percent prediction limits.

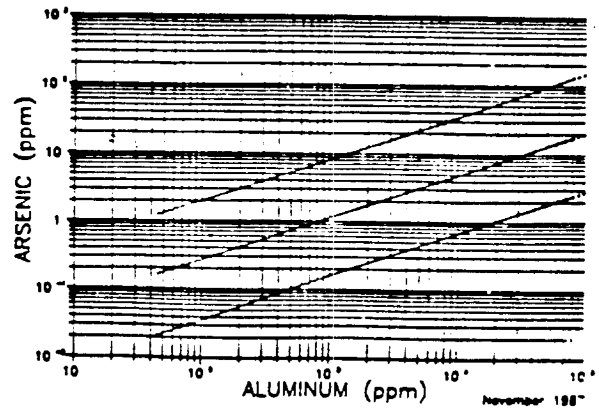
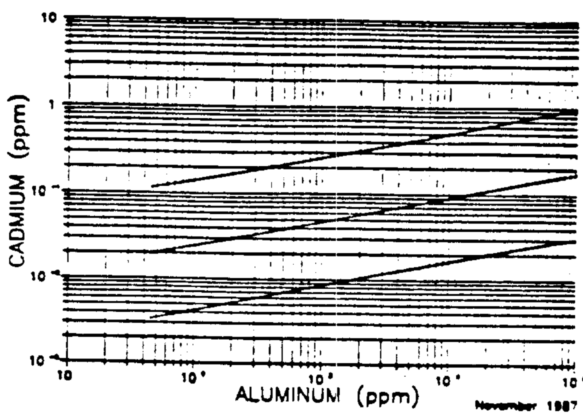


Figure 5.2—Cadmium/aluminum regression line with 95 percent prediction limits.



Source: Figures 5.1 – 5.7 from Fla. Dep. Environ. Prot. 1988.

Applying the Interpretive Tool

The interpretive tool, using metal and aluminum relationships, allows results of sediment chemical analyses to be used for a variety of environmental information needs, including

- **Distinguishing natural versus enriched metals concentrations in coastal sediments.** The degree of enrichment can also be estimated by the deviation from the expected natural range.

- **Comparing metal concentrations within an estuary.** Absolute metal concentrations in coastal sediments will vary depending on many factors, including sediment grain size, mineralogy, and anthropogenic metal sources. Normalizing metals to the reference element—aluminum—allows comparisons of metal concentrations among sites within an estuary.

- **Comparing investigative results from different estuaries.** By normalizing metal concentrations to aluminum, we can assess relative metal enrichment levels and rank estuaries according to specific metal enrichment problems.

- **Tracking the influence of a pollution source.** In some cases, we can determine the extent of metal-enriched sediments. This delineation focuses attention on real, rather than perceived, problems.

- **Monitoring trends in metal concentrations.** By periodically examining sediments at permanent sampling stations or along known pollution gradients, the technique may provide a much-needed device for cost-effective monitoring of the overall estuary pollution climate and the effectiveness of watershed control measures.

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Figure 5.3—Chromium/aluminum regression line with 95 percent prediction limits.

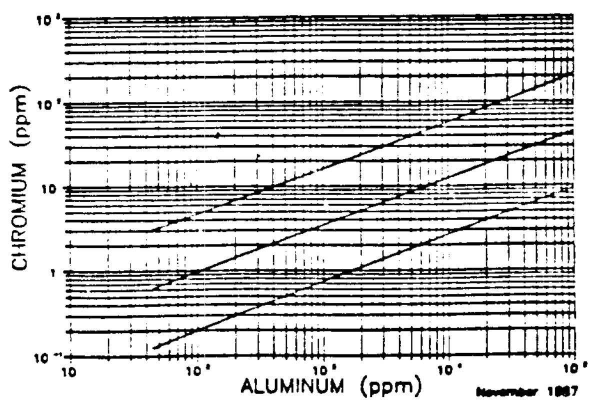
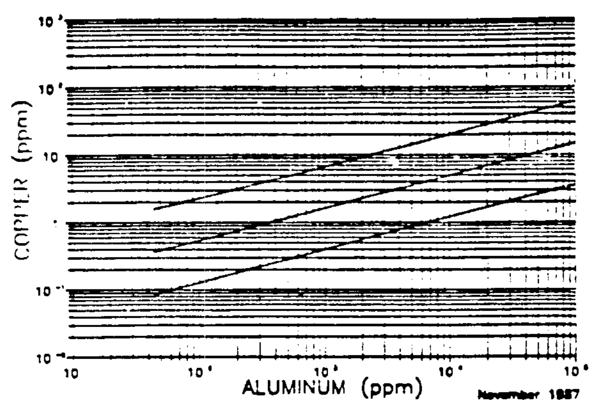


Figure 5.4—Copper/aluminum regression line with 95 percent prediction limits.



- **Determining procedural or laboratory errors.** The location of points on the metal/aluminum figures can signal possible errors, including sample contamination in the field or laboratory and analytical or reporting errors.

- **Screening tool to promote cost-effective use of tests.** A variety of tests (e.g., elutriate, bioassay) demonstrate potential release to the water column or toxicity of metals in sediments. This interpretive tool can reduce the time and cost of testing by screening sediments and selecting for further testing only those whose metal concentrations exceed expected natural ranges.

Interpretive Tool Limitations

This approach provides an interpretive tool to evaluate metals concentrations in estuarine sediments. Funding limitations in Florida have prevented collecting and analyzing sediment samples from freshwater systems to see if the tool can be used in those aquatic systems. However, such sampling is now being done in Washington State and was completed in Illinois. Tool use requires knowing local conditions and applying professional judgment and common sense. Consider the following points when using this tool:

1. The interpretive tool is useless without reliable data; results from single, nonreplicated samples should never be used. Ideally, collect sediment samples in triplicate. If budget constraints dictate analysis of only duplicate samples, archive the third sample. If a disparity in the results of the replicate analyses occurs, retrieve and analyze the archived sample to resolve the problem.

2. Carefully analyze sediment metals using techniques appropriate for saline conditions and capable of providing adequate detection limits. Because naturally occurring aluminum and other metals are tightly bound within the sediment's crystalline structure, the metals analyses methods must include complete sediment digestion. If aluminum is not completely released by a thorough digestion, metal-to-aluminum ratios may appear to be unusually high. Complete digestion requires the use of hydrofluoric (HF) acid during the digestion process.

3. Mercury presents special problems, both in the laboratory and in interpretating the results. Since mercury is more volatile than the other metals, use a different digestion procedure employing a lower temperature. Natural mercury concentrations are very near routine analytical detection limits, reducing precision and accuracy. Furthermore, mercury's apparent weak inverse relationship with aluminum precludes using aluminum as a reference element.

   To analyze mercury, the Florida Department of Environmental Protection (DEP) assumed that the maximum mercury value in the clean sediment data set (0.21 ppm mercury) represents the maximum mercury concentration found in Florida's natural sediments. To evaluate sediment samples, consider those containing less than 0.21 ppm mercury as typical of clean sediments. Samples with greater than 0.21 ppm mercury should be suspected as being enriched and should be interpreted similarly to other metals that fall outside the 95 percent prediction limits.

4. Aluminum concentrations in the data set from which these guidelines were prepared ranged from 47 to 79,000 ppm. The data set, to the extent possible, represents various natural clean sediments found in Florida estuaries. The majority of samples recovered from Florida estuarine sediments will have aluminum concentrations within this range. Some clay-rich sediments, especially in northwest Florida, may contain aluminum concentrations exceeding 79,000 ppm. Kaolinite, illite (muscovite), montmorillonite, and chlorite—four commonly occurring marine clays—contain aluminum concentrations of approximately 21 percent, 20 percent, 15 percent, and 10 percent, respectively.

   Theoretically, the maximum aluminum concentration in a natural marine sediment is about 210,000 ppm (21 percent) if the sediment is composed of pure kaolinite. Since sediments are not pure clay, the aluminum concentration in estuarine sediment samples should be considerably less than this theoretical maximum; in only a few instances should aluminum concentrations exceed 100,000 ppm (10 percent aluminum). Carefully examine any samples containing greater than 100,000 ppm aluminum for evidence of contamination or analytical error.

5. During the construction of the "trimmed clean" data set, some points containing low aluminum values were removed from the cadmium, lead, nickel, and zinc data. Since the lowest overall aluminum value was 47 ppm, the regression lines and prediction limits for these four metals have been extrapolated down to an aluminum value of 47 ppm.

6. At stations where a metal concentration exceeds the 95 percent prediction limit, the metal must be considered enriched. We cannot immediately assume, however, that a finding of enrichment indicates a problem. Some samples from natural clean sediments may contain metal concentrations that exceed the 95 percent prediction limit. Interpretation of metal concentrations, using these metal-to-aluminum relationships, must also consider sediment grain size, mineralogy, coastal hydrography, and proximity to sources of metals.

Figure 5.5—Nickel/aluminum regression line with 95 percent prediction limits.

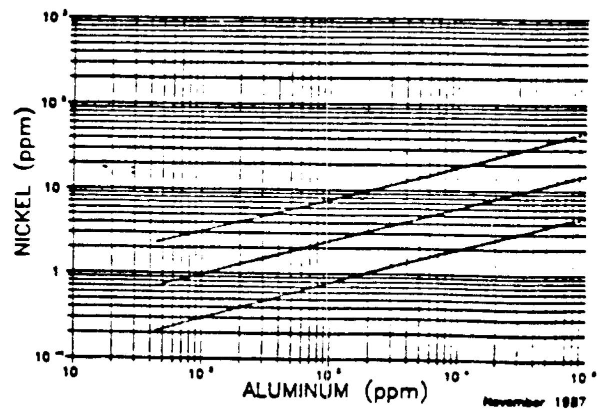
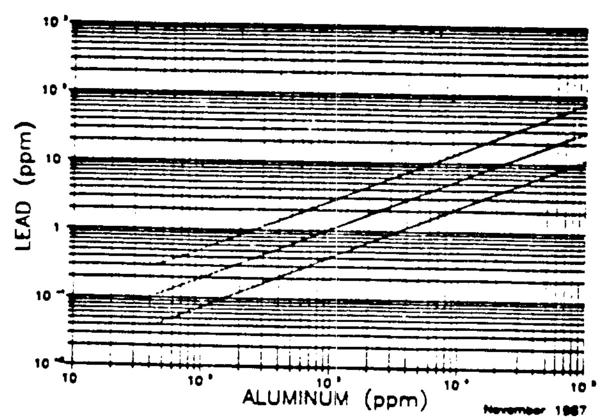


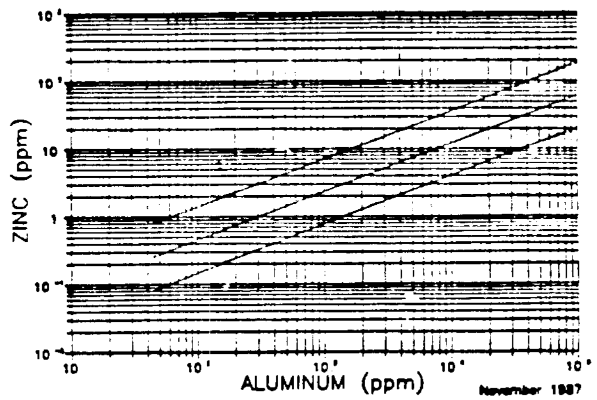
Figure 5.6—Lead/aluminum regression line with 95 percent prediction limits.



Determining the Ecological Significance of Enriched Sediments

Sediment chemistry data alone do not provide an adequate basis to identify or manage potential sediment quality problems. After determining that

Figure 5.7—Zinc/aluminum regression line with 95 percent prediction limits.



sediments are anthropogenically enriched with pollutants, we must next determine whether these sediment-bound pollutants are harmful to the environment. Biologically-based sediment quality assessment guidelines (SQAGs) also are required to interpret the ecological significance of sediment chemistry data. Numerical SQAGs support assessing the potential effects of sediment-associated contaminants.

Various approaches help formulate sediment quality guidelines (SQGs) (Chapman, 1989; Persaud et al. 1989; Beak, 1987 and 1988; U.S. Environ. Prot. Agency, 1989a,b; Sediment Criteria Subcommittee, 1989 and 1990; and MacDonald et al. 1991). The major approaches by which SQGs are developed are

- Sediment background approach (SBA);
- Spiked sediment bioassay approach (SSBA);
- Equilibrium partitioning approach (EqPA);
- Tissue residue approach (TRA);
- Screening level concentration approach (SLCA);
- Sediment quality triad approach (SQTA);
- Apparent effects threshold approach (AETA); and
- National status and trends program approach (NSTPA).

To date, no effects-based SQAGs apply directly to Florida conditions. While effects-based SQAGs have been developed specifically for a few regions of the country (i.e., Puget Sound is using an apparent effects threshold approach), the EPA Science Advisory Board (SAB) cautions against using these guidelines outside the areas for which they were developed (Sediment Criteria Subcommittee, 1989). The SAB has also questioned the validity of the sediment quality criteria that EPA is currently developing (i.e., using the equilibrium partitioning approach). These SAB evaluations suggest that SQAGs under development in other jurisdictions will not likely address Florida's immediate requirement for sediment assessment tools.

Ideally, SQAGs should be developed from dose-response data that describe acute and chronic toxicity of individual contaminants to sensitive life stages of resident aquatic organisms. These data should be generated in controlled laboratory studies, where the influences of important environmental variables—such as total organic carbon (TOC), acid volatile sulfide (AVS), salinity, and others—are identified, quantified, and compared to the values predicted by appropriate models (e.g., EqP models). Finally, the results of these studies should be validated in field trials to ensure that guidelines derived from these data will apply to a broad range of locations. Understanding the factors that influence toxicity also supports site-specific sediment quality assessments by evaluating and modifying the preliminary guidelines.

Unfortunately, data are insufficient to derive numerical SQAGs using the ideal approach. Currently, only a limited number of controlled laboratory studies (i.e., spiked-sediment bioassays) have been conducted to assess the effects of sediment-associated contaminants on estuarine and marine organisms. In spite of this limitation, other data are routinely collected that clarify the toxic effects of these contaminants. Specifically, a variety of whole sediment toxicity tests have assessed the biological significance of contaminant concentrations in sediments from specific geographic locations. Toxicity tests were performed on benthic organisms (e.g., bivalve mollusks, shrimp, amphipods, polychaetes, nematodes, chironomids and other arthropods) and on pelagic organisms (e.g., *Daphnia*, oyster larvae, luminescent bacteria [Microtox]). Numerous field studies also assessed the diversity and abundance of benthic infaunal species (e.g., bivalve mollusks, arthropods, amphipods) and epibenthic organisms (e.g., echinoderms, crustaceans). Many of these studies collected matching data on the contaminant concentrations in sediments. Studies that report matching sediment chemistry and biological effects data provide highly relevant information to the SQAGs derivation process.

A suitable strategy for deriving SQAGs for Florida recognizes the limitations of the existing database to evaluate the potential biological effects of sediment-associated contaminants. In addition, the strategy must address the immediate requirement for defensible SQAGs and the long-term requirement for increased reliability and applicability of these guidelines (i.e., guidelines that account for the environmental characteristics influencing the bioavailability of sediment-associated contaminants).

To provide Florida with a sediment assessment tool, the Florida DEP Contaminated Sediment Management Unit, in association with MacDonald Environmental Sciences, reviewed the preceding approaches to identify those applicable to Florida's coastal conditions. Selecting an appropriate procedure to derive guidelines for Florida's coastal waters necessitates evaluating each approach in light of the state's specific needs. As such, criteria were established to objectively evaluate the approaches and select a relevant strategy to derive these guidelines. The primary considerations in selecting a strategy were practicality, cost-effectiveness, scientific defensibility, and broad applicability to sediment quality assessment. These include the following considerations:

1. Practicality is a central consideration in developing SQAGs. Numerical SQAGs must be easy to use and understandable. The immediate need for these assessment tools necessitates selecting an approach that can be quickly implemented.

2. As in most states, Florida has limited resources to support SQAG development and implementation. Financial and personnel limitations make collecting significant quantities of additional data improbable. Therefore, the approach must develop numerical SQAGs with the current data, and it must be amenable to reevaluation as new data become available.

3. For SQAGs to be effective in Florida, they must be effects-based (i.e., consider biological effects) and scientifically defensible. Key evaluation criteria to assess various approaches include their potential to consider factors that control the bioavailability of sediment-associated contaminants, to establish cause-and-effect relationships, and to apply to all classes of chemicals and mixtures of contaminants that can occur in Florida. In addition, they must be compatible with other tools, such as the metals tools discussed previously. Potential approaches should explicitly consider data from Florida and elsewhere in the southeastern United States and provide a way to account for site-specific environmental conditions.

4. The inherent uncertainty associated with each approach requires guidelines to support identifying ranges of contaminant concentrations that may have high, moderate, and low probabilities of adverse biological effects.

5. SQAGs must address the specific needs of the agencies that manage environmental quality. For example, SQAGs should be relevant to the design, implementation, and evaluation of environmental quality monitoring programs by identifying contaminants and sites likely to cause adverse biological effects. This information would help identify the need for further investigations at sites with specific contaminant concentrations that exceed the SQAGs. Guidelines should also help identify areas that need remediation; however, they would not necessarily be used to establish clean-up levels. Furthermore, guidelines should contribute to regulatory programs by evaluating source control measures and/or the need for further biological and chemical testing to support regulatory decisions.

Each approach has deficiencies that limit its direct application in Florida. For this reason, an integrated strategy for deriving numerical SQAGs was recommended for the state of Florida (MacDonald, 1993). This strategy provides relevant near-term assessment tools and a basis to refine these guidelines as the necessary data become available.

Using the recommended approach, numerical SQAGs were developed for 25 priority contaminants in Florida coastal waters (MacDonald, 1993) using a modification of the National Status and Trends Program approach (Long and Morgan, 1990). The guidelines, from numerous investigations of sediment quality conducted throughout North America, are based on a weight-of-evidence linking contaminant concentrations and adverse biological effects. The guidelines represent a cost-effective response to a practical need for assessment tools. However, these guidelines are preliminary and will likely be revised or refined with results from field validation and other related studies conducted in Florida and else-

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where in North America. The guidelines should be used with other interpretive tools to conduct comprehensive and reliable assessments.

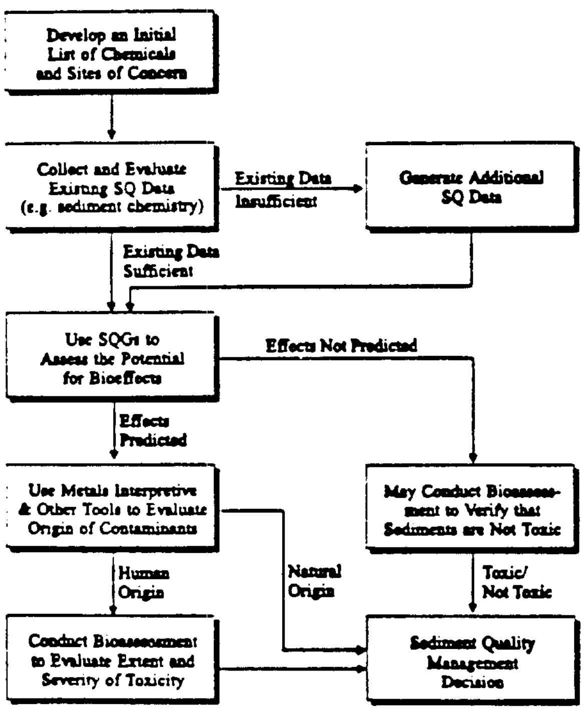
Effects-based SQAGs help assess the potential for biological effects associated with various contaminant concentrations. MacDonald (1993) derived no observed effects levels (NOELs) and probable effects levels (PELs) to define three ranges of contaminant concentrations: the probable effects range, the possible effects range, and the no effects range.

The probable effects range is the range of specific contaminant concentrations in sediment within which biological effects are usually or always observed (probable effects range ≥ PEL). Sediments with contaminant concentrations within the probable effects range *represent significant and immediate hazards to exposed organisms*. Sites with concentrations of one or more contaminants that fall within the probable effects range should be given the highest priority in implementing sediment quality management options. However, direct biological assessment is required to determine the nature and extent of effects that could be manifested.

The possible effects range is the concentration range of a specific sediment contaminant with uncertain adverse biological effects (NOEL < possible effects range < PEL). This range is likely to be dependent on factors, such as bioavailability, that may influence the toxicity of the substance. Sediment-associated contaminants *represent potential hazards to exposed organisms* when concentrations fall within this range. Sediments with contaminant concentrations within this range may require further assessment to determine the biological significance of the contamination. In general, further assessment would be supported by biological tests designed to evaluate the biological significance of sediment-associated contaminants to key species of aquatic biota.

The no effects range is the range of sediment contaminant concentrations where biological effects are rarely or never observed (no effects range ≤ NOEL). Sediments with concentrations of contaminants within the no effects range are *of acceptable quality* for those contaminants. In general, further investigations of sediment quality conditions within the no effects range are relatively lower priority. However, biological testing may be required to validate the results of the initial potential assessment for adverse biological effects, particularly in sediments with low levels of TOC, AVS, and/or other variables that could influence the bioavailability of sediment-associated contaminants.

Figure 5.8—Framework for conducting site-specific assessments of sediment quality.



Source: MacDonald, 1993.

Assessing Sediment Quality in Florida

MacDonald (1993) developed a framework (Figure 5.8) for the Florida DEP for future use of sediment quality assessment guidelines and related tools. This framework identifies essential considerations to address in conducting site-specific sediment quality assessment programs. The following elements comprise the framework:

- Collect historical land and water use information;
- Collect and evaluate existing sediment chemistry data;
- Collect supplemental sediment chemistry data;
- Conduct preliminary assessment of the potential for biological effects of sediment-associated contaminants;

- Evaluate natural versus anthropogenic sources of sediment-associated contaminants;
- Conduct biological assessment of sediment quality; and
- Implement management of sediment quality.

This framework consistently assesses sediment quality in marine and estuarine areas. However, the framework is not intended to replace accepted sediment testing protocols, such as those developed for the ocean disposal of dredged material. Instead, it provides general guidance to support the sediment quality assessment process.

Step 1. Collect Historical Land and Water Use Information

The first phase of a site-specific sediment quality assessment involves collecting and reviewing the site's pertinent historical information. Information required includes the types of industries and businesses that operate or have operated in the area, the location of wastewater treatment plants, land use patterns in upland areas, runoff management systems, residential developments, and other historic, ongoing, and potential activities within the area. These data help to identify sources that could contaminate aquatic ecosystems. Information on the chemical composition of wastewater effluent discharges, contaminants likely to be associated with nonpoint sources, and physical/chemical properties of those substances helps to develop an initial list of chemical concerns.

Information should also be collected that helps define the site's environmental management goals. Environmental management goals in estuarine and marine systems may be based on protecting the whole ecosystem, maintaining viable populations of sport and commercial fish species, protecting human health (e.g., swimmable and fishable), or a variety of other considerations (e.g., seagrass restoration, reestablishment of shellfish, regional runoff management). As such, information on existing site uses helps make decisions on the level of investigations that should be conducted.

Step 2. Collect and Evaluate Existing Sediment Chemistry Data

Collecting and evaluating existing sediment chemistry data is critical to the site-specific sediment quality assessment process. Sediment chemistry data typically are generated under various environmental programs. Collect relevant data to support a preliminary assessment of sediment quality. These data should be fully evaluated to determine their applicability. This evaluation should cover the overall quality of the data set and the degree to which the data represent current site conditions.

Assessment of sediment quality also requires information that adequately represents the site's contemporary environmental conditions. Therefore, knowing the age of the chemistry data is essential to determine the data's applicability. Natural degradative processes in the environment can lead to reduced concentrations of sediment-associated organic contaminants. Major events, such as storms, can transport sediments between sites, and industrial developments and/or regulatory activities can alter the sources and composition of contaminants released into the environment. Thus, assessments of sediment quality should be undertaken with the most recent data available.

In addition to temporal variability, the chemistry of bed sediments varies spatially as well. Therefore, a single sample likely represents only a small proportion of the geographic area. For this reason, data from a number of stations are required to represent a site's sediment quality conditions. The actual number of stations required depends on the size of the area, the concentrations of sediment-associated contaminants, and the variability of contaminant concentrations.

Another important factor to consider in evaluating existing sediment quality data is the variables analyzed. The list of analyses must reflect potential contaminant sources from area land and water use activities. For example, in harbors, variables such as pentachlorophenol (used to preserve pilings), tributyltin (used in antifouling paints for ships), and copper (used in antifouling paints for pleasure crafts) should be measured. Similarly, highly elevated concentrations of polycyclic aromatic hydrocarbons and lead are often associated with urban runoff discharges. In agricultural areas, persistent pesticides and nutrients should be considered in sediment quality assessments.

If the results of the data evaluation indicate that sediment chemistry data are acceptable, we can proceed with the preliminary assessment of the potential for biological effects. However, if the sediment chemistry data are of unacceptable quality or do not adequately represent the site, additional data may be required to complete the assessment.

Step 3. Collect Supplemental Sediment Chemistry Data

The third stage in assessing sediment quality involves generating supplemental sediment chemistry data. Additional testing may be required when data are insufficient to support the assessment of sediment quality at a site. The initial list of chemical concerns provides a defensible way to identify potential analyses for the sediment quality monitoring program.

Sampling programs should delineate temporal and spatial and vertical and horizontal variability in sediment contamination and explicitly identify quality assurance/quality control measures to implement. Collection, handling, and storage of sediment samples should follow established protocols, and analytical methods and detection limits should be appropriate. Total digestion of sediment samples with a strong acid (e.g., hydrofluoric) is required. A focused, well-designed monitoring program ensures that the resulting data will support a defensible sediment quality assessment.

Step 4. Conduct Preliminary Assessment of the Potential for Biological Effects of Sediment-Associated Contaminants

Sediment chemistry data alone are not adequate to assess the hazards posed by sediment-associated contaminants to aquatic organisms. Interpretive tools can determine if these contaminants are present at concentrations that could impair the designated uses of the aquatic environment. Effects-based guidelines to assess sediment quality provide a scientifically defensible way to evaluate the potential effects of sediment-associated contaminants on aquatic organisms. The three ranges of contaminant concentrations were discussed previously.

Step 5. Evaluate Natural Versus Anthropogenic Sources of Sediment-Associated Contaminants

Interpretation of environmental metals data is difficult because absolute metal concentrations in coastal sediments are influenced by various factors, including sediment mineralogy, grain size, organic content, and anthropogenic enrichment. These factors result in metals levels that can vary over several orders of magnitude at uncontaminated sites in Florida (Schropp et al. 1990). While numerical, effects-based sediment quality assessment guidelines provide essential information to evaluate sediment-associated metals, they should not be used alone to evaluate the quality of marine and estuarine sediments. Instead, assessments of sediment quality should evaluate the potential for adverse biological effects and the degree of anthropogenic enrichment. Using this approach, metals concentrations would be considered a serious concern when they exceed the biological effects-based guidelines and are anthropogenically enriched.

In the past, determining whether estuarine and coastal sediments were anthropogenically enriched with metals was difficult, requiring comprehensive, site-specific assessments. However, as discussed previously under "Assessing Sediments Contamination," Florida has developed a practical approach to assess metals contamination in coastal sediments. This procedure relies on normalization of metal concentrations to a reference element aluminum.

Step 6. Conduct Biological Assessment of Sediment Quality

Biological testing is essential in assessing sediment quality. The nature and extent of available information creates significant uncertainty in predicting the biological significance of sediment-associated contaminants (i.e., most of the data used do not support a cause-and-effect relationship). Therefore, biological testing—generally a suite of biological tests—is required to provide reliable information on the toxicity of bed sediments and to confirm the results of the preliminary sediment quality assessment.

In Florida, further biological testing supports three distinct aspects of sediment quality assessment. First, biological testing may assess sediment toxicity at sites where the concentrations of one or more contaminants fall within the probable and possible effects range. Second, biological testing may assess toxicity sediments likely to contain unmeasured substances. Third, biological data assess whether the recommended SQAGs are applicable to Florida coastal waters. Additional biological testing determines the systematic differences between the sensitivities of species represented in the Biological Effects Data System (BEDS) (MacDonald, 1993) compared to the sensitivities of species that reside in Florida coastal waters. In addition, ancillary biological testing determines the systematic differences between the toxicity—as affected by bioavailability and other factors—of a substance in sediments represented in BEDS compared to Florida sediments. In

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some cases, biological testing will require site-specific SQAGs to assess the potential effects of sediment-associated contaminants.

The biological testing program should address whole sediment toxicity, but it may also consider potential effects in the water column. Evaluation of whole sediment toxicity is a key component of the sediment quality assessment process in regulatory and management applications. Biological tests that assess potential water column effects are generally more applicable, for example, in programs concerned with regulating disposal of dredged materials.

A number of tests can evaluate the biological significance of sediment contamination. These tests may be as simple as short-term bioassays on a single contaminant using a single species or as complex as microcosm studies investigating the long-term effects of contaminant mixtures on ecosystem dynamics. In addition, tests may be designed to assess the toxicity of whole sediments (solid phase), suspended sediments, elutriates, sediment extracts, or pore water. Organisms routinely tested include microorganisms, algae, aquatic macrophytes, invertebrates, and fish.

Other biological information can assess sediment quality. For example, comparing biological indicators, such as the diversity and abundance of benthic invertebrate communities, at test sites and appropriate ecoregion reference sites provides a means of assessing the relative toxicity of test sediments. Various statistical procedures can help identify contaminants associated with observed biological effects using adequate sediment chemistry data. In addition, spiked-sediment bioassays can establish cause-and-effect relationships for specific substances or contaminant mixtures. Further, tests to evaluate pore water toxicity provide information that can identify the toxic elements of contaminated sediments. Information on contaminant level in aquatic biota and on bioaccumulation help determine contaminant levels in sediments to protect the health of humans and of wildlife that consume aquatic organisms.

Step 7. Implement Management of Sediment Quality

The objective of the sediment quality assessment process is to provide information that supports environmental quality management. Management decisions will depend on various factors, including the nature and severity of the contamination, the potential for exposure of aquatic organisms, management goals for the site, availability of remediation technology, costs associated with remediation, and public expectations. By integrating information on these factors, managers and others can make defensible decisions on remediating, preventing, and monitoring contamination.

We can make several sediment quality management decisions using information available from the environmental assessment. At some sites, no additional action is warranted. Other sites may require monitoring for trends in sediment quality. Seriously contaminated sites may require some remedial action to achieve environmental management goals. These remedial actions could include removing and treating toxic materials, isolating or capping contaminated sediments, implementing source control measures, or no action at all (i.e., permit natural degradation and sedimentation to mitigate contaminant effects).

MacDonald (1993) stresses the importance of combining the effects-based guidelines and the metals interpretive tool. MacDonald examines data on levels of sediment-associated lead from two geochemically distinct systems, Biscayne Bay and Apalachicola Bay, to illustrate the integrated sediment quality assessment framework. Figure 5.9 shows a summary of the available data (Fla. Dep. Environ. Prot. 1993) on the levels of sediment-associated lead in the Miami area. The data, sorted by increasing concentration, were assigned sample numbers from 1 to 108. Evaluation using the SQAGs suggests that approximately 15 percent of the samples fall within the probable effects concentration range (exceed the PEL of 160 mg/kg). Another 20 percent fall within the possible effects range (between NOEL and PEL). Therefore, comparing sediment chemistry data with numerical SQAGs suggests a relatively high probability of observing adverse biological effects. Further examination of the data using the metals interpretive tool (Figure 5.10) demonstrates that sediments from this area are clearly anthropogenically-enriched with lead. Roughly 90 percent of the samples exceed the 95 percent prediction limits established for clean sites. Concordance between the effects-based and the geochemically based tool suggests that the Miami area should have priority in further investigations to evaluate sediment toxicity.

In Apalachicola Bay, roughly 20 percent of the samples had levels of lead that exceeded the NOEL of 21 mg/kg (Figure 5.11). Comparison of the ambient lead levels in Apalachicola Bay with SQAGs suggests possible adverse biological effects at a significant number of sites. However, fur-

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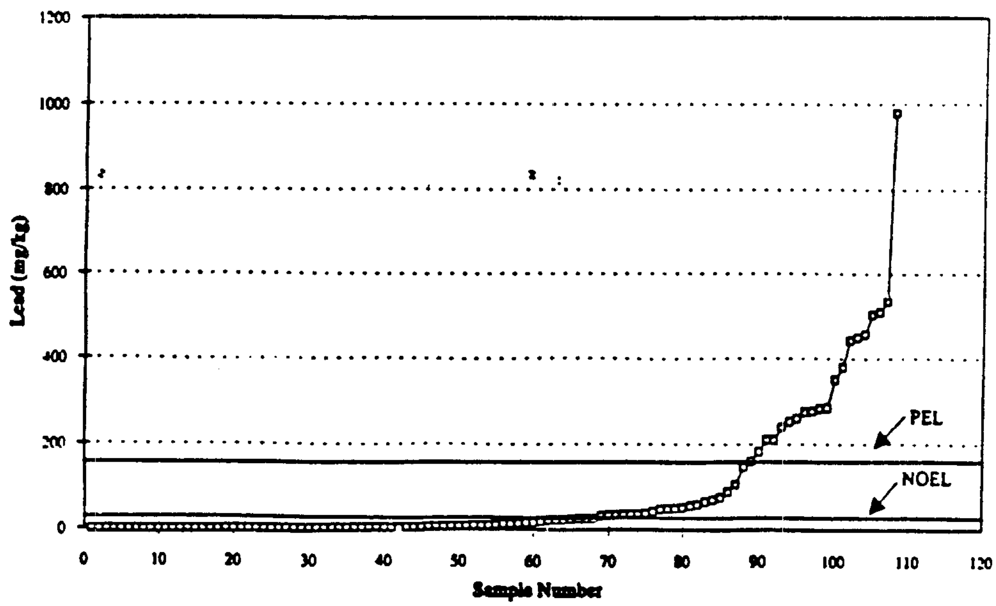
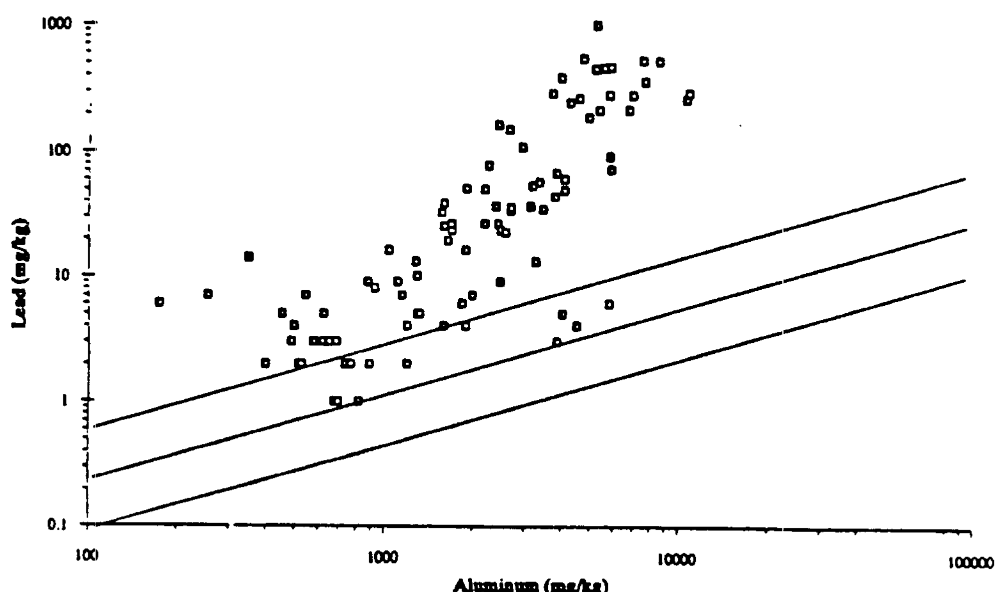
Figure 5.9—Lead concentrations in sediments in Biscayne Bay.



Source: Fla. Dept. Environ. Prot. 1993.

Figure 5.10—Aluminum normalized concentrations of lead in Biscayne Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

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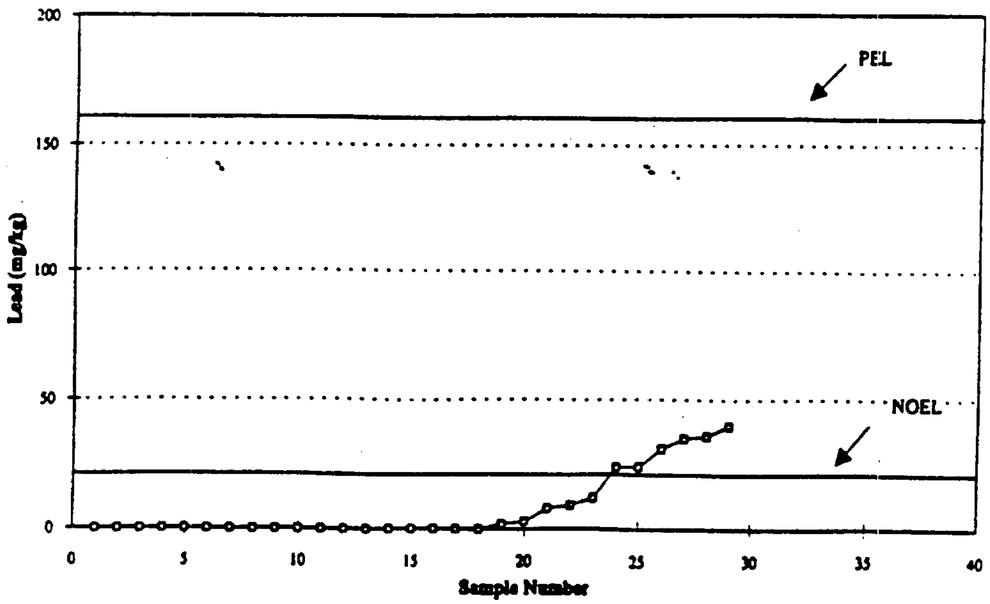
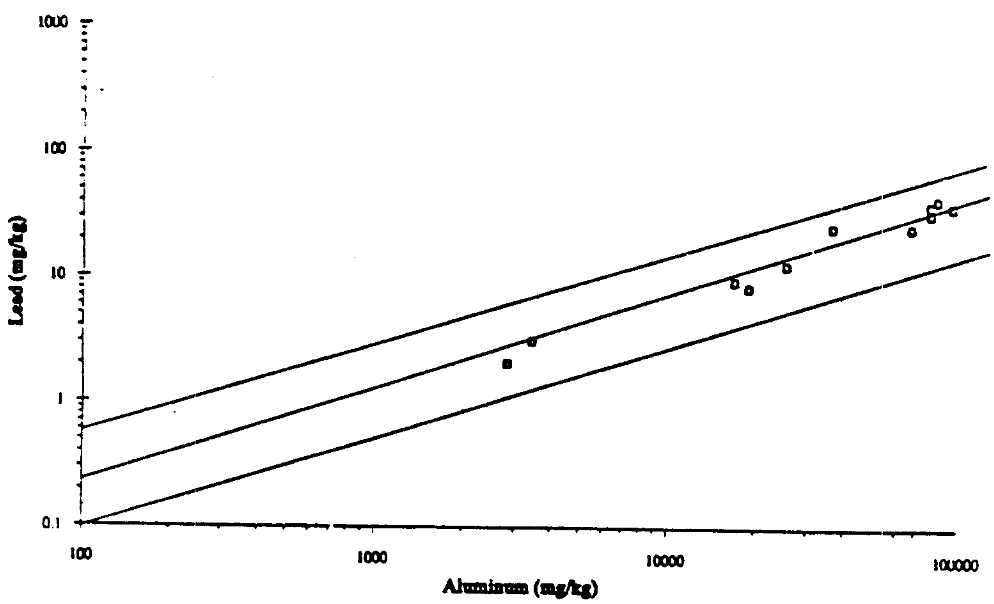
Figure 5.11—Lead concentrations in Apalachicola Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

Figure 5.12—Aluminum normalized concentrations of lead in Apalachicola Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

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ther evaluation using the metals interpretive tool indicates that aluminum-normalized lead level is indicative of those measured in clean sediments in Florida (Figure 5.12). While the effects-based tool predicts the possibility of adverse effects at some sites, the geochemical tool demonstrates that lead concentrations in Apalachicola Bay occur naturally and, as such, should not be considered hazardous to aquatic organisms. This system does not require further investigations to evaluate the extent of sediment toxicity.

Recommended Sediment Assessment Approach Limitations

Sediment quality assessment guidelines using the recommended approach are preliminary values and should be refined as new information becomes available. This approach has several limitations and considerations:

- The approach determines the potential for sediment-associated contaminants to induce biological effects. We cannot infer direct cause-and-effect relationships when comparing chemical data to the recommended guidelines.

- The SQAGs apply to marine and estuarine waters only, not to freshwater systems.

- The SQAGs are not expressed as factors thought to control the bioavailability of sediment-associated contaminants (i.e., total organic carbon for nonpolar organics and acid volatile sulfide for divalent metals).

- The data used to derive the SQAGs consist primarily of acute toxicity study results. Few data exist on the chronic responses of aquatic organisms to contaminants associated with sediments.

- The recommended guidelines should be used with other assessment tools and protocols, such as the Florida Department of Environmental Regulations metals interpretive tool and the Green Book (U.S. Environ. Prot. Agency and Army Corps Eng. 1991) to provide comprehensive evaluations of sediment quality.

- The recommended guidelines were developed using information from various North American locations. These data may not represent Florida's diverse sediment types. For this reason, exercise caution in using these guidelines, particularly in carbonate-dominated sediments.

Sediment Quality Assessment Guideline Applications

The recommended sediment quality assessment strategy should provide consistency in evaluating Florida's sediment quality. While the SQAGs represent an integral element of this strategy, they should be used with other assessment tools to efficiently and cost-effectively evaluate ambient sediment quality conditions. In this context, these SQAGs may be used to

- Interpret the results of sediment quality monitoring data. SQAGs may assess the potential adverse biological effects of specific concentrations of sediment-associated contaminants.

- Support the design of sediment quality monitoring programs. SQAGs may evaluate existing sediment chemistry data and rank areas and chemicals of concern according to their potential association with adverse biological effects. As such, monitoring priorities may be more clearly and effectively identified.

- Identify the need for site-specific investigations to support regulatory or watershed management decisions, including source controls and regional urban management sites. SQAGs can evaluate existing data to determine if additional testing (e.g., sediment toxicity bioassays) is needed.

- Evaluate the hazards associated with increased contaminant levels at specific sites. SQAGs may act as early-warning tools for watershed management or regulatory action before contaminant levels become problematic.

- Support a preliminary assessment of the applicability of EPA's developing sediment quality criteria. The SQAGs can assess the protection level these criteria afford to aquatic organisms.

- Facilitate multijurisdictional agreements on sediment quality issues and concerns. SQAGs can establish site-specific sediment quality objectives to help define governmental responsibilities in preventing and remediating sediment contamination.

These guidelines provide a consistent way to evaluate sediment quality in Florida. However, they are preliminary and their application is limited. Therefore, SQAGs should not be used

- In lieu of water quality criteria. However, these guidelines may be used in regulatory programs to evaluate effectiveness and identify the need for more stringent regulations;
- To define uniform values for sediment quality statewide (i.e., they should not be used as sediment quality criteria). Ambient environmental conditions may influence the applicability of these guidelines at specific locations;
- As criteria to dispose of dredged material or to replace formal assessment protocols established to dispose of dredged material; or
- Directly as numerical clean-up levels at severely contaminated sites (e.g., Superfund sites).

Recommended Reading

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CHAPTER 6

Biological Community Assessments

Traditionally, monitoring surface waters to assess their health and the effects of pollution discharges has relied upon chemical and physical measurements of the water column. While this approach assesses the effects of continuous discharges—such as wastewater treatment plants and industrial sources—it cannot accurately determine environmental impairments from intermittent sources such as urban runoff. This chapter discusses the development and use of biological community assessments to detect the effect of nonpoint source pollution on aquatic life.

Intermittent discharges create shock loadings to a waterbody, and the ecological effects depend on many variables and complex interactions. Moreover, many runoff pollutants become attached to sediment particles or settle quickly, exerting detrimental effects over a long period. Furthermore, urban runoff degrades habitat (e.g., channel and bank erosion) and causes tremendous siltation, neither of which are detected by water chemistry sampling.

Monitoring biological communities is an additional approach that can enhance surface water quality assessment and management. While chemical data reflect short-term conditions that exist when a particular sample is collected, biological communities accurately indicate overall environmental health because they continuously inhabit receiving waters and react to various long-term chemical and physical influences. Aquatic organisms also integrate a variety of environmental influences—chemical, physical, and biological.

Biological assessment involves integrated analyses of functional and structural components of the aquatic communities. Bioassessments are best used to detect aquatic life impairments and assess their relative severity. Once an impairment is detected, additional chemical and biological toxicity testing can identify the causative agent and its source. Both biological and chemical methods are critical in successful pollution control and environmental management programs. They are complementary, not mutually exclusive, ways to enhance overall program effectiveness.

Some advantages of bioassessments are that

- Biological communities reflect overall ecological integrity (chemical, physical, and biological).
- Over time, biological communities integrate the effects of different stressors, providing a measure of fluctuating environmental conditions.
- By assessing the integrated response to highly variable pollutant inputs, biological communities provide a practical approach for monitoring runoff source impacts and the effectiveness of best management practices.
- Routine monitoring of biological communities can be relatively inexpensive, particularly when compared to the cost of assessing toxic substances.
- The public is highly interested in the status of biological communities as a measure of environmental health.
- Biological communities offer a practical way to evaluate habitat degradation typically associated with urban runoff discharges.

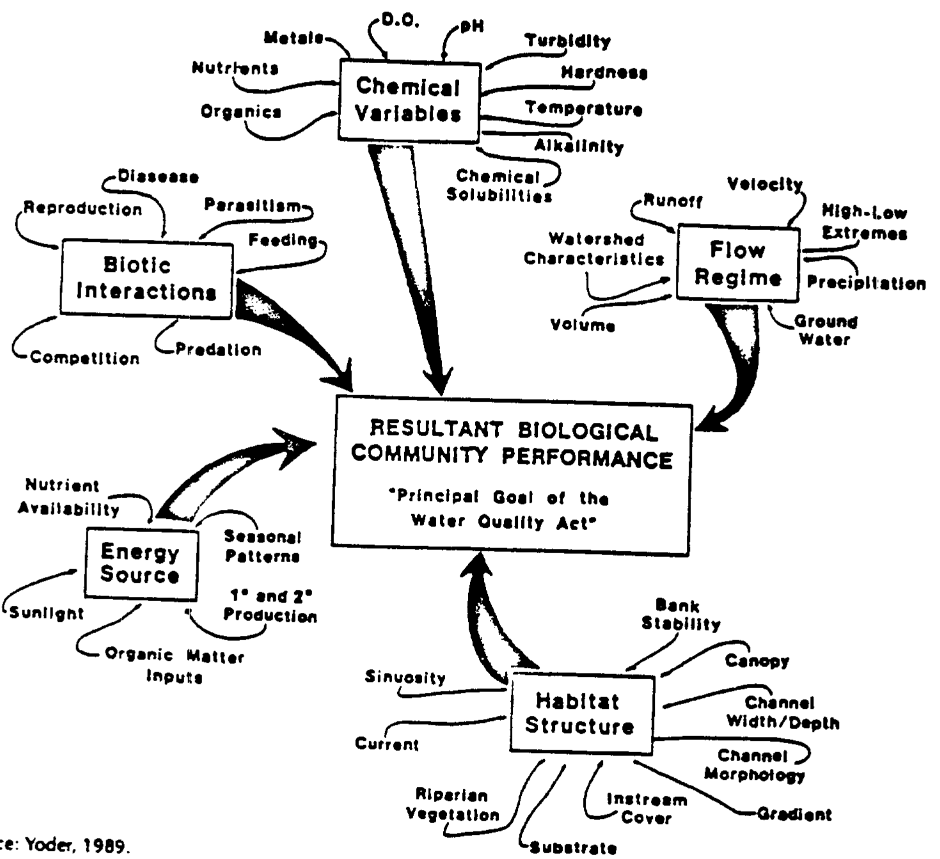
Biological Integrity

Karr et al. (1986) grouped environmental factors affecting most aquatic ecosystems into five major classes: chemical variables, biotic interactions, flow regime, habitat structure, and energy source. These factors interact to determine the integrity of water resources reflected by the resident aquatic life (Figure 6.1). Alterations to the physical, chemical, or biological processes can adversely affect the aquatic biota and, therefore, the biological integrity of the waterbody. Efforts to protect and restore waters by using only one or two of the five factors will likely fail if other factors are involved (Karr et al. 1986). Monitoring methods integrating all five classes are necessary to maintain and improve surface water quality and aquatic life resources.

Recent advances in computer technology and, more important, in biological assessment techniques make the current approach more practical. Advances include geographic information systems and available digitized databases, refined laboratory and field methods, standard assessment techniques, a practical and useful definition of biological integrity, and the regional reference site concept. These advances provide a framework to incorporate biological community assessments and "biocriteria" into surface water management programs.

Although the principal goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters, difficulties in defining an ecological approach to assessing biotic integrity has led regulatory agencies to rely primarily on chemical

Figure 6.1—Important chemical, physical, and biological factors that influence and determine biological community performance in surface waters.



Source: Yoder, 1989.

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measurements. However, Karr and Dudley (1981) define biotic integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitats within a region." This definition is based on measurable characteristics of aquatic communities and comparisons to a regional reference site.

Despite the many recent advances in bioassessment techniques, state-specific ecoregions, methods to delineate reference sites, and rapid bioassessment (RBA) methods are badly needed. These techniques offer the best means of accurately assessing the impacts of urban runoff and other nonpoint sources of pollution. Conducting this essential development work requires special expertise, adequate funding, and time.

To date, ecoregion reference sites have been selected and sampled, and RBA techniques have been developed and refined only for riverine systems. Work is just beginning to refine and test RBA methods for lakes, and little progress has been made on developing RBA methods for estuaries. These aquatic systems need standard assessment techniques and quantitative biocommunity evaluation criteria.

Ecoregions and Reference Sites

Spatial frameworks can profoundly influence the effectiveness of research, assessment, and management of many water resource problems, especially those caused by urban runoff and nonpoint sources. Traditionally, we have relied on spatial frameworks based on political boundaries, watersheds, hydrologic units, or physiographic regions. However, these areas do not correspond to patterns in vegetation, soils, land surface form, land use, climate, rainfall, or other characteristics that control or reflect spatial variations in surface water quality or aquatic organisms.

Water quality management is slowly moving beyond the technology-based, uniform national standards approach that is point source oriented. The new approach recognizes land/water interactions, nonpoint sources, and regional variations in attaining water quality. Water quality assessments need a regional framework to

- Compare regional land and water patterns;
- Compare ecological similarities and differences;
- Compare habitat similarities and differences;
- Establish realistic, achievable chemical and biological standards;
- Assess the effects of all pollution sources within a watershed, especially intermittent discharges;
- Predict the effectiveness of management practices;
- Prioritize assessment and management efforts;
- Locate monitoring and special study sites; and
- Extrapolate site-specific information to larger areas.

Omernik (1987) proposed using spatial frameworks based on ecological regions (ecoregions) to assess the health of aquatic systems. Ecoregions reflect similarities in the type, quality, and quantity of water resources and the conditions affecting them. Therefore, regional patterns of environmental factors reflect regional patterns in surface water quality.

Using an ecoregional framework, we can sort out spatial variability in the environmental characteristics that we wish to manage. Delineating ecoregions requires collecting and examining reference material to understand the area. This includes determining what the ecoregion looks like, its dominant environmental features, the kinds of natural and human impacts influencing resource quality, and the characteristics supporting the regional delineation. Different environmental features drive each ecoregion. In some parts of the country, land-surface form dominates vegetation, soil formation, and land use; annual precipitation more strongly affects these characteristics in other areas.

Defining, delineating, describing, and depicting ecoregions involves a systematic collection and analysis of diverse environmental information (Figure 6.2). This process is described completely in *Regionalization as a Tool for Managing Environmental Resources* (U.S. Environ. Prot. Agency, 1989a). Ecoregions are defined at hierarchical levels for the conterminous United States (Figure 6.3). More detailed subregions have been developed for Arkansas, Colorado, Minnesota, Ohio, and Oregon. Continued subregion

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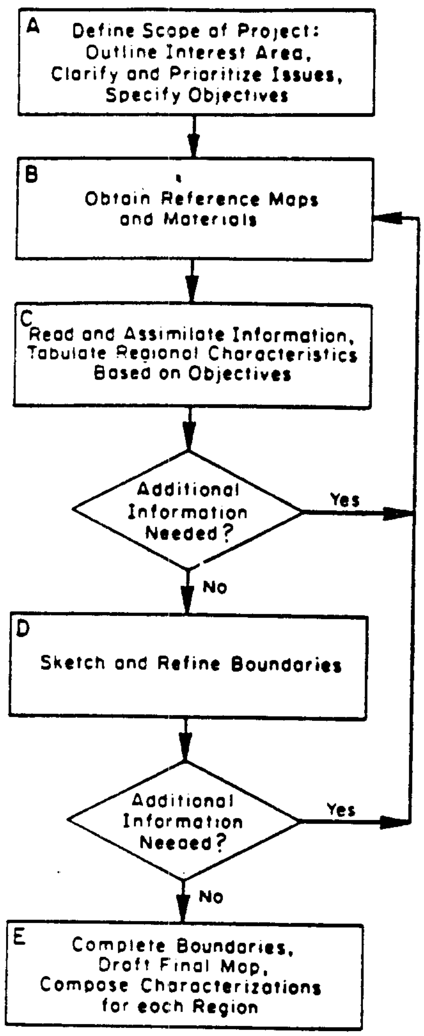
Figure 6.2—Steps to develop regionalization.



Source: U.S. Environ. Prot. Agency, 1989a.

development is underway in Alabama, Florida, and Appalachia. Additionally, subregions are being planned in other states, largely because of biological criteria development and enhanced assessment and management of nonpoint sources.

Once ecoregions are delineated and field verified, ecoregion reference sites should be selected. An essential component of the management framework, these sites allow us to evaluate the environmental health of a locale by comparing it to a known reference site. This is a key concept in Karr and Dudley's (1981) definition of biotic integrity, which compares site evaluations to the aquatic community of "natural habitats within a region." Ecoregion reference sites used in water resources management must have two essential components: They must represent the ecoregion and have ecological conditions reasonably attained, given current background conditions.

Selecting ecoregion reference sites allows us to approximate attainable quality by measuring the physical, chemical, and biological quality of streams draining watersheds that represent the region's natural environmental characteristics and have received the least amount of human influence. Select sites according to the following steps (U.S. Environ. Prot. Agency, 1989a):

1. Specify environmental characteristics affecting water quality such as soil type; vegetative cover; amount, intensity, and timing of annual or seasonal precipitation; topography and slope; and occurrence of natural geologic deposits.

2. Map areas that share similar characteristics.

3. Select watersheds from within those areas.

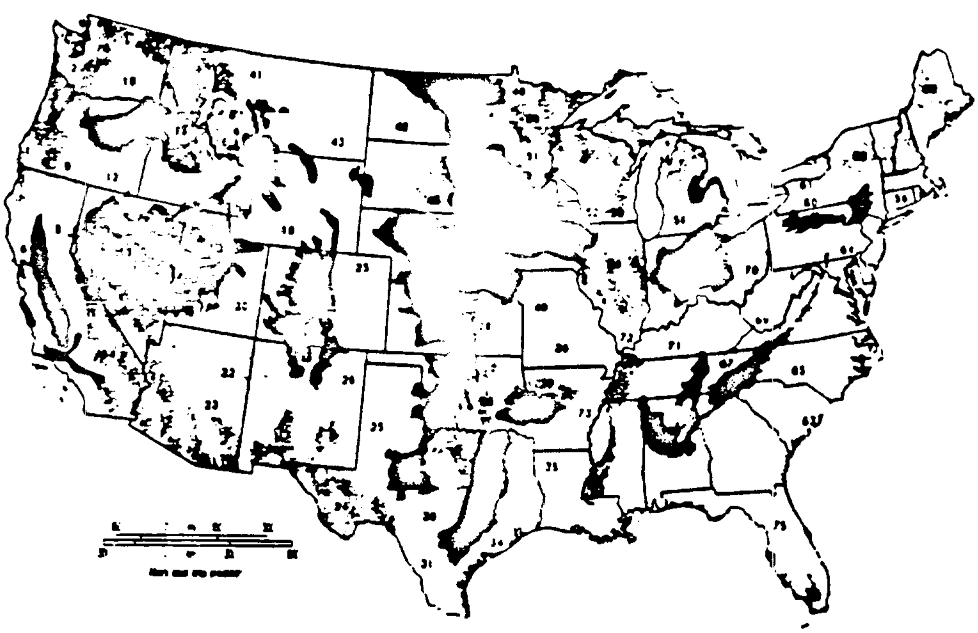
4. Eliminate watersheds where access is prohibited.

5. Eliminate watersheds affected by human influence. Since this will likely leave an insufficient number of watersheds, add those subject to the least anthropogenic influences. Unfortunately, in many parts of the country, pristine watersheds do not exist. However, given regional land use practices, the least affected watersheds should identify reasonable expectations in the region.

6. Verify the site's suitability to ensure the accuracy of mapped information and to eliminate inappropriate watersheds. Site visits are essential. Make use of local expert opinion.

7. Collect physical, chemical, and biological data to generate reference data that define the range of regionally achievable quality. Use this data to compare the quality of other sites. The next section discusses the type of and ways to collect biological data.

Figure 6.3—Ecoregions of the conterminous United States.



Source: U.S. Environ. Prot. Agency, 1989b.

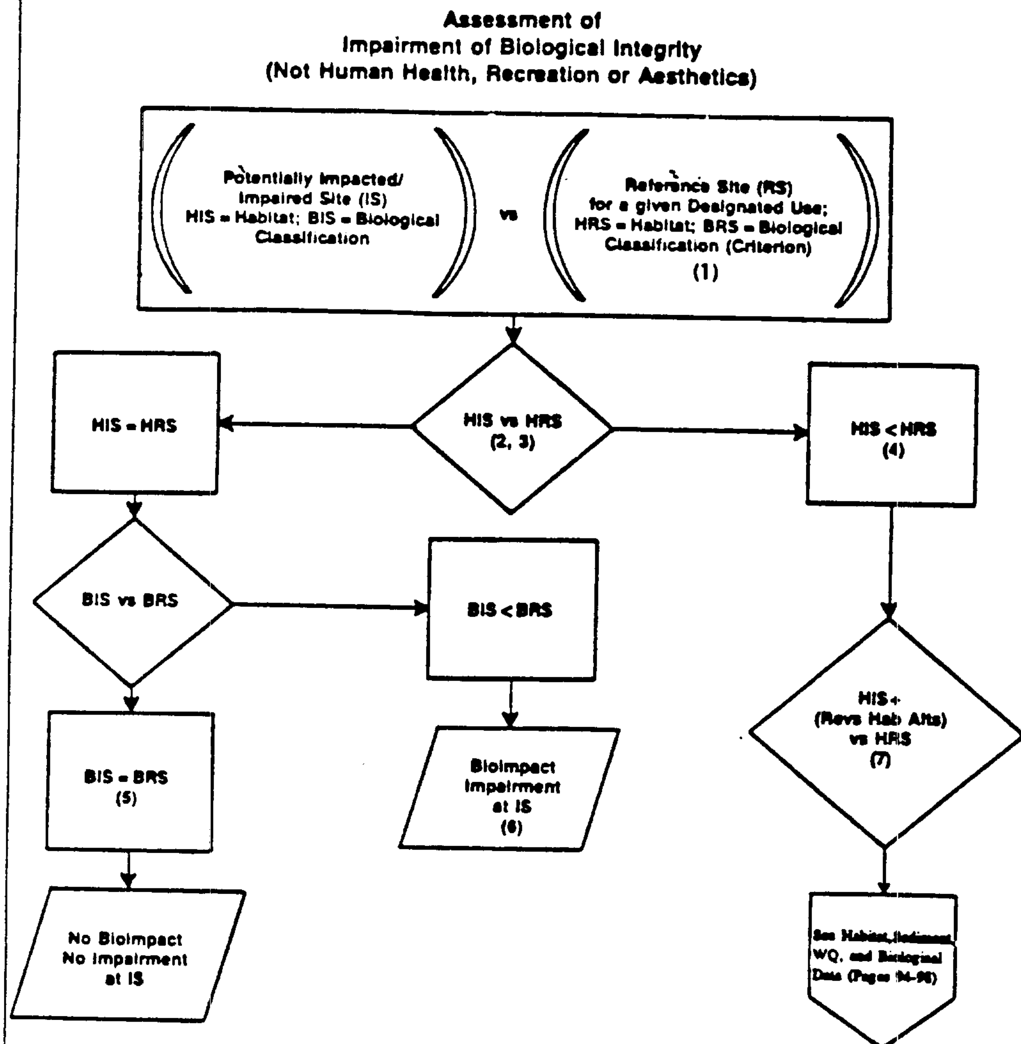
Rapid Bioassessment Protocols

In 1985, U.S. EPA conducted a survey to identify states that routinely perform biological assessments and evaluate their field methods. A workgroup of state and EPA biologists reviewed existing methods and refined protocols for monitoring benthic macroinvertebrates. Incorporating comments from state and staff, EPA also developed a set of fish protocols. *Rapid Bioassessment Protocols for Use in Streams and Rivers* (U.S. Environ. Prot. Agency, 1989b) contains a more comprehensive discussion of this topic.

The rapid bioassessment protocols (RBPs)—also known as community bioassessment protocols—advocate an integrated assessment, comparing habitat (physical structure and flow regime) and biological measures with empirically defined reference conditions (Figure 6.4). Reference conditions are established through systematic monitoring of actual sites (ecoregion reference sites) that represent the natural range of variation in "least disturbed" water chemistry, habitat, and biological condition.

Of these three components of ecological integrity, ambient water quality may be the most difficult to characterize because of the complex array of chemical constituents that affect it. Therefore, the implementation framework presented in Figure 6.4 first describes the development of an empirical relationship between habitat quality and biological condition and then refines this relationship for a given region. As additional information is obtained from systematic monitoring of potentially impacted and site-specific control sites, the predictive power of the empirical relationship is enhanced. Once the relationship between habitat and biological potential is understood, water quality impacts can be objectively discriminated from habitat effects, and management efforts can focus on the most important source of impairment.

Figure 6.4—Bioassessment decision matrix (numbers in parenthesis refer to numbered Explanatory Notes).



Source: U.S. Environ. Prot. Agency, 1989b.

Figure 6.4—Explanatory Notes

1. The reference site (RS) should represent a database consisting of the best attainable physical habitat, water/sediment chemistry, and biological parameters for specific environmental conditions. Acceptable ranges for the habitat and biological parameters of concern are based on this reference database.

   In the RBP assessment scheme, selected parameters are integrated to define generic habitat categories and bioclassifications. The integrated characterizations describe important attributes of the designated use and represent criteria for attainment/nonattainment of the designated use. Figure 6.4 also illustrates how designated uses and criteria may be established or refined as ambient monitoring activities proceed and how new data are incorporated into the reference database.

   Considerable effort may be required initially to identify reference sites and the habitat and biological characteristics of a specified aquatic life use.

Figure 6.4—Explanatory Notes continued

Alternatively, data required to define new or refined use characterizations and assessment criteria could be collected through implementation of an effective ambient monitoring program. However, when the *initial* reference database includes a spectrum of least disturbed habitats and concomitant biotic conditions, the need for site-specific controls may be greatly reduced. The value of a comprehensive reference database becomes more evident with progression through the implementation framework.

2. The purpose of the habitat assessment is to determine whether the impaired site (IS) has the potential to support a biological community comparable to that of the reference (see note 6).

3. Applicable ranges for several important habitat characteristics are generally incorporated into the habitat assessment field sheets, and the habitat evaluation can be made quickly onsite. However, preliminary reconnaissance is especially helpful when impaired site habitat (HIS) proves to be much lower in quality than reference habitat (HRS) and an evaluation of reversible habitat alterations (attainability) may also be necessary. Reconnaissance information allows planning for the additional work needed to characterize more appropriate reference sites.

4. In the early stages of developing assessment criteria for a given aquatic life use, HIS may often appear degraded relative to the HRS database. The likelihood of such an outcome is proportional to the richness of the initial HRS database. As more potentially impacted stations are assessed, however, certain stations will be shown to support

   - Biological communities equivalent to the reference sites despite apparent habitat deficiencies. Information from such sites will enrich the reference database and broaden the applicability of the use designation.

   - A relatively degraded community limited by intrinsic or irreversible habitat constraints. In this case, the original use is not attainable, and data collected from such a site should be used to revise the use designation.

5. The robustness of the comparison between the biological condition at the impaired site (BIS) and that at the reference (BRS) is limited by the rigor of the assessment procedure used (e.g., many versus few replicates) and the scope of the overall assessment (i.e., the number of biological community segments actually evaluated). The comparison of BIS and BRS is useful to detect or confirm *appreciable* impact to the biotic community and may be insensitive to certain subtle and/or threshold effects.

6. If BIS equals BRS, no detectable impairment occurs. This conclusion assumes no overriding limitations on the biological potential of IS relative to RS that are not accounted for by the previous habitat comparison (see note 2). Factors that could uniquely affect IS are discussed in station siting. For example, stations RS and IS may be located on a first order stream with primary organic inputs from a coniferous forest. In this situation, certain characteristics of the benthic community, such as taxa richness, may actually increase with organic enrichment from point source discharges rather than decrease as otherwise expected. This atypical situation should be assessed as if HIS plus reversible habitat alterations) is less than HRS (note 7).

7. The HIS plus reversible habitat alterations versus HRS comparison amounts to a simplistic use attainability analysis (UAA) that only considers habitat. The comparison involves scaling up the observed habitat parameter values to the extent that they might be feasibly improved. For example, bank stability, bank vegetation, and streamside cover could be greatly enhanced by fencing a pasture and planting trees, whereas other parameters may be unalterable. This mini-UAA can help to assess site-specific potential in the determination of actual impairment. If HIS and HRS are *potentially* equivalent, then use impairment can be appropriately assessed regarding resident biota. If HIS and HRS are not equivalent even when reversible habitat alterations are considered, biological effects may not be independent of habitat constraints. These potential scenarios are discussed in more detail in the section on integration of habitat, sediment, water quality, and biological data.

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The following are major steps in using EPA's rapid bioassessment protocols along with a brief discussion of some key considerations:

1. **Assessment of the structural/compositional and functional characteristics of the benthic macroinvertebrate community.**

   ■ **Seasonality for benthic collections.** Optimum biological sampling will correspond to invertebrates recruitment cycles, which vary with climate.

   ■ **Methods for benthic collections.** Considerations include natural versus artificial substrates; single versus multiple habitat sampling; and sampling coarse particulate organic material such as leaves, twigs, and bark.

   ■ **Benthic sample processing and enumeration.** Handling samples consistently is important because detailed comparisons are made among stations and sites.

   ■ **Benthic environmental tolerance characterizations.** Assessment of biological condition is based on the calculation of several metrics. Certain metrics rely on classifying benthic taxa according to their relative sensitivity to pollution. However, the meaning of pollution tolerance varies around the country, requiring each state to adapt established tolerance classification systems.

2. **Assessment of the structural/compositional and functional characteristics of the fish community.**

   ■ **Seasonality for fish collections.** The preferred sampling season is middle to late summer, when stream flows are less variable and more moderate.

   ■ **Methods for fish collections.** Electrofishing, seines, and rotenone are the most commonly used collection methods. Each has advantages and disadvantages.

   ■ **Sampling representative habitats.** The sampling station should represent the stream reach, incorporating at least one riffle, run, and pool if these habitats are typical. Sampling is most effective near shore and cover, such as macrophytes, boulders, snags, and brush.

   ■ **Fish sample processing and enumeration.** Standardized processing of fish samples should include identification of species, recording incidence of external abnormalities, and weighing (if biomass data are desired).

3. **Assessment of the structural/compositional and functional characteristics of the algal community.**

   ■ Note: See *Rapid Bioassessment Protocols* (U.S. Environ. Prot. Agency, 1989b) for a discussion of the advantages of using benthic macroinvertebrates, fish, and algae.

4. **Assessment of habitat type occurrence and quality.**

   ■ **Habitat, as affected by in-stream and surrounding topographical features.** This assessment largely determines aquatic community potential. Both the habitat's quality and quantity affect the structure and composition of its biological communities. Consider both physical characteristics and water quality parameters in assessing habitat.

   ■ **Physical characteristics.** These include estimating watershed land uses and their associated pollutant discharges/loadings; stream characteristics such as width, flow, and depth (in riffles, runs, and pools); substrate types; sediment odors, oils, and extent of deposits; extent of canopy cover; and human alterations such as dams, channelization, bottom scouring, channel stability/erosion, or modified shorelines.

   ■ **Water quality observations.** These should include recent and current weather conditions, temperature, dissolved oxygen, pH, conductivity, turbidity, and water odors or surface oils.

5. **Integration of benthic macroinvertebrate, fish, and habitat assessments using quantitative indices.**

   ■ **Species richness.** This figure should reflect the health of a community by measuring the variety of organisms present (total number of genera or species).

   ■ **Modified Hilsenhoff biotic index.** This index summarizes the overall pollution tolerance of the benthic arthropod community.

   ■ **Scraper and filtering collector functional group ratio.** This ratio provides

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insight into potential disturbance factors. Predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source.

- **EPT (Ephemeroptera, Plecoptera, Trichoptera) and Chironomidae abundance ratio.** The relative abundance of these four major invertebrate groups is used as a measure of community balance.
- **Percent contribution of the numerically dominant taxon to the total number of organisms.** This indicates community balance at the lowest positive taxonomic level.
- **EPT index.** This summarizes taxa richness within the insect orders that are generally pollution sensitive.
- **Community similarity indices.** These are used to compare biological communities at impacted sites and reference sites.
- **Ratio of shredder functional feeding group and total number of individuals collected.** This compares the shredder community at an impacted site and at a reference site.
- **Index of Biotic Integrity (IBI).** This broad index is grounded in fisheries community ecology that incorporates zoogeography, ecosystem, community, population, and individual perspectives.

6. **Careful choice of sampling locations to ensure that generally comparable habitats exist at each station.**
   - **Consider community differences.** Otherwise, differences attributable to a degraded habitat will be difficult to separate from those attributable to water quality degradation.
   - **Avoid locally modified sites.** These include small impoundments and bridge areas.
   - **Consider entering waters.** Avoid sampling near the mouths of tributaries entering large waterbodies, since these areas will have habitats more indicative of larger waterbodies.
7. **Use effective quality assurance and quality control procedures to ensure the usefulness of environmental monitoring data.**
   - **Develop a QA project plan.** It should describe the specific objectives, procedures, and methods for all staff working on the project.
   - **Training.** Train staff conducting the assessments consistently to ensure complete and standardized assessments.
   - **Achieve consistency.** Each agency must define its specific sampling methods, laboratory procedures, and analytical and validation techniques (e.g., replicate samples).
   - **Consider subjective habitat characterization.** Take special care in conducting the evaluation. Appropriate training and periodic cross-checks are essential.
   - **Routinely calibrate all field instruments.**

EPA (U.S. Environ. Prot. Agency, 1989b) presents five rapid bioassessment protocols—three for benthic invertebrates and two for fish. The appropriate bioassessment approach depends on the study objectives. RBPs I and IV are screening tools to help determine if biological impairment exists. Benthic RBP I and fish RBP V are more rigorous and provide more objective and reproducible evaluations than RBPs I and IV. RBPs II, III, and V are semiquantitative and use an integrated analysis technique to provide continuity in evaluating impairment among sites and seasons. Each of the RBPs is summarized briefly.

- **Rapid Bioassessment Protocol I—Benthic Macroinvertebrates and Rapid Bioassessment Protocol IV—Fish.** These RBPs provide a screening mechanism to identify biological impairment. They are not intended to quantify the degree of impairment nor provide definitive data to establish cause-and-effect relationships. They allow a cursory assessment, using cost and time efficiencies to evaluate a large number of sites, identify major water quality problems, and help plan and develop management strategies.

- **Rapid Bioassessment Protocol II—Benthic Macroinvertebrates.** This RBP provides information to rank sites as severely or moderately impaired so that additional study or regulatory/management action can be planned. Like RBP I, this protocol can be used as a screening tool and allows agencies to evaluate a large number of sites with relatively little time and effort. The more documented procedures and integrated metrics of

RBP II promotes better consistency and allows better comparison among sites.

- **Rapid Bioassessment Protocol III—Benthic Macroinvertebrates and Rapid Bioassessment Protocol V—Fish.** These two RBPs provide a consistent, well-documented biological assessment. Like RBP II, they provide information for ranking site impairment and a way to compare repeatable results over time (trend monitoring). These RBPs include taxonomic identifications to the lowest practical level, thereby providing information on population as well as community level effects. They include an integrated assessment of metrics and can be used to develop biocriteria.

Habitat, Sediment, Water Quality, and Biological Data

Relationship between Habitat Quality and Biological Condition

An overall assessment of ecological condition first evaluates habitat quality, then analyzes the biological components in light of these data.* If adverse effects are likely, then sediment and water chemistry sampling and evaluating potential pollution sources within the watershed should be undertaken. As the principal determinant of biological potential, habitat sets the context for interpreting biosurvey results. Along with sediment quality, habitat can be used as a general predictor of biological condition. Routine water chemistry can also help to characterize certain impacts.

In RBPs I and IV, which involve minimal biological sampling, habitat evaluation carries considerable weight in the final assessment. However, in RBPs II, III, and V, the biological evaluations are more rigorous and take precedence. The habitat assessment plays a supporting role within these protocols. It identifies obvious constraints on the site's attainable potential, helps select appropriate sampling stations, and provides basic information for interpreting biosurvey results. Sediment assessment, as discussed in Chapter 5, should be added to this methodology.

A site's attainable biological potential is determined primarily by habitat quality. The relationship between habitat quality and biological condition can be seen as a sigmoid curve (Figure 6.5), with community response varying with habitat quality. In the upper segment of the curve, good quality habitat (supporting or comparable) will often support high quality communities. Responses to minor alterations in habitat will be subtle and inconsequential. However, as habitat quality declines, discernible biological impairment results. In the absence of confounding water quality effects, this relationship is roughly linear.

In areas of severe habitat degradation, predicting the degree of biological impairment is more difficult. Community structure depends less on habitat diversity, which is usually simplified by degradation, and more on the opportunistic colonization strategies of a relatively few tolerant species. These opportunists have adapted to environmental conditions unfavorable to most other species. In the absence of competition, they thrive—or at least survive—in these marginal conditions. Therefore, biological measures, particularly those used in the RBPs, are relatively insensitive to habitat variations in this range. A nonsupporting characterization may correspond to either a moderately or severely impaired biological condition, depending on the specific site.

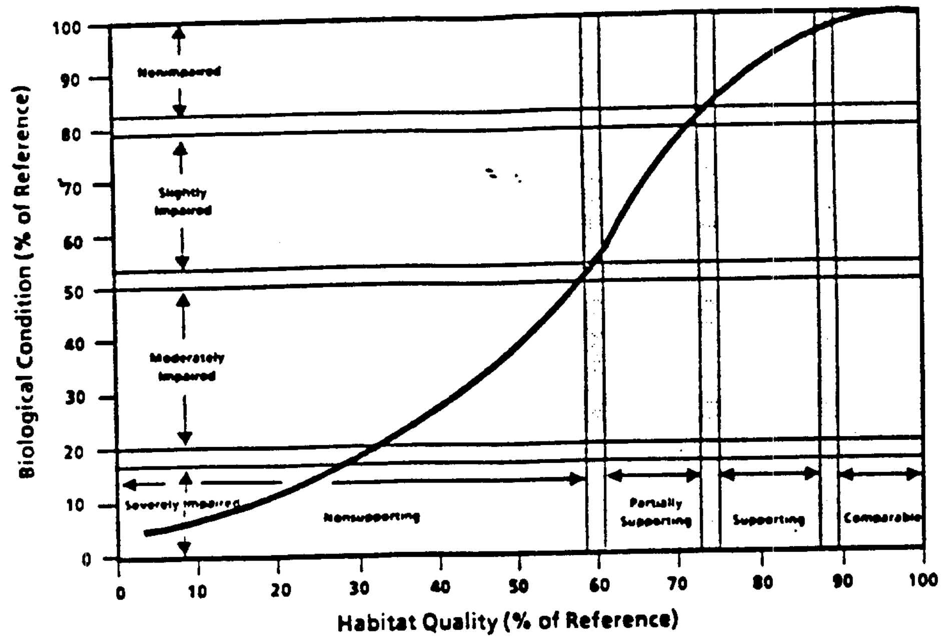
When habitat, sediment, and biological data are systematically collected together, empirical relationships can be quantified and subsequently used for screening impact sites, scoping field activities, and discriminating water quality impacts from habitat degradation. By acquiring a multiple-site database, confidence bounds can be established for the habitat/indigenous community relationship.

A theoretical relationship of habitat quality and biological condition as affected by water quality problems (organic or toxic loadings) can also be hypothesized (Figure 6.6). Curve II indicates the general relationship of biological condition to habitat quality in the absence of water quality/sediment effects. Curve II may resemble a sigmoid curve as illustrated in Figure 6.6. Curve III represents a situation where organic pollution or toxicants will adversely affect biological condition regardless of the habitat quality.

In areas of good or excellent habitat, biological communities reflect degraded conditions when water quality/sediment effects are present. However, as habitat degrades to a poor condition from water quality/sediment problems, community response may be less dramatic because of the presence of tolerant and generally opportunistic species. Curve I represents a situation indicative of nutrient enrichment, which will artificially sus-

* *Material in this section was adapted from U.S. Environ. Prot. Agency, 1989b.*

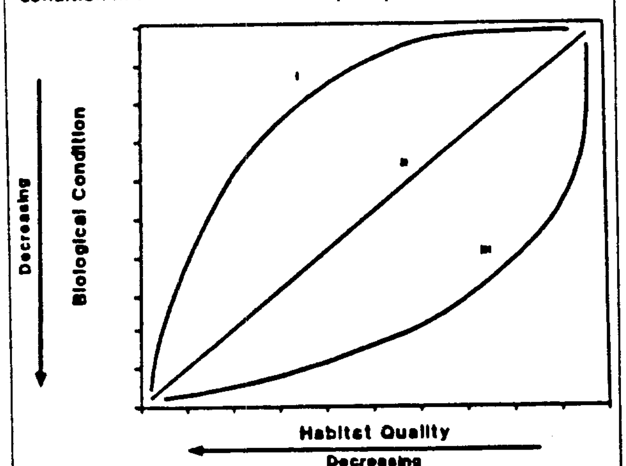
Figure 6.5—Relationship between habitat and biological condition.



Source: U.S. Environ. Prot. Agency, 1989b.

tain a more diverse fauna than dictated by the habitat quality. However, at some point along the curve as habitat degradation proceeds, nutrient enrichment will no longer support a diverse community, resulting in a drastic decrease in biological condition.

Figure 6.6—Relationship of habitat quality and biological condition in the context of water quality.



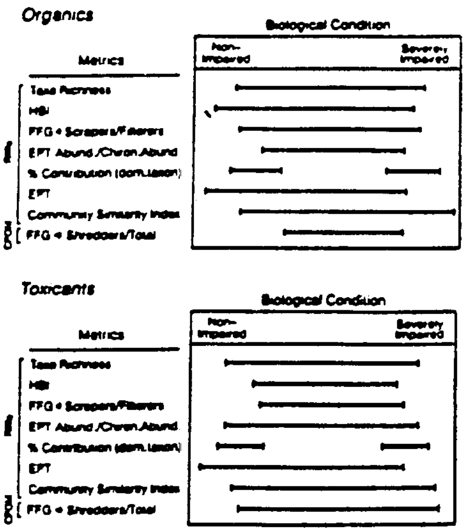
Source: U.S. Environ. Prot. Agency, 1989b.

Bioassessment Technique

Biological assessment components are evaluated using eight metrics (measurements) for benthic RBPs II and III and 12 metrics for fish RBP V. The pollution sensitivity range exhibited by each metric differs among metrics (Figures 6.7 and 6.8). Some are sensitive to a broad range of biological conditions; others only to some conditions. Sensitivity of metrics may also vary depending on whether organic or toxic impacts are being evaluated (Figure 6.7). The considerable overlap in the sensitivity ranges helps reinforce final conclusions regarding biological condition, while metrics that can better differentiate responses at the impairment range extremes enable a more complete bioassessment. This integrated analysis approach thus allows a broader assessment of condition than an analysis using any single metric. However, information from individual metrics enhances overall data interpretation.

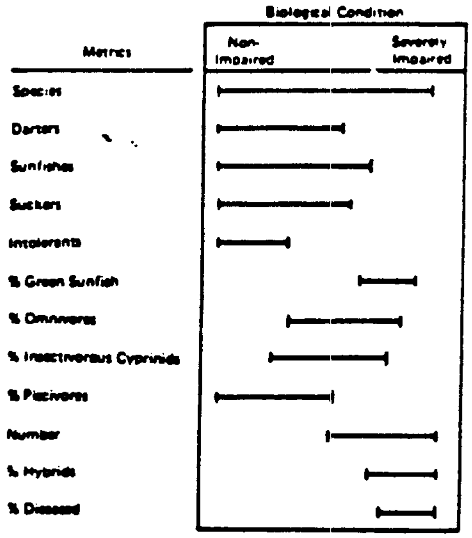
Certain metrics are designed to be better estimators of either organic or toxic effects. For exam-

Figure 6.7—Range of sensitivities of RBP II and III benthic metrics in assessing biological condition in response to organics and toxicants.



Source: U.S. Environ. Prot. Agency, 1989b.

Figure 6.8—Range of sensitivities of RBP V fish metrics in assessing biological condition.



Source: U.S. Environ. Prot. Agency, 1989b.

ple, the Hilsenhoff Biotic Index—a macroinvertebrate index—uses a tolerance classification scheme based on organic pollution effects. Functional group representation can be altered by either organics or toxicants (Figure 6.7). Although toxicants somewhat affect scrapers and filter/feeders, their ratio can best be used to assess organic enrichment. A reduction in the value obtained for scrapers and filter feeders can indicate a reduction in the quality of the periphyton as a food source and/or an increase in the suspended fine particulate organic matter (FPOM). Filter feeders are also affected by FPOM contaminated by toxicants.

The relative abundance of shredders in the benthic community is a good indicator of toxic problems. Vegetation sprayed with pesticides eventually becomes a coarse particulate organic matter (CPOM) food source for shredders. Therefore, depending on toxicant concentrations, CPOM may affect shredders. The ratio of the abundances of EPT taxa and chironomids may also function as a toxicant indicator.

The 12 IBI metrics, used in fish protocol V, also represent differing sensitivities (Figure 6.8). For example, municipal wastewater discharges typically affect total abundance and trophic structure (Karr et al. 1986), while unusually low total abundance generally indicates a toxic effect. However, some nutrient deficient environments support a limited number of individuals, and an increase in abundance may indicate organic enrichment. Bottom dwelling species that depend on benthic habitats for feeding and reproduction are particularly sensitive to the effects of siltation and benthic oxygen depletion and are good indicators of habitat degradation.

For the benthic and fish biosurveys and habitat assessment, scores are assigned to each metric or parameter based on a decision matrix. For habitat assessment, parameter quality is evaluated through visual observation. The score assigned to each habitat parameter is a function of a range of scores and is weighted by its contribution to the total habitat quality. The scores assigned to the benthic and fish metrics are based on computed values of the metrics and a station comparison, where the regional or stream reference station serves as the highest attainment criterion. Comparing the total score computed for the metrics or parameters with the reference station score provides a judgment about impairment of biological condition.

Effects indicated by the aquatic community need to be evaluated in a habitat quality context.

A poor habitat for riparian vegetation, bank stability, or stream substrate would not favorably support a well-balanced community structure. Habitat quality constraints may prohibit attaining a higher quality biological condition.

An Integrated Assessment Approach

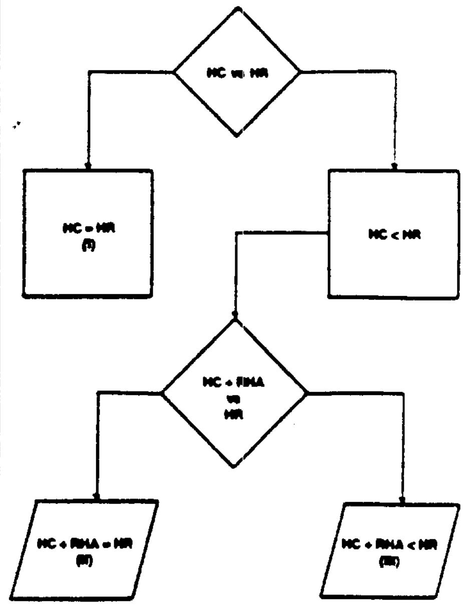
Assessing sediment, characterizing watersheds, and mapping pollution sources can be used to determine potential hot spots in watersheds and subbasins. Bioassessment and water chemistry sampling can then assess the aquatic system's actual health in these locations. A bioassessment should initially focus on habitat quality. Based on a regional reference, the habitat at an impacted site may be equal to or less than the desired quality for that particular system. If the habitat and reference are equal, then we can make a direct comparison of biological conditions as discussed in Figure 6.4. If the habitat is lower in quality than the reference, the first step is to evaluate the habitat potential. A site-specific control may be more appropriate than a regional reference for assessing an impact site. If so, select an appropriate site-specific reference site to ensure that its habitat and sediment characteristics represent the area. Once the appropriate reference site type is determined, possible outcomes of the bioassessment are

- No biological effects;
- Effects due to habitat degradation;
- Effects due to sediment or water quality; or
- Effects due to a combination of sediment, water quality, and habitat degradation.

After habitat problems are identified, separating the impairment cause from sediment or water quality problems is usually difficult. Figure 6.9 illustrates the approach to assessing biological effects. Selecting an appropriate station of comparison to evaluate biological impact begins with an evaluation of habitat at the potential control station. This comparison assumes that a regional reference database is available for the site being studied. Reference data used for comparison may be obtained from a single reference site. However, a reference database derived from numerous sites is much preferred and strongly recommended.

Scenario I depicts the situation where the habitat quality at the control station (HC) is equivalent to that at the regional reference (HR). If the control station habitat is degraded relative to that at the reference site, it becomes necessary to consider the effect that reversible habitat alterations (RHA) may have on habitat quality (Scenarios II and III). Reversible habitat alterations are those habitat parameters that can potentially be altered by remedial action (i.e., bank stabilization, bank vegetation, streamside cover).

Figure 6.9—Evaluation of habitat at a site-specific control relative to that at a regional reference.



Key:
HC = Habitat quality at control station
HR = Regional reference
RHA = Reversible habitat alterations

Source: U.S. Environ. Prot. Agency, 1989b.

If habitat quality at the control station (HC) is equivalent to that at the regional reference station (HR) as in Scenario I, then a biological assessment can be used to evaluate the potential water quality effects at the control site (Figure 6.10).

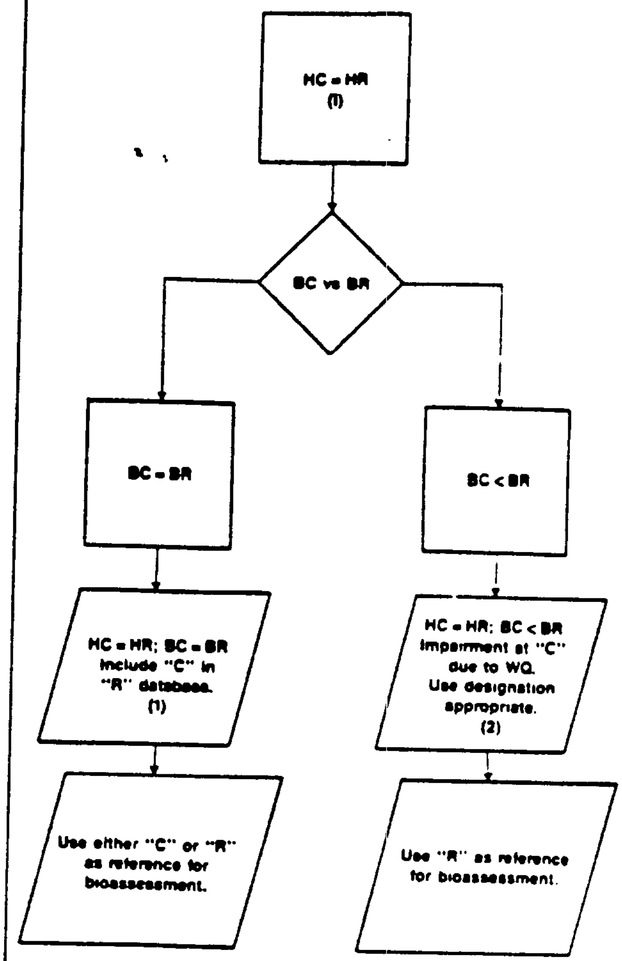
1. If impairment is not detected in a comparison of biological condition at the control station (BC) to biological condition at the reference station (BR), then C should be included in the R database; either C or R may be used as a reference for biological assessment at the impact

site (I). C would be the best indicator of a site-specific situation and would be more appropriate for use in determining water quality effects of point source pollutants, since it would be located on the same waterbody and would integrate all other background sources of impairment, other than the point source being evaluated. The reference would be more appropriate in an assessment of intermittent or nonpoint sources, since finding a nearby site-specific control that would not be impacted by the impact sources being assessed is virtually impossible. If R is based on an extensive database, then using R as a reference would provide a better estimate of acceptable variation in a data set.

2. If biological impairment is detected at C relative to R, the impairment may be attributed to water quality or sediment effects. The use designation at C is probably appropriate, but R should be used as the bioassessment reference site because of the impairment at C.

Specific approaches to evaluate environmental health for differing combinations of habitat conditions, biological condition, water quality, and sediment quality are discussed in section 8.3 of *Rapid Bioassessment Protocols for Use in Streams and Rivers* (U.S. Environ. Prot. Agency, 1989b).

Figure 6.10—Evaluation of water quality effects. (numbers in parenthesis refer to points of discussion in text).



U.S. Environ. Prot. Agency, 1989b.

Biocriteria

To implement water quality standards under the Clean Water Act, EPA requires states to include biological criteria in addition to water chemistry criteria. However, for various reasons, states have relied primarily on surrogate chemical criteria and narrative biological criteria (e.g., concentrations shall not cause imbalances of flora and fauna) to measure the health of biological communities. This situation is changing as EPA places increased emphasis on more quantitative biological criteria and as states begin assessing and managing urban runoff and nonpoint sources.

Yoder (1991) emphasizes five major needs to derive and establish scientifically defensible numeric biological criteria (biocriteria):

1. An operational definition of biological integrity. Karr and Dudley (1981) provide a workable, practical definition: "The ability of an aquatic community to support and maintain a structural and functional performance comparable to the natural habitat of a region."

2. The establishment of ecoregions and ecoregion reference sites.

3. The development and refinement of multimetric community measures such as the Index of Biotic Integrity, the Index of Well-Being (Iwb), and the Invertebrate Community Index (ICI).

4. Standardized, thorough, and cost-effective biological assessment techniques such as the RBPs discussed previously.

5. Trained, experienced, and knowledgeable staff.

In recent years, the Ohio Environmental Protection Agency (EPA) incorporated biocriteria into its water quality standards regulations. These biocriteria are based on a system of tiered aquatic life uses. The five classes include coldwater habitat, warmwater habitat, exceptional warmwater habitat, modified warmwater habitat, and limited resource waters. Ohio has defined these designations qualitatively in ecological terms and established quantitative or narrative chemical criteria for each.

Ohio derived numerical biocriteria for rivers and streams for three classes of waters—warmwater habitat, modified warmwater habitat, and exceptional warmwater habitat—based on in-stream fish and macroinvertebrate communities. Sampling conducted at more than 300 "least impacted" reference sites provided the ecoregional framework and established attainable, baseline expectations for each region and for the individual use classes.

Ohio EPA used three biological indices—IBI, I_{wb}, and ICI—to establish its biocriteria. Criteria for each index are defined by organism group, biological index, site type (fish), ecoregion, and aquatic life use designation. Modified I_{wb} and IBI criteria were defined for each of the five Ohio ecoregions for three site types: headwaters (drainage areas – 20 mi^2 [51.8 km^2]), wading sites (streams sampled with wading methods, usually 20-300 mi^2 [51.8-777 km^2]) and boat sites (streams sampled with boat methods, usually 200-6,000 mi^2 [518-15,540 km^2]). The calibration of the indices and the resultant biocriteria consider the effect of stream size and sampling gear selectivity.

Ohio established ecoregional biocriteria for the warmwater habitat class at the 25th percentile value of the reference site data for each ecoregion index. It set criteria for the exceptional warmwater habitat class at the 75th percentile, based on a statewide—not ecoregion—assessment of data from reference streams. In addition, Ohio established modified warmwater habitat criteria for some streams with physical habitat so altered that the expected warmwater habitat use could not be realistically attained but could support some semblance of a warmwater habitat community. The two biocriteria (25th percentile values) established for this class were for sites in the Huron/Erie Plain and for sites in the rest of the habitat.

Ohio EPA also established a process to determine the use attainment of Ohio's lotic surface waters. Attainment is assessed primarily based on biological monitoring and the ability to achieve the use class biocriteria. Nonattainment depends on the magnitude of departure from the ecoregional biocriteria (e.g., within four IBI units of the ecoregion criteria) and the distance downstream over which the departure is sustained. Generally, attainment is achieved by meeting all three numeric indices. Attainment is considered partial if at least one organism group index does not meet expectations but is no lower than a fair narrative rating, and the other organism group exhibits attainment. Nonattainment occurs if none of the indices meet ecoregional biocriteria or if one organism group gets a poor or very poor narrative rating, even if the other group exhibits attainment.

EPA (U.S. Environ. Prot. Agency, 1989a) presents an example of how Ohio EPA uses these biocriteria to assess waterbody impairment. A warmwater habitat stream, located in the Erie/Ontario Lake Plain ecoregion, receives point source discharges. Each graph in Figure 6.11 indicates various levels of attainment of each index, with the lines tracing the longitudinal profile of the index values along the stream. In this case, above the pollution sources, the stream attains its regional warmwater habitat biocriteria—40 for the IBI, 8.0 for the I_{wb}, and 36 for the ICI). Each index shows impairment below the discharges, followed by movement toward recovery. Each index responds somewhat differently.

This biological assessment framework accurately assesses the environmental health of surface waters as seen by a comparison of Ohio's use attainment conclusions (Table 6.1).

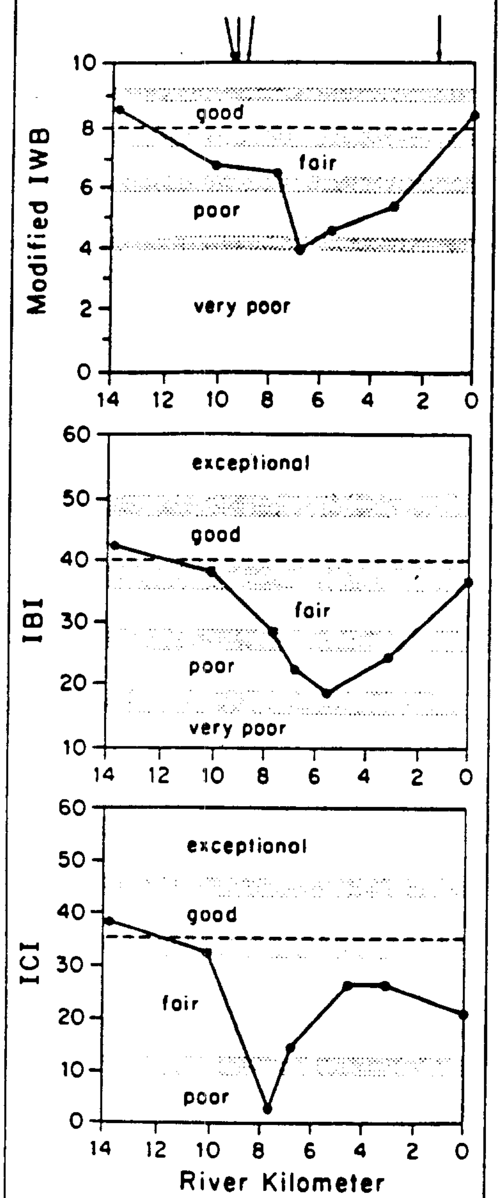
Table 6.1—Comparison of percent of stream segments attaining aquatic life uses, based on biosurvey and in-stream chemical data.

CHEMICAL ATTAINMENT	BIOSURVEY ATTAINMENT			
	FULL	PARTIAL	NON	TOTAL
Full	17	18	17	52
Partial	2	1	6	9
Non	4	6	28	39
Total	23	25	52	

Note: Rows indicate full attainment, partial attainment, or nonattainment based on in-stream water chemistry; columns indicate attainment based on biosurveys.

Source: U.S. Environ. Prot. Agency, 1989a.

Figure 6.11—The Ohio Environmental Protection Agency uses biocriteria to interpret the significance of environmental impacts. Pollution discharges are indicated by the arrows at the top of the figure; applicable biocriteria are indicated by the dashed lines.



Source: U.S. Environ. Prot. Agency, 1989a.

Conclusions drawn from Table 6.1 include

- Based on chemical data, 52 percent of the segments fully attained aquatic life uses;
- Based on biosurvey data, only 23 percent achieved full attainment;
- Both assessments agreed on full attainment in 17 percent of the cases, with overall agreement on 46 percent; and
- In 35 percent of the cases, chemical data indicated full attainment, but biosurvey data indicated partial or nonattainment. In nearly half of these cases, impairments were due to habitat, flow modifications, or siltation.

Recommended Reading

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CHAPTER 7

Erosion Prevention and Sediment Control

In considering urban runoff control during construction, erosion prevention and sediment control must be considered individually. However, for effective site control, these efforts are linked. Erosion prevention reduces the amount of sediment generated from the land. Once erosion occurs, sediment control practices are necessary to limit the downstream movement of the sediment. This chapter examines erosion prevention and sediment control and offers specific recommendations for management.

For many years, erosion and sediment control during construction has been recognized as a major component of an urban runoff management program. Local sediment control programs generally date back to the early 1970s. The USDA SCS published an excellent pamphlet entitled "Conquest of the Land through 7,000 Years" (U.S. Dep. Agric. 1978). This document discusses the fall of several civilizations as a result of poor soil stewardship.

The economic impacts of off-site sedimentation are defined by several barometers, including dredging costs for local reservoirs or shipping channels, drainage channel maintenance by local departments of public works, cost of water treatment, and the cost to remove sediments from water intake structures. Not only is the removal of sediments expensive, but the transport and final disposition may be the single most costly item of the entire maintenance operation. Depending on the land use of the watershed draining to the area where sediment is being removed, the sediments may need testing for toxicity. Consideration must be given to where the spoil material can be safely placed.

Visibility makes sediment more easily identified than other pollutants. Visually inspecting streams after a storm can easily document the problem—water, by nature, is not brown. Sediments in streams, rivers, reservoirs, and estuaries mostly result from accelerated erosion because of societal impacts. Geologic erosion does occur, but mostly in arid areas where vegetation struggles to establish itself and survive. In areas with rainfall adequate to maintain dense stands of vegetation, sediment in streams generally comes from accelerated erosion resulting from lack of effective ground cover.

Design Considerations

Erosion Prevention

Erosion prevention requires reducing the amount of land that is disturbed to decrease sediment detachment and mobilization. Urban runoff management considerations reflect a similar philosophy to that contained in the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) and National Pollutant Discharge Elimination System (NPDES) stormwater guidances. The first consideration should be pollution prevention and source reduction.

Soil should not be considered a waste product but rather a resource to be protected. Minimizing areas subject to disturbance reduces the amount of work that the more traditional structural erosion and sediment controls must accomplish. Unless the land was actively engaged in another use, the site's native vegetation prior to development probably provided more effective ground cover than any proposed vegetation.

When land is disturbed, phasing of construction projects and rapid revegetation and stabilization of exposed areas must be considered. Phasing of a project limits the area exposed at any one time. It also assists the land developer in determining how to develop the site. Too often, an entire site is disturbed and left unstabilized for a long period.

Once an area has been disturbed, the single most important erosion control practice is stabilization with the intended ground cover. When the intended ground cover cannot be immediately provided, apply a temporary ground cover such as seed and straw mulch.

Sediment Control

Even with effective, timely site stabilization, a construction site generates sediments. Sediment control functions primarily as perimeter control, although interior site controls could also reduce the work (trapping need) that perimeter controls must perform. The type of runoff that is intercepted prior to sheet or concentrated flow dictates the type of sediment controls.

In sheet flow, the initial form that overland flow takes, runoff travels at a uniform depth over the ground. Generally, sheet flow will exit from a maximum slope length of about 100 ft (30.48 m). Once flow exceeds that length, areas of concentrated flow form small rivulets and channels. Sediment control practices designed for areas of sheet flow construct barriers so that water ponds or accumulates and filters through the barriers. Straw bale dikes and silt fences, the two most commonly used sheet flow practices, are effective only when sheet flow transports sediment.

Once flow is concentrated, sediment trapping practices are the only effective way to control sediment. These controls consist of two elements: a means to convey or divert runoff such as diversion berms or swales, and the actual trapping practice. Diversion dikes or swales travel across slopes and direct sediment laden runoff into trapping devices. Designs are cited in most state and local sediment control handbooks. Trapping devices include sediment traps and basins. The two practices function identically—their main difference being the size of drainage area—relying exclusively on settling. Sediment traps are used for smaller drainage areas. Sediment basins are used for larger drainage areas and, as such, must be designed and constructed to prevent overtopping or failure. This could pose downstream safety hazards. Retention time is determined by the practice's holding capacity. Around the country, most jurisdictions use .5 in (1.27 cm) of runoff storage per acre draining to the practice. These practices hold the sediment-laden water long enough for the sediment to drop to the bottom and then discharge the runoff. The amount of holding time depends on the discharge volume (.5 in per acre) and sediment particle composition.

Sediment traps function for smaller drainage areas, generally under 5 acres (2.02 ha). Traps are simpler to design and construct, even through their storage volumes are identical to sediment basins. A failed trap generally has a minor impact.

Historical Problem Areas

While most states have sediment control laws, most laws are ineffective, weak, or for the most part ignored. An effective program requires laws that are equitable and consistently applied throughout a jurisdiction. Programs not having well-defined criteria and review and inspection procedures will not be successful. A major problem, unique to erosion and sediment control, is that control practices are temporary. Therefore, a land developer may perceive that not implementing and maintaining needed practices saves money.

That perception is not totally accurate. Accelerated soil erosion also incurs costs. Topsoil loss requires fertilizers to stabilize the final site; the loss of fill material on elevated sites, such as highway embankments, requires replacement for final site elevation—all at a cost.

Despite the economic tradeoffs, many land developers fear that implementing good site sediment control practices are an economic burden when they must compete with others who do not implement such controls. Erosion and sediment controls, uniformly mandated and enforced, would place all developers on a equal footing.

Therefore, the driving mechanism for an effective erosion and sediment control program is a clearly defined uniform law defining responsibilities and enforcement options. The law should mandate the review and approval requirements before site clearing and enforcement options if control measures are inadequate. These requirements must have a solid legal basis, as they will surely be tested.

Another problem involves public construction. Public works agencies, highway agencies, and other public construction programs are generally not required to meet the same restrictions as private construction. When included, public construction frequently does not meet acceptable levels of performance. Enforcement mechanisms such as stop work and civil or criminal penalties are not considered viable options because they lead to cost overruns financed by the public. To achieve an effective control program, all agencies must comply with the laws and regulations.

Utility construction can also cause significant problems. A sewer, electric, cable, gas, or other utility contractor may cut through diversion dikes or other controls put in place by the general contractor. In these situations, responsibility for repair can be difficult to determine.

Plan Review

Local agencies should require a plan review before construction begins. Plans must define criteria and standards before receiving final approval. On small sites, normally reviewed as a general permit, the land developer might agree to implement needed practices such as straw bales or silt fences. Larger sites, where concentrated runoff flow exists or is expected, need detailed individual reviews to ensure that adequate practices are included. Requiring a developer to have only a pollution prevention plan on site, without a detailed plan review and approval procedure, will not provide downstream resource protection.

From a staffing standpoint, the number of plans estimated per year will determine how many individuals are required for plan review. The average plan reviewer can review two to six plans a day, depending on the plan's complexity. The larger a site and the more movement of earth, the greater is the degree of review and the time required. In addition, the reviewer can expect over 50 percent of the original submissions to be incomplete or contain errors in the site control approach. This will require modifications and another review. However, this number will decrease as the program grows and developers gain experience. Each subsequent review takes time and reduces the staff's ability to tackle new projects.

The review and approval time frame is another area of confusion and controversy that limits program success. In many areas, local jurisdictions have approved development plans without requiring erosion and sediment controls—often years before projects are built. Time limits should be set for previously approved projects to be resubmitted for approval.

Inspection

Inspectors are the backbone of any erosion and sediment control program; regular inspection of construction activities is the mark of a successful program. A site review program ensures that controls are implemented and maintained. An inspector, who can normally inspect from three to five sites a day, should visit each site frequently enough to ensure adequate site control throughout construction. To ensure proper site control, Maryland and Delaware *require that active construction sites be inspected about once every two weeks.* Rarely, however, does a local program have adequate inspection staff even in states with aggressive program implementation.

Inspectors should complete and provide to the owner/developer a site inspection form that discusses site conditions, details areas requiring improvement, and establishes a time frame for corrective actions. Consistency and follow-up inspections are critical to good site control and maintenance. Failure to inspect the site for corrections at the appropriate time may cause the contractor to reduce efforts to control sediment or prevent erosion.

Implementation

The effectiveness of the initial implementation of erosion and sediment control depends on the contractor's experience and the thoroughness of the approved plans. Plans should include adequate legal authorization to stop work and apply penalties if necessary. Site conditions often call for control modifications. In highway construction, for example, controls are often based on final site conditions rather than initial runoff patterns. Since these controls may not function until the final stages of the project, interim plans and measures are needed.

Maintenance

Proper maintenance of erosion and sediment controls is often difficult. While many contractors may meet requirements to implement erosion and sediment controls, they often do not include the costs of maintaining those controls in their initial bids. Because maintenance costs reduce a contractor's profit, compliance after erosion and sediment control facilities are installed requires more aggressive enforcement.

Another problem occurs when a contractor clears an entire site for grading and development, leaving the site bare throughout construction. A better practice is to phase clearing to maintain existing ground cover until disturbance is necessary.

Filled sediment traps or basins present another maintenance problem. Material removed from periodic cleaning is often placed in an area that lacks sediment control. Inspections determine when sediment trapping devices should be cleaned and where the spoil material should be placed—generally upstream of the sediment traps.

Measuring Success

Measuring the success of any preventive program is difficult since programs are based on preventing resource degradation rather than on measurable improvements. This is particularly true in erosion and sediment control, where no practice is 100 percent effective in totally preventing adverse impacts to downstream resources. Documented case studies have shown that miles of stream reaches can be affected for years. Therefore, resource degradation should be limited to the shortest possible time frame and the shortest possible distance downstream.

Science

Many practices—such as temporary stabilization and phasing of controls—are beneficial, but actual performance data are lacking. Other practices, such as sediment trapping devices, are documented but more information is needed to adequately predict expected performance. Other controls recognized as being needed—phasing of development, vegetative practices and temporary stabilization—are qualitative in their design and performance.

Controlling erosion and sediment in arid areas is different from control in "water rich" areas, and additional research on this subject is needed. Once erosion and sediment control practices are installed, the character of sediment discharges changes dramatically. The offsite impact of these practices has not been documented.

Recommended Approach

Inadequate site control during construction can devastate downstream resources more than any action other than a release of chemicals. The extent of the devastation depends on the rainfall characteristics of a given area. Therefore, implementing a site control program is essential for an overall program to succeed.

While the adverse impacts from land developing activities is well documented, our implementation of control programs is lacking. More control programs must be developed to ensure that all construction activities, private and public, are required to implement control practices.

Erosion Control

A number of items could be established as erosion control criteria:

1. Site phasing could be used to limit the total area of bare soil that is exposed at any one time. For example, Delaware sediment and stormwater regulations permit no more than 20 acres (8 ha) of land to be cleared at a time. Once land grading is initiated on that parcel, a developer may remove stumps, roots, brush, and organic material from a second 20-acre parcel. Actual clearing or grading of that second parcel may not proceed, however, until the first parcel has been either temporarily or permanently stabilized.

   Certain types of activities require flexibility to clear land in excess of 20 acres. These activities include highway interchanges, shopping malls, and other large projects. However, the land developer should make a written request stating why the 20-acre limit causes an undue hardship.

   The selection of 20 acres as a clearing limit is arbitrary. Any reasonable limit can be used as long as the land developer considers the site's development and limits soil exposure.

2. Revegetation must be required and its time frame specified. In arid regions, revegetation requirements should be related to predevelopment geologic erosion rates or seasons.

   Since rainfall patterns vary seasonably in many areas, these variations should be considered in setting a revegetation timetable. For example, seeding could be deferred until seasonal conditions allow for vegetative growth, but mulching for temporary stabilization would be required. Mulches can include organic materials such as straw or wood fiber, stone, matting, or chemical stabilizers.

   Policies for timing revegetation also vary. Delaware selected a 14-day time frame based on its ability to inspect sites approximately every two weeks and the frequency of expected rainfall. This policy requires the land developer to pay prompt attention to stabilization once a grading operation has been completed. Also, a number of states, such as Maryland and Delaware, require temporary or permanent stabilization if an area remains exposed and no site work is planned for a period of time.

Sediment Control

Several items could be considered for sediment control:

1. While sediment control is less effective than erosion control, it still must be considered to deal with overland flow. Two common mechanisms used to remove a particle in suspension are filtration and sedimentation. Practices effective for sheet flow include filtration controls such as straw bale dikes and silt fences. Effective lengths of slope prior to the onset of concentrated flow is approximately 100 ft (30.5 m). In general, flow lengths greater than 100 ft should have sedimentation practices such as sediment traps or basins.

2. Interior and perimeter controls are important considerations for sediment controls. A number of jurisdictions will allow a reduction in sizing of perimeter controls if interior controls, such as temporary stabilization of selected areas, traps, or filtration practices, are used. However, since the effectiveness of sedimentation practices rely on detention time, undersizing perimeter sediment controls can prevent adequate functioning of the perimeter trap or basin. These practices must be designed to handle the total expected flow. One effective way to reduce their size is to divert clean water away from the disturbed areas, thereby reducing the expected flow to the control.

3. The size of control practices depends somewhat on a region's rainfall. However, most states use a simple method to compute trap or basin size—they are sized equally—based on a set amount of storage per acre of drainage entering the trap or basin. Since the early 1970s, Maryland's Soil Conservation Service has recommended a volume of 1,806 ft^3 (51.2 m^3) of storage per acre, based on a silt loam soil and a desire to reduce suspended solids by 70 percent.

   Delaware uses a size criterion of 3,600 ft^3 (102 m^3) per acre draining to a control practice. This figure provides peak control of a two-year storm for a disturbed site condition, using predevelopment considerations. It also improves the sediment trapping ability of the control practice. The 3,600 ft^3 per acre size is not considered excessive for urban runoff management regulations and has not proven controversial. Other jurisdictions, like South Carolina, use an individual approach requiring hydrological analysis of each site to achieve a specified treatment level.

   Choosing one approach over another depends on monitoring results and ease of implementation. In general, control strategies and practices should be kept simple—the more complex a program, the more potential for error.

4. When implementing erosion and sediment control, consolidate efforts to reduce total costs. Permanent runoff basins, for example, can easily function to control sediment during construction with several modifications to the outlet structure. When the construction phase is complete, follow these guidelines to ensure an appropriate transition:

   - The sediment basin should be dewatered and the accumulated material spread, stabilized, or otherwise removed from site.
   - The pond bottom should be regraded to design requirements and the outlet structure altered to meet the approved design.
   - The pond area should be stabilized with vegetation runoff. If the runoff pond is a constructed wetland, the plants should be placed after the entire construction site and pond area are stabilized to reduce turbidity and prevent excessive sedimentation within the basin or on the plant community.

Programmatic Considerations

Education

Education may be the single most important program component, especially in light of limited resources. Education should be targeted to specific audiences and prioritized, with initial efforts directed toward the regulated community such as developers and contractors.

Delaware and Maryland require contractors to send a representative to a certification program. The three-and-a-half hour program educates contractors on the need for runoff management and their responsibilities under the program. As of 1987, Maryland has certified over 10,000 individuals. Since Delaware's program began in 1991, over 2,000 individuals have been certified. These programs continue to be popular with contractors.

Educational efforts also should be directed at plan designers and plan reviewers, inspectors, and the general public. Educational programs increase the visibility of the sediment control program which, in turn, increases its acceptance by the regulated community and the general public. In a time of diminishing resources, public acceptance often translates into political support to minimize funding reductions.

Staffing

The erosion and sediment control plan should be implemented by a defined program staff. Relying on building plan reviewers and building inspectors to implement the program reduces the program's effectiveness, with the inspection and enforcement component suffering most. Delaware has implemented an innovative approach to inspection and enforcement through its Certified Construction Reviewer (CCR) program.

The state or local plan approval agency may require that the developer provide a CCR to inspect the site weekly and submit an inspection form to the developer, contractor, and the responsible inspection agency. To qualify, the CCR attends a 32-hour training course that covers such topics as water quantity and quality, soils, vegetation, site inspection procedures, and laws and regulations. Upon passing a final examination, the individual receives certification. The CCR must submit accurate, weekly reports but is not required to initiate enforcement action. The public agency must still conduct periodic inspections and initiate enforcement, but the CCR program represents a means to reduce public inspection requirements.

Consistency

A regulatory program requires consistency to be successful. Submission requirements should be based on site conditions, with basic standard items required in every case. Inspection and enforcement requirements should mandate site control implementation and maintenance. Erosion and sediment control requirements should be supported through an effective and consistent enforcement mechanism. Helpful documentation can include check lists for plan review and inspection forms for site review. Above all, a coherent policy of progressive enforcement is essential.

Consistent policy is also necessary for public agency compliance. Expect governmental agencies to resist additional regulatory requirements. A common response is compliance with the intent of the law but not with submission and approval requirements. Field implementation and maintenance of controls will be poor unless all parties agree to accept authority and commitment to implementation.

Recommended Reading

The following resources contain excellent information on erosion and sediment control processes and strategies. They will also provide assistance to jurisdictions considering establishing a design or construction handbook. Most of these documents must be purchased.

Erosion and Sediment Control Planning and Design Manual
North Carolina Department of Natural Resources and Community Development of Land Resources
Land Quality Section
P.O. Box 27687
Raleigh, NC 27611

State of Delaware, Delaware Erosion and Sediment Control Handbook, 1989
Delaware Department of Natural Resources and Environmental Control
Division of Soil and Water Conservation
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

Soil Erosion and Sediment Control Handbook
Rhode Island Resource Conservation and Development Area
5586 Post Road, Box 6
East Greenwich, RI 02818

Erosion and Sediment Control Handbook, 3rd Ed., 1992
Virginia Department of Conservation and Recreation
Division of Soil and Water Conservation
203 Governor Street, Suite 206
Richmond, VA 23219-2094

Stormwater Management Manual for the Puget Sound Basin (Technical Manual)
Department of Ecology
State of Washington
Mail Stop PV-11
Olympia, WA 98504-8711

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CHAPTER 8

Urban Runoff Treatment Practices

Urban runoff management in its broadest and most comprehensive form involves controlling both the quantity and quality of runoff. Control options are commonly called best management practices (BMPs).

Quantity control practices regulate the peak flow rate and sometimes the total volume from precipitation. Water quality control practices prevent the initial release of pollutants into urban runoff, or once they are released, reduce the quantities that enter surface or groundwaters. Completely recapturing released pollutants is impossible, and the expense increases for higher and higher levels of recapture. Prevention is more efficient and cost-effective. This chapter examines the principles of runoff quantity and quality control and details a number of treatment practices.

Control practices are categorized in a number of ways. One system is as follows:

- **Quantity control practices.** Methods of detaining runoff to regulate its rate of release to receiving waters or to infiltrate runoff into the ground so that it does not become surface flow.
- **Management practices.** Ways of doing business to prevent pollutant releases.
- **Source control practices.** Specific actions taken at potential sources to prevent pollutants from contacting precipitation or runoff.
- **Erosion and sediment control practices.** A variety of techniques used to control areas that have been bared from construction in progress or have not been revegetated after construction or other activities.
- **Treatment practices.** Facilities that remove pollutants already in runoff.

These practices are often divided into structural and nonstructural groups. Nonstructural practices mainly embrace preventive actions that do not require building anything, such as management and source control practices. Many erosion and sediment control practices are also preventive, although some—like filter fabric fences and sedimentation ponds—treat runoff containing eroded sediments and involve construction or hardware installation. While quantity control can be nonstructural (e.g., policies to retain natural soil and vegetation cover), it generally involves building a facility such as a detention pond or an infiltration device. Treatment practices are usually structural.

This chapter covers permanent structural quantity control and treatment practices. Chapter 14 provides specific criteria for inspecting these facilities after construction and periodically thereafter to determine maintenance needs. Chapter 12 covers management and source control practices. Erosion and sediment control practices are covered in Chapter 7 and their inspection in Chapter 14.

Structural quantity control and treatment practices can also be grouped in various ways, one of which is the following:

- **Storage practices**
  - Ponds—wet ponds, extended-detention dry ponds, and dry ponds
  - Vaults and tanks
  - Oil separators
- **Vegetative practices**
  - Swales
  - Filter strips
  - Wetlands—natural and constructed
  - Landscape management (i.e., urban forestry)

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- **Infiltration practices**
  - Basins
  - Trenches
  - Perforated pipes
  - French drains
  - Porous pavements
- **Filtration practices**
  - Sand filters
  - Leaf compost filters
  - Catch basin filters (various media)

The ponds, vaults, and tanks under storage practices can benefit quantity control, quality control, or both. However, dry ponds drain too quickly to provide any substantial runoff treatment. Enclosed vaults and tanks are limited in biological activity and are usually too small to function well in water quality control. Therefore, these devices are only effective for quantity control. Wetlands and all infiltration options can also supply quantity and quality control. The remaining practices are largely treatment devices.

In a number of instances, one mode of operation (storage, vegetative treatment, or infiltration) predominates but the practice incorporates other modes. For example, wetlands involve both storage of water and vegetative action. Also, most ponds infiltrate some water unless they are lined.

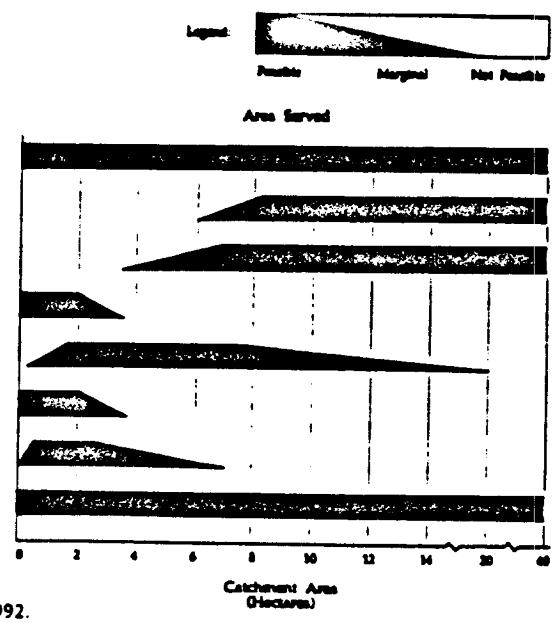
The trend is to combine the capabilities of two or more options by establishing "treatment trains" arranged in series, a strategy discussed at the end of this chapter.

Practice Selection

Success in applying any management practice initially depends on selecting the appropriate option for the site's control objectives and conditions. The objectives must be clearly delineated at the outset and conditions investigated in enough detail to match the practice to the site. Objectives might include whether quantity control, quality control, or both are to be provided; what pollutants are to be treated; and what, if any, side benefits are to be produced. Conditions that determine a practice's relevance include service area, soils, hydrogeologic conditions, and circumstances of the receiving water and nearby properties.

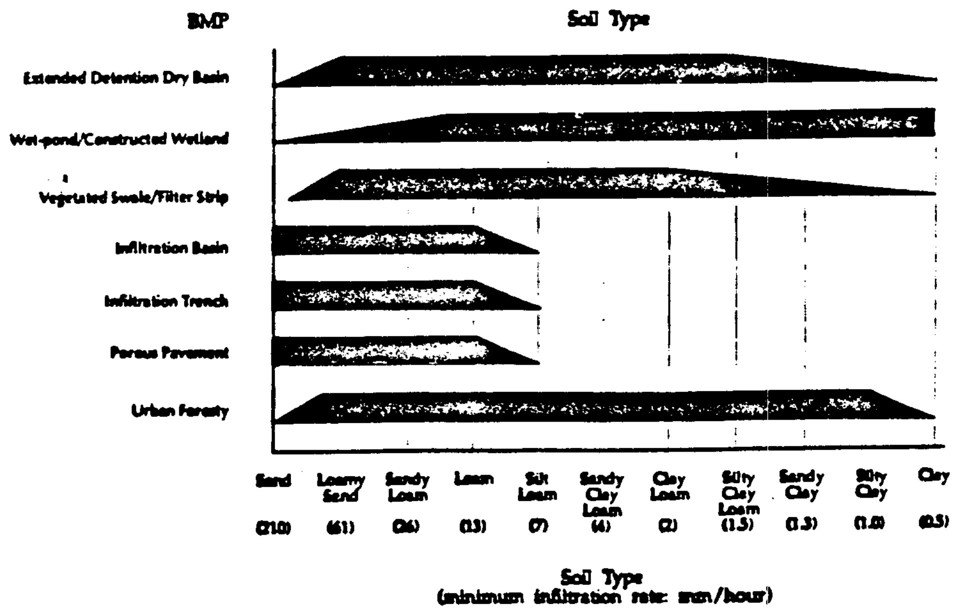
The British Columbia Research Corporation (1992) developed charts that incorporate these considerations, adapting and extending earlier work by Schueler (1987) and the Washington Department of Ecology (1992). Figures 8.1 and 8.2 and Tables 8.1 through 8.4 present these charts as aids in practice screening.

Figure 8.1—Applicability of treatment practices relative to catchment area.



Source: British Columbia Res. Corp. 1992.

Figure 8.2—Applicability of treatment practices relative to soil type.



Source: British Columbia Res. Corp. 1992.

Table 8.1—Constraints on treatment practices.

BMP	SLOPE	HIGH WATER TABLE	CLOSE TO BEDROCK	PROXIMITY TO FOUNDATIONS	SPACE CONSUMPTION	MAXIMUM DEPTH LIMITATION	HIGH SEDIMENT INPUT	THERMAL IMPACTS
Oil-water separator	●	●	■	■	●	○	○	●
Extended detention dry basin	●	●	■	●	○	●	■	●
Wet pond / Constructed wetland	●	●	■	●	○	○	■	○
Vegetated swale	■	○	■	■	●	●	○	●
Vegetated filter strip	■	■	■	■	●	●	○	●
Infiltration basin	■	○	○	■	■	○	○	●
Infiltration trench	○	○	○	○	●	○	○	●
Porous pavement	○	○	○	○	○	○	○	●
Urban forestry	●	■	●	■	●	●	●	●

● Generally not a restriction.
■ Can be overcome with careful site design.
○ May preclude the use of a BMP.

Source: British Columbia Res. Corp. 1992.

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Table 8.2—Comparative quantity control benefits provided by water quality control practices.

BMP	PEAK DISCHARGE CONTROL			VOLUME CONTROL	GROUNDWATER RECHARGE/LOW FLOW MAINTENANCE	STREAMBANK EROSION CONTROL
	2-YEAR STORM	10-YEAR STORM	100-YEAR STORM			
Oil-water separator	○	○	○	○	○	○
Extended detention dry basin	●	●	●	○	○	●
Wet pond	●	●	●	○	○	●
Constructed wetland	●	●	●	■	■	●
Vegetated swale / Filter strip / Urban forestry	■	○	○	■	■	○
Full infiltration basin	●	■	○	●	●	●
Combined infiltration-detention basin	●	●	●	●	●	●
Off-line infiltration basin	○	○	○	●	●	●
Full infiltration trench / Porous pavement	●	■	○	●	●	●

● Usually provided.
■ Sometimes provided with careful design.
○ Seldom or never provided.

Source: British Columbia Res. Corp. 1992.

Table 8.3—Potential pollutant removal effectiveness of treatment practices.

BMP	CONTAMINANT						
	SUSPENDED SOLIDS	OXYGEN DEMAND	TOTAL LEAD	TOTAL ZINC	TOTAL PHOSPHORUS	TOTAL NITROGEN	BACTERIA
Oil-water separator	○	◆	◆	◆	◆	◆	◆
Extended detention dry basin	●	■	●	■	■	○	◆
Wet pond	●	■*	●	■	■*	○*	◆
Constructed wetland	●	●*	●	●	●*	●**	◆
Vegetated swale	●	○	●	■	○	○	◆
6 meter-wide turf filter strip	○	○	○	○	○	○	◆
30 meter-wide forested filter strip	●	●	●	●	◆ ■	■	◆
Infiltration practices	●	●	●	●	●	■	●

● High potential for removal.
■ Moderate potential for removal.
○ Low potential for removal.
◆ Insufficient knowledge.
* May be subject to exports of nutrient-enriched and deoxygenated water.

Source: British Columbia Res. Corp. 1992.

Table 8.4—Potential auxiliary benefits of treatment practices.

BMP	AQUATIC HABITAT CREATION	WILDLIFE HABITAT CREATION	NO TEMPERATURE INCREASE	LANDSCAPE ENHANCEMENT & AESTHETICS	RECREATIONAL BENEFITS	PUBLIC SAFETY	COMMUNITY ACCEPTANCE
Oil-water separator	○	○	●	○	○	●	●
Extended detention dry basin	○	●	●	■	■	■	■
Wet pond	●	●	○	●	●	■	●
Constructed wetland	●	●	○	■	■	■	■
Vegetated swale	■	■	■	■	○	●	●
Vegetated filter strip	○	●	●	■	■	●	●
Infiltration basin	○	●	●	■	■	●	■
Infiltration trench	○	○	●	○	○	●	●
Porous pavement	○	○	●	○	○	●	●
Urban forestry	○	●	●	●	■	●	●

● Usually provided.
■ Sometimes provided with design modifications.
○ Seldom provided.

Source: British Columbia Res. Corp. 1992.

The recently issued California Storm Water Best Management Practice Handbooks (Camp, Dresser, McKee et al. 1993) refined the process of practice selection further with several recommendations (Municipal Handbook, Section 3), one of which was the following evaluation criteria:

- Ability to meet regulatory requirements;
- Effectiveness in pollutant reduction;
- Public acceptance;
- Ability to be implemented;
- Institutional constraints; and
- Cost.

The handbook recommends assigning a rank of 1 to 5 to each practice for each criterion. Each criterion can be weighted differently by assigning a weighting multiplier.

Principles of Runoff Quantity Control

Purpose and Goals

Controlling runoff quantities is important because, as discussed in Chapter 3, hydrologic change can produce extensive ecological impacts in small-scale aquatic systems where much valuable habitat for fish and other biota is located. The possible role of hydrologic changes in degrading valued salmon resources and recent flooding have stimulated efforts to improve quantity control programs and facilities, especially in the Pacific Northwest.

This chapter does not fully discuss design for quantity control, but it does present the key principles that should be applied. These principles are currently being integrated into some of the older runoff management manuals developed in the Northwest. New versions of manuals by Washington Department of Ecology (1992) and King County Surface Water Management Division (1990) will likely integrate these principles. Several texts present the current state of the art in some detail, including Bedient and Huber (1988), Urbonas and Stahre (1993), Wanielista (1990), and Wanielista and Yousef (1993).

The goal of quantity control in runoff system design is to maintain the predevelopment hydrograph—the maximum runoff rate, dynamics, and total volume—after a change in the watershed. This means replacing the depression and below-ground storage removed or bypassed in development. Maintaining the predevelopment hydrograph requires replacing all of the lost depression and soil storage. This is done only through extensive new infiltration opportunities or with large detention volumes that hold water while the slow processes of evaporation and infiltration operate. Matching predevelopment peak rate alone means recovering one-third to two-thirds of the lost storage. Even this less restrictive criterion generally requires much larger detention volumes than customarily demanded in existing regulations.

Analysis and Control

Effective runoff quantity control depends on substantial hydrologic analysis, only now being established. The analysis depends on

- Obtaining and properly using precipitation records for the place and time to be controlled;
- Good estimates of peak runoff flow rates and volumes of critical conditions;
- Relating water movement through and beyond the quantity control device with the effect of temporary storage in the device ("routing"); and
- Using this information to set the size of the storage volume and design the outlet structure, which controls the release rate.

The first two steps pose difficult problems. Precipitation records generally lack geographic coverage, length, frequency of recording, and accuracy. Two options to estimate peak runoff are to use models based on selected precipitation events (e.g., the 25-year frequency, 12-hour duration rainfall) or a computerized continuous simulation model.

Excluding the rational method—which is completely inadequate for this purpose—the most common event-based models are the USDA SCS' curve number method and its derivatives. These models have several liabilities, such as the arbitrariness of the selected events. Because they have no way to represent depression and soil storage of runoff, they tend to overpredict the peak runoff rate before development occurs, when the storage potential is significant. Consequently, while the objective is to match the predevelopment rate, the target is set too high. To compensate for this shortcoming, base the design on a selection of events or apply a safety factor to flow rate or storage volume size and discharge rate estimates.

Another problem with event-based models is their inability to deal with unpredictable storm dynamics. If a second storm arrives before the first one drains, the facility could overflow. To compensate for this fault, select as the basis events of longer duration and some of the less frequent, larger events. In the Pacific Northwest where winter rains are frequent and prolonged, the solution is to use a seven-day event duration, which produces larger storage facilities.

Continuous simulation models—EPA's Storm Water Management Model (SWMM) or Hydrologic Simulation Program-Fortran (HSPF)—have some important advantages over event-based models. These computer models consider such complexities as soil storage and infiltration. Given sufficient input data and proper use, they can simulate a range of conditions spanning many years—critical conditions like rain-on-snow and closely spaced storms that could cause a basin to overflow. On the other hand, these models require more and better precipitation data than are often available; additional data to represent soils, topography, and vegetation; and considerable expertise.

The Pacific Northwest is also developing "runoff files" for the HSPF model. Runoff files are unit area hydrographs for limiting precipitation conditions and site characteristics. The user merely specifies those characteristics and the location. A routing routine provides pond size and release rate.

Another Northwest strategy deals with the potential impacts of greater total volumes caused by development, even if peak rates do not increase. As pointed out previously, real volume control can result onl· ··om replacing lost depression and soil storage. However, limiting peak flow to a rate lower than before development can at least partially compensate for the additional stress on stream channels from extra volume. One possibility is to limit the two-year peak release rate after development to half of the predevelopment peak release rate associated with the two-year, 24-hour event.

Treatment Practices

Pollution Removal Mechanisms

To properly specify, design, and operate treatment practices, one needs to understand the mechanisms that can operate to prevent pollutants from entering receiving waters. Table 8.5 lists all the principal mechanisms that can capture, hold, and transform various classes of contaminants in

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urban runoff and the factors that promote the operation of each mechanism to improve water quality.

A factor to consider in the functioning of all mechanisms is time. The effectiveness of settling a solid particle is directly related to the time provided to complete sedimentation at the particle's characteristic settling velocity. Time is also a crucial variable to determine the degree that chemical and biological mechanisms operate. Characteristic rates of chemical reactions and biologically mediated processes must be recognized to obtain treatment benefits. For all of these reasons, water residence time is the most basic variable to apply effective treatment practice technology.

The information in Table 8.5 can also be arranged by features that promote specific pollutant control objectives. The following features fulfill the most common objectives:

- **Features that help achieve any objective**
  - Increasing hydraulic residence time
  - Low turbulence
  - Fine, dense herbaceous plants
  - Medium-fine textured soil
- **Features that help achieve specific objectives**
  - Phosphorus control
    - High soil exchangeable aluminum and/or iron content
    - Addition of precipitating agents
  - Nitrogen control
    - Alternating aerobic and anaerobic conditions
    - Low toxicants
    - Circumneutral pH
- **Metals control**
  - High soil organic content

Table 8.5—Summary of pollutant removal mechanisms.

MECHANISM	POLLUTANTS AFFECTED	PROMOTED BY
Physical sedimentation	Solids, BOD, pathogens; particulate COD, P, N, metals, synthetic organics	Low turbulence
Filtration	Same as sedimentation	Fine, dense herbaceous plants; constructed filters
Soil incorporation	All	Medium-fine texture
Chemical precipitation	Dissolved P, metals	High alkalinity
Adsorption	Dissolved P, metals, synthetic organics	High soil Al, Fe high soil organics (met.); circumneutral pH
Ion exchange	Dissolved metals	High soil cation exchange capacity
Oxidation	COD, petroleum hydrocarbons, synthetic organics	Aerobic conditions
Photolysis	Same as oxidation	High light
Volatilization	Volatile petroleum hydrocarbons and synthetic organics	High temperature and air movement
Biological microbial decomposition	BOD, COD, petroleum hydrocarbons, synthetic organics	High plant surface area and soil organics
Plant uptake and metabolism	P, N, metals	High plant activity and surface area
Natural die-off	Pathogens	Plant excretions
Nitrification	NH_3-N	Dissolved oxygen > 2 mg/L, low toxicants, temperature > 5-7°C, circumneutral pH
Denitrification	NO_3+NO_2-N	Anaerobic, low toxicants, temperature > 15°C

Source: R.R. Horner.

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High soil cation exchange capacity
Circumneutral pH

- **Organics control**
  Aerobic conditions
  High light
  High soil organic content
  Low toxicants
  Circumneutral pH

These features differ in what degree of control the treatment system designer and operator have over the operation. Fortunately, several features that promote all favorable mechanisms (possibly excluding the soil) are under a high degree of control. Features that promote more specific objectives require more intervention, such as developing some desired soil condition.

Sources of Detailed Information

The main treatment practices, the principles that govern their operation, and the primary design considerations are featured in a number of government manuals and other texts. These sources are valuable in planning, design, plan review, construction, and operational activities. The primary reference, however, should be the manual of the jurisdiction where the site is located. In addition to the material presented in this chapter and the listed sources, Chapter 14 includes inspection checklists and diagrams that provide details on design configurations and operations.

Storage Practices

Wet Ponds

Ponds reduce runoff pollutants by settling solids and allowing a variety of physical, chemical, and biological mechanisms to capture or transform dissolved pollutants. Settlement of fine solids and the soluble pollutant removal mechanisms all require time in quiescent or pool storage—from several days to as many as three weeks for maximum performance. Therefore, wet ponds, which have a permanent storage pool, offer substantially greater treatment advantages than ponds that dry out between storms. Unless they are lined, most ponds infiltrate some water to the soil and are often referred to as retention/detention ponds.

Figure 14.9 illustrates a typical wet pond, showing a number of the design recommendations discussed in the following paragraphs.

▮ *Sizing Calculations and Expected Performance.* Unlike in the design of wastewater treatment plants, knowledge is insufficient as yet to design runoff ponds to obtain a specific level of treatment. However, EPA's Nationwide Urban Runoff Program (NURP) included a comprehensive investigation of pond design and associated performance at 13 locations. The investigation concluded that performance could best be related statistically to the "volume ratio." This is the ratio of pool storage volume to "mean storm volume," a statistical measure expressing the runoff volume associated with the long-term average rain storm quantity (U.S. Environ. Prot. Agency, 1986).

EPA produced total suspended solids removal curves for different climatological regions. Figure 8.3, for example, shows the curve for all of the United States east of the 96th meridian, approximately along the western Minnesota border. Reductions of other pollutants were related to total suspended solids (TSS), as illustrated in Figure 8.4. Generally, a volume ratio of about 2.5 is necessary to achieve 75 percent TSS reduction, where corresponding phosphorus removal is approximately 50 percent. Each incremental increase of the ratio above 2.5 yields decreasing benefits, reflecting the fact that the pollutants easiest to capture are removed first. The results indicate that pollutants with significant amounts in dissolved forms cannot be reduced by more than 50 to 60 percent in a wet pond.

In the phosphorus example, reduction of 60 percent is approached only as the volume ratio grows toward 5. Ponds of this size generally provide two to three weeks of pool storage hydraulic residence time and consume 3 to 7 percent of the contributing catchment, depending on impervious area, slopes, rainfall characteristics, and other factors (Walker, 1987; Hartigan, 1989; Kulzer, 1989). Further improvement in phosphorus removal can be achieved in several ways, although all have practical limitations (Walker, 1987). They include

- Deepening the pond, although a practical limit of perhaps 2.5 m (about 8 ft) is imposed by the possibility that the bottom waters may become anaerobic;
- Infiltrating more water;
- Enhancing the plug-flow characteristics by design features;
- Installing certain aquatic plants, perhaps coupled with regular harvesting; or
- Chemical treatment.

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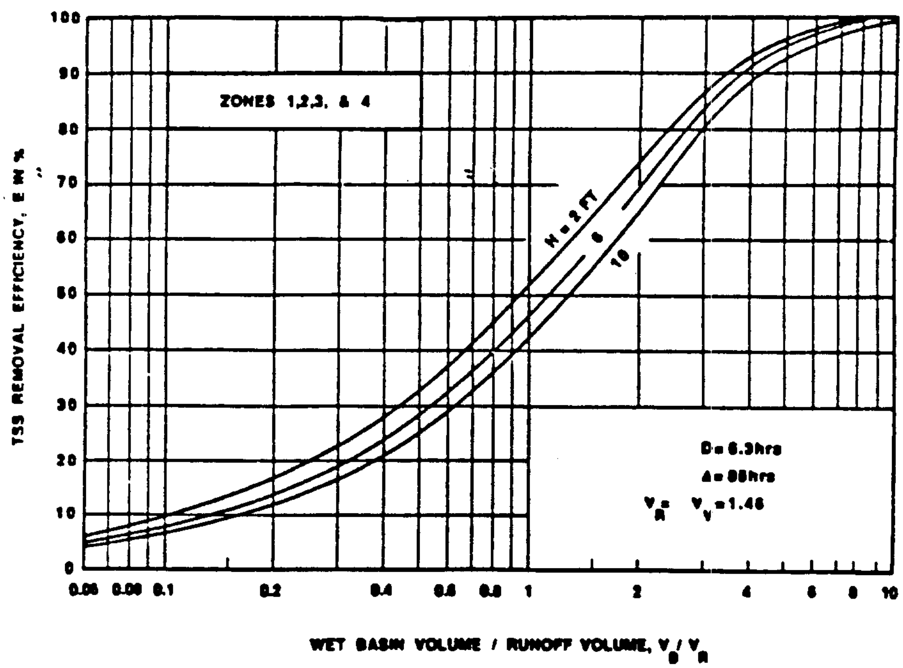
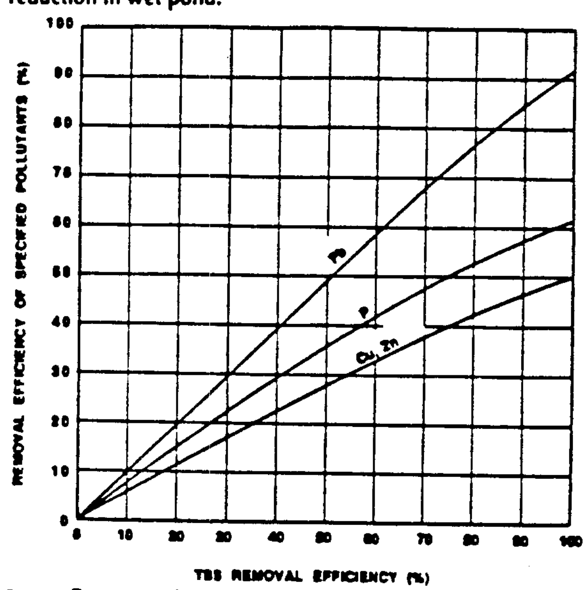
Figure 8.3—Total suspended solids (TSS) reduction curves for wet ponds in the United States east of the 96th meridian.



Source: Dorman et al. 1988.

Figure 8.4—Reductions of lead (Pb), phosphorus (P), copper (Cu), and zinc (Zn) in relation to total suspended solids (TSS) reduction in wet pond.



Source: Dorman et al. 1988.

A number of agencies have adopted the NURP pond guidelines as a design basis, including the Metropolitan Washington Council of Governments (Schueler, 1987), the Federal Highway Administration (Dorman et al. 1988), and the state of California (Camp, Dresser, McKee et al. 1993). The guidelines help set performance objectives for pollutants of interest and calculate the pool storage volume from the graph and climatological statistics for the region to reach those objectives.

Other agencies have specified either a certain runoff quantity or a precipitation event as the design basis. For example, treating the first 1 in (2.5 cm) of runoff provides treatment to most storms and total runoff volume in an average year. The Washington Department of Ecology (1992) selected the six-month, 24-hour rainfall event as the "water quality design storm." The treatment system (the pool storage in a wet pond) should provide sufficient volume to hold runoff from this storm. In Seattle, this event produces about 1.2 in (3.05 cm) of rain. With a mean rain storm of 0.48 in (1.22 cm) at this location, the NURP volume ratio is thus approximately 2.5 for any runoff coefficient.

▮ *Design Recommendations.* Better performance can be expected by enlarging the surface area to gain volume as opposed to deepening the pond. A large surface area-to-volume ratio shortens the solids' settling distance and allows better aeration and light penetration to promote biological pollutant removal mechanisms.

Other design features are also important to performance. Features that reduce the tendency of water to short circuit, which raises actual hydraulic residence times toward the theoretical values, include the following (Schueler, 1987; Horner et al. 1989; Kulzer, 1989):

- Two or more distinct cells to promote plug flow;
- Effective length-to-width ratio of at least 5:1, preferably, and at least 3:1 at a minimum;
- Inlet and outlet remote from each other or shielded by baffling;
- Low inlet velocity;
- Uniform flow distribution across the inlet pond; and
- Discharging water with minimum turbulence from mid-depth rather than near the bed or surface.

Other safety features that should be incorporated in wet pond designs include the following:

- Side slopes of at least three horizontal to one vertical;
- An emergency overflow weir stabilized to avoid erosion and possible failure during high flow;
- A shallow "safety bench" at least 10 ft (3 m) wide at the toe of the slope surrounding the perimeter;
- A buffer planted to discourage young children from approaching the pond;
- An outlet structure placed out of reach to children; and
- Fencing to protect children from any remaining dangerous areas.

Extended-Detention Dry Ponds

With insufficient time to operate dissolved pollutant removal mechanisms, sedimentation is the main means to reduce pollutants in extended-detention basins. This method is especially good for capturing solids or other contaminants connected with particulates. In fact, Kuo et al. (1988) showed that extended detention was more cost-effective compared to dry or wet ponds or infiltration. This practice can also be the best choice where water is insufficient or too unreliable to sustain a wet pond or constructed wetland.

▮ *Sizing Calculations and Expected Performance.* Like wet ponds, extended-detention dry ponds are usually sized to capture a particular fraction of the runoff. In addition, this type of pond drains within a set period when filled with the design runoff volume, typically 24 to 40 hours.

Four NURP extended-detention ponds in Washington, D.C., with detention times of four to 18 hours offered at least 70 percent TSS removals with at least six hours of detention, and long-term total phosphorus reductions ranging from 13 to 56 percent (Schueler and Helfrich, 1989). Based on these somewhat conflicting results, Schueler (1987) estimated the upper limit of possible phosphorus reduction at 40 to 50 percent after 48 hours. Others, however, view the reliable efficiency to be much lower, perhaps 20 to 33 percent (Gibb et al. 1991). Schueler et al. (1992) now appear to agree with that assessment, quoting 10 to 30 percent. Stahre and Urbonas (1990) analyzed the available estimates of long-term efficiencies for various pollutants with a 40-hour detention time, as follows:

TSS	50 to 70%
chemical oxygen demand	20 to 40%
total phosphorus and total nitrogen	10 to 20%
lead	75 to 90%
zinc	30 to 60%
hydrocarbons	50 to 70%
bacteria	50 to 90%

▮ *Design Recommendations.* Extended-detention pond performance generally benefits from the same design features as wet ponds to prevent short circuiting. Schueler (1987) recommends incorporating the removal capabilities of plants by managing part of the basin as a shallow wetland. Schueler and Helfrich (1989) suggest an extended-detention wet pond, with a relatively small permanent pool that expands temporarily.

Oil Separators

Oil separators, devices that separate dispersed oil and water, are limited to capturing free or unemulsified oil. The two basic types are the Ameri-

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can Petroleum Institute (API) separator and the coalescing plate (CP) separator. The API separator is a baffled tank that separates large volumes of free oil. The CP device separates free oil in much smaller volumes because it provides a large surface area for oil collected by the corrugated plate pack. Various spill-control devices are sometimes included in this type of treatment practice. The unit is used to catch small spills—it is not capable of separating dispersed oil. Figure 8.14 illustrates three oil separators.

API and CP separators were developed for industrial wastewater treatment. This wastewater is generally much higher in oil than most urban runoff, flow rates are more uniform, and the unit can get more operator attention. The separators are best used when discharge concentrations of oil and grease are higher than usually measured in general urban runoff. These concentrations are usually below 20 mg/L—often far below, unless an oil spill has occurred. Even the best CP separators cannot reduce concentrations below 10 mg/L, however. Therefore, these devices should be used mainly where petroleum products are handled, where vehicle traffic is heavy (e.g., trucking bases), and possibly where automobiles frequently come and go (expanding and contracting engine seals leak more oil than when engines run continuously). Otherwise, vegetated treatments can handle the usual relatively low concentrations. Spill control units should be installed anywhere slugs of oil could enter runoff, including residential areas where individual automotive maintenance is common.

▮ *Sizing Calculations and Expected Performance.* Following are procedures to size the two basic types of separators:

API SEPARATOR

1. Find oil drop rising velocity (V_p, cm/s):

$$V_p = (G/18 \cdot \mu) \cdot (d_p - d_c) D^2 \qquad [1]$$

where: μ = Dynamic viscosity of oil at coldest service temperature (use 0.015 poise at 5°C if no other information is available);

$d_p - d_c$ = Density difference between oil and water (use 0.1 g/cc if no other information is available);

D = Oil drop diameter (use 0.006 cm if no other information is available).

Convert V_p to ft/s by dividing by 30.48 cm/ft.

2. Find depth (d, ft):

$$d = (60 \cdot Q/2 \cdot V_h)^{0.5} \qquad [2]$$

where: Q = Design flow rate (cfs);

V_h = Horizontal velocity (3 ft/min or 15 times V_p, whichever is smaller; 0.5 ft/min is recommended if no other information is available).

Recommended range = 2 to 8 ft.

3. Set width in the range 2 to 3.33 times the depth.

Recommended range = 4 to 16 ft.

4. Find length (L, ft):

$$L = (d/V_p) \cdot V_h \qquad [3]$$

where: V_p = 0.033 ft/min is recommended if no other information is available.

5. Set baffle height-to-depth ratios at 0.85 for top baffles and 0.2 for bottom baffles.

CP SEPARATOR

1. Find V_p as above.
2. Find effective separation area = Q/V_p.
3. Select a unit from a manufacturer's catalog that provides at least the needed effective separation area.

A CP separator is theoretically capable of capturing free oil droplets down to 5 µm in diameter, although that performance requires a large unit. In contrast, the API type is practically limited to removing drops with diameters no smaller than 150 µm. How each reduces concentration depends on oil characteristics. CP separators can generally produce an effluent in runoff having no more than 10 mg/L oil and grease.

▮ *Design Recommendations.* A CP separator is marketed both with plates horizontal and at an angle. Angled plates are less prone to clogging by solids. The normal placement is 45 to 60 degrees from horizontal. Plates should be closely spaced to minimize oil rise distance without confining the flow so much as to raise velocity to a high level and create excessive turbulence; 3/4 in (1.90 cm) is a common spacing. Specific recommendations to improve success with API and CP units are the following:

- Exclude runoff from roofs and other areas not likely to contain oil;
- Place any pump being used downstream so as to prevent mechanical emulsification;

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- Avoid detergent use upstream to prevent chemical emulsification;
- Provide a forebay sized at 20 ft^2 (1.86 m^2) of surface area per 10,000 ft^2 (929.0 m^2) of drainage area; and
- Provide an afterbay in which to place absorbents.

Vegetative Practices

Swales and Filter Strips

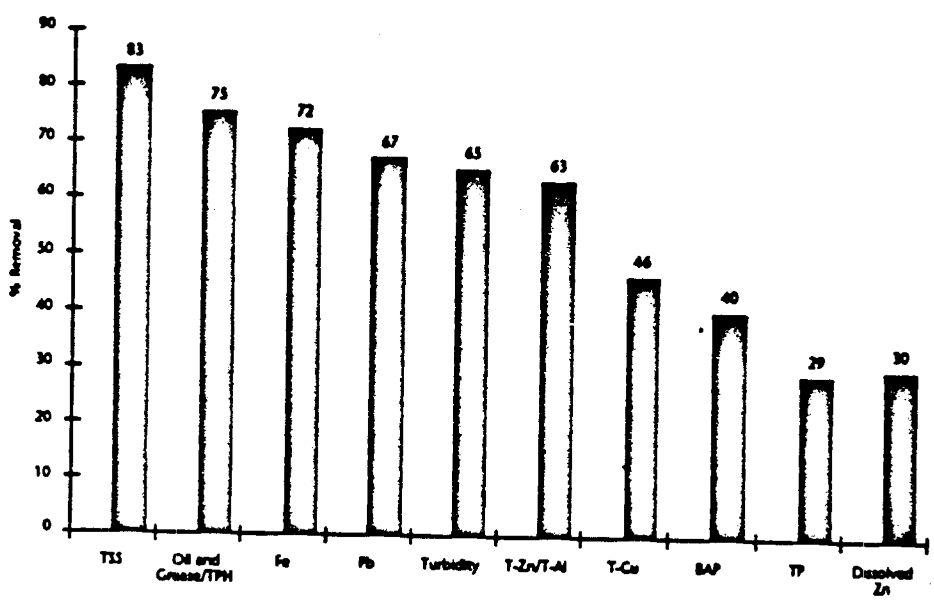
Treatment practices that use terrestrial grasses and other fine herbaceous plants are sometimes called biofiltration. These plants can be installed in a channel in which water flows at some depth—a swale—or on a broad surface area that has sheet flow—a filter strip. Biofilters can also have wetland plants in areas with the hydrology to sustain them.

A vegetated treatment strives for a plant stand that serves as a good filter. Ideal characteristics are dense, uniform growth of fine-stemmed plants tolerant of the area's water and climatological, soil, and pest conditions. Native plants generally combine the best properties. Plants serve mainly as filters; pollutant uptake is not a very important removal mechanism. Therefore, a number of species and mixes appropriate to the area will work equally well.

■ *Sizing Calculations and Expected Performance.* The results of a performance investigation of a grass swale, recently completed in the Puget Sound area of Washington (Municipality Metro. Seattle, 1992), refined a previously developed design procedure and recommended design features consistent with good performance. The report details the full design procedure, criteria, and guidelines that are excerpted here.

Figure 8.5, which summarizes the performance results, shows that the swale was relatively effective in capturing solids, oils, and the least soluble metals. The swale was less effective for more soluble metals, especially their dissolved fractions, and less yet for phosphorus. Nitrogen (not shown) exhibited little if any removal; fecal coliform's capture was inconsistent. Therefore, biofilters should generally be considered the sole

Figure 8.5—Average pollutant removal over six storms in a grass swale with an average hydraulic residence time of nine minutes.



TPH = total petroleum hydrocarbons
T = total
BAP = biologically available phosphorus

Source: Municipality of Metro. Seattle, 1992.

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treatment only to reduce solids and oil. In fact, they are a better choice than oil separators to remove low concentrations of oil and grease from urban runoff. Vegetation can reduce concentrations to even lower levels, while no feasible separator can decrease them below 10 mg/L. The vegetation option is also much cheaper. One theory suggests that biofilters reduce nutrients considerably better if growth is carefully mowed and removed before it dies and releases phosphorus and nitrogen; however, that hypothesis is unproven.

The design procedure uses Manning's equation of open channel flow to obtain a swale width for a given flow and slope and selected water depth. The velocity resulting in this size channel is then compared to a criterion, and the length is calculated using a hydraulic residence time criterion. A key study result is that a residence time of nine minutes is needed to achieve the highest and most reliable performance. Performance began to deteriorate noticeably when residence time fell below five minutes, recommended as the absolute minimum. A filter strip design is handled in the same general way but with a more shallow flow depth. Steps are as follows:

1. Determine the design flow rate (Q, cfs) by appropriate hydrologic analysis. Use as a basis continuous simulation with a computer model, a design rainfall event (e.g., six-month, 24-hour storm), or a set fraction of total runoff (e.g., first inch).

2. Determine slope (s, ft/ft) and select vegetation, design vegetation height, and shape if a swale. Normally, swales are parabolic or trapezoidal to avoid erosion in sharp corners of rectangular or V shapes. The trapezoidal shape is easier to construct and will tend to assume a parabolic shape over time.

3. Set design flow depth (y, ft). A grass swale's depth should not exceed one-third of the grass height in infrequently mowed swales, or one-half of the grass height in regularly mowed swales, up to a maximum of 3 in (7.62 cm). In swales with wetlands vegetation, the depth should be at least 2 in (5.08 cm) below the height of the shortest species. A filter strip's depth should be no more than 0.5 in (1.27 cm).

4. Solve Manning's equation for the width, using the conditions established in steps 1 through 3.

$$Q = 1.49 \cdot A \cdot R^{0.67} \cdot s^{0.5}/n \quad [4]$$

where: A = cross-sectional area (ft^2);
R = Hydraulic radius (ft) = A/wetted perimeter;
n = Manning's roughness coefficient.

The Puget Sound study used experiments to determine a value of n for flow below the full height of a local common grass mix. The recommended values are, unless other information is available, 0.20 in (0.5 cm) for grass biofilters to be mowed regularly and those with herbaceous wetland plants and 0.24 in (0.6 cm) for infrequently mowed swales.

Solutions of Manning's equation for two configurations follow:

TRAPEZOIDAL SWALE

$$b = Q \cdot (n/1.49) \cdot y^{1.67} \cdot s^{0.5} - Z \cdot y \quad [5]$$

$$T = b + 2 \cdot y \cdot Z \quad [6]$$

FILTER STRIP

$$T = Q \cdot (n/1.49) \cdot y^{1.67} \cdot s^{0.5} \quad [7]$$

where: T = Top width (ft);
b = Bottom width (ft);
Z = Side slope (ft/ft; should be no steeper than 3 horizontal to 1 vertical).

The bottom width of a swale should be no less than 2 ft (0.61 m) if it will be mowed and no more than 8 ft (2.44 m), unless it will be hand finished to get a completely level bottom. If b does not fit into this range, investigate how Q can be reduced by splitting flow, or set b = 8 ft (2.44 m) and proceed with the analysis, or specify hand finishing.

5. Compute A for the configuration:

TRAPEZOIDAL SWALE

$$A = b \cdot y + Z \cdot y^2 \quad [8]$$

FILTER STRIP

$$A = T \cdot y \quad [9]$$

6. Find flow velocity (V, ft/s): V = Q/A. If V is greater than 0.9 ft/s, which will knock over most grass and reduce settling of finer particles, investigate how Q can be reduced, or change the width and/or depth.

7. Compute length (L, ft):

$$L = V \cdot t \cdot 60 \text{ s/min} \quad [10]$$

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where: t = Hydraulic residence time (min); t should be at least nine min, preferably, and no less than five min.

For swales, L should be at least 100 ft (30.38 m), a length below which flow short circuiting is more likely. If the length in a straight configuration cannot be fit to the site, investigate using a wide-radius curved path, reducing Q or changing the width and/or depth.

8. If flows larger than Q can enter the biofilter, the grass probably will be knocked over and provide no treatment until it becomes upright again. Therefore, flow regulation upstream or a bypass are recommended. If one of these measures is not provided, the velocity and depth with the largest flow rate must be calculated. If the velocity is above a level known to be erosive, the facility must be enlarged to accommodate it (use 3 ft/s maximum, if other information is lacking). The calculation procedure is standard and covered in open channel discussions in fluid mechanics texts, as well as in the previously cited report.

9. If the biofilter is a swale, once the maximum possible depth of flow is established, specify the swale's final depth. It should be at least 6 in (15.24 cm) deeper than the maximum possible flow depth.

Design Recommendations. The following features maximize the success in establishing biofilters and in their performance:

- Locate the biofilter away from building and tree shadows to avoid poor plant growth from lack of sunlight.
- If the longitudinal slope is less than 2 percent or the water table can reach the root zone of vegetation, plant water-resistant vegetation to survive standing water or install an underdrain system to assist drainage. However, underdrains may not be practical with a large filter strip.
- If the longitudinal slope is in the 4 to 6 percent range, provide check dams approximately every 50 to 100 ft (15.24 to 30.48 m) to reduce velocity. However, check dams may not be practical on a larger filter strip.
- If the slope on which a swale is installed exceeds 6 percent, place swale to traverse the slope so that no slopes reach more than 4 percent, or 6 percent with check dams.
- Make the lateral slope entirely uniform to avoid any tendency for the flow to channelize.
- Introduce the flow so that entrance velocity is dissipated quickly, flow is distributed uniformly, and erosion is avoided (e.g., by using a riprap pad or some means of level spreading).

Natural Wetlands

Wetlands naturally regulate both water quality and quantity. In recent years, natural wetlands have been used for both purposes, sometimes with engineering changes such as modified inflow and outlet structures. This practice has been legally uncertain, since wetlands are classified as "waters of the United States" under the Clean Water Act (CWA). Using such waters to transport and treat waste is generally prohibited. However, some interpretations of the CWA allow the practice under limited circumstances. EPA's policy is not to use natural wetlands to treat urban runoff. Of course, wetlands treat water by default when they happen to receive runoff from an urbanized watershed.

Therefore, some attention has been paid to managing wetlands receiving urban runoff to learn how negative impacts can be avoided or minimized. The Puget Sound Wetlands and Stormwater Management Research Program is a long-term (1986-1996) comprehensive effort to follow ecological developments in wetlands through the urbanization process and learn what causes degradation and how it might be avoided. The program has produced preliminary management guidelines (King County Resour. Plann. Sec. 1993), with continued refinement as more information becomes available. The following summary excerpts key guideline provisions. Specifics pertain to freshwater-palustrine wetlands in the Pacific Northwest, but these limits would likely be appropriate in similar communities.

Management Guidelines. Hallmarks are to

- Manage on a watershed or subbasin scale and context, so that the values of all water resources are considered and all alternatives for solving water quality and quantity problems are evaluated.
- Emphasize practices, such as source controls, that prevent the development of problems. Back up those approaches with measures that reduce the effects of problems before wetlands or other water

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resources are involved, such as pretreatments.

The guidelines are presented here as an example of a state strategy for managing wetlands. The guidelines, consistent with legal interpretations made by EPA Region 10 and the Washington Department of Ecology, state the conditions under which natural wetlands can be used for improving runoff quality:

- Situations must be analyzed case by case;
- Restoration or enhancement of a previously degraded wetland is warranted, and other wetland functions can be upgraded along with benefiting runoff water quality;
- Source control and treatment practices are applied in accordance with specific guideline recommendations, and any prevailing water quality standards are met; and
- The wetland is not one of certain rare or otherwise valuable types—estuarine, forested, peatland, or otherwise designated by recognized heritage and preservation programs—and does not provide habitat for rare, threatened, or endangered species.

The law is even less clear about the status of wetlands proposed for use only for runoff storage or incidentally affected by urban runoff. Of course, since all runoff contains contaminants, any distinction is artificial. Still, potential hydrologic effects are distinct from water quality impacts. In fact, the Puget Sound research has found that hydrologic change has more implications than water quality for wetland ecosystems where runoff is relatively low in pollutants. This program has devoted considerable effort to quantifying these hydrologic impacts—keying especially on plant and amphibian communities—and devising guidelines to overcome them. The following hydrologic guidelines specify limits on the wetland's hydroperiod—the depth (stage), frequency, duration, and pattern of inundation.

1. Depth limits—all wetlands, all year

Limit postdevelopment increase in annual maximum depth to 11.81 in (30 cm) (for 1.01-to-100-year return interval rainfall events).

Limit postdevelopment average monthly water level fluctuation (WLF) to

- An increase of 1.97 in (5 cm) if predevelopment WLF is greater than or equal to 5.9 in (15 cm);
- A maximum of 7.9 in (20 cm) if predevelopment WLF is less than 5.9 in (15 cm).

Note: WLF = Maximum depth – average depth in a time period.

2. Frequency and duration limits

These guidelines envision a fluctuating stage over time before development that could fluctuate more, both higher and lower; after development, these greater fluctuations are called "excursions." The guidelines set limits on the amount of the excursions and the total time, over one or more episodes, that can occur in a given period.

All wetlands—February 1 – May 31

- Limit postdevelopment stage excursions of up to 3.14 in (8 cm) above the predevelopment stage to a total duration of 24 hours in any 30-day period.

All wetlands—June 1 – September 30

- Limit postdevelopment stage excursions above or below the predevelopment stage to no more than 11.81 in (30 cm).
- Limit postdevelopment stage excursions of up to 5.9 in (15 cm) above or below the predevelopment stage to a total duration of 72 hours in any 30-day period.
- Limit postdevelopment increase or decrease in dry period—when pools dry down to the soil surface everywhere in the wetland—to two weeks.

Peat wetlands—bogs and fens (as more specifically defined by the Washington Department of Ecology)

- Limit postdevelopment stage excursions above the predevelopment stage of any amount to no more than once a year.
- Limit postdevelopment stage excursions of up to 5.9 in (15 cm) above or below the predevelopment stage to a total duration of 24 hours.

Forested wetlands and zones—wetlands or zones with at least 30 percent cover of trees at least 20 ft (6.1 m) tall

- Limit postdevelopment stage excursions of up to 7.9 in (20 cm) above the predevelopment stage to a total duration of 48 hours in any seven-day

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period during March 1 to May 31 and to 96 hours over the full growing season, March 1 to August 31.

- Avoid sediment accumulation of more than 7.9 in (20 cm) in any year.

Sedge meadows—wetlands or zones with at least 20 percent cover by *Carex, Eleocharis, Scirpus*, and/or *Dilichium*

- Avoid sediment accumulation of more than 5.9 in (15 cm) in any year.

These guidelines are fairly complex to apply. Establishing predevelopment conditions requires either monitoring water levels or accurate hydrologic modeling. Postdevelopment conditions can only be established by predictive modeling. Monitoring need not be done with continuously recording instruments; simple crest-stage and staff gages are adequate. However, a continuous simulation by computer model is almost necessary for postdevelopment analysis.

The guidelines are also difficult to observe; peak runoff rate control alone is not enough, and total runoff volumes must also be controlled to prevent hydroperiod changes in a storage basin like a wetland. As pointed out in the previous discussion of quantity control, volume control is accomplished only through infiltrating excess runoff produced by urban landscapes.

Constructed Wetlands

Wetlands specifically constructed to capture pollutants from runoff draining urban and agricultural areas are gaining attention as versatile treatment options. Several major works have recently covered constructed wetland treatment, including Hammer (1989), Strecker et al. (1992), Olson (1992), and Schueler (1992). Horner (1992a) assembled a short course manual incorporating findings and recommendations from these various sources. This discussion draws on these resources and should provide a concise summary of the current state of urban runoff treatment by constructed wetlands and how to proceed in developing projects.

From a legal and regulatory standpoint, constructed wetlands are designed, built, and continuously maintained to treat waste. Thus, under the CWA they are not regarded as "waters of the United States." While no regulations control water quality within, discharge is regulated in the same way as any treatment system.

This designation contrasts with wetlands built for such purposes as mitigation of wetland losses under CWA section 404 or to develop waterfowl habitat, known as "created wetlands." These systems have the same legal protections as natural wetlands, including prohibition against conveying or treating waste. They usually have multiple functions, with water quality improvement only incidental; entering water must be managed to prevent damage to intended functions. A constructed wetland also differs in purpose and legal status from a wetland restoration, which returns a degraded system with reduced acreage or functional ability to the condition preceding its degradation. If the wetland is not completely restored but one or more functions are increased, it is termed an enhanced wetland. Restored and enhanced wetlands also have the same legal protections as natural wetlands.

The principal advantages of constructed wetlands over other treatments are

- More diversity in structure, which offers potential for relatively effective control of most pollutants;
- Wider range of potential side benefits;
- Relatively low maintenance costs; and
- Wider applicability and more reliable service than infiltration.

The disadvantages of constructed wetlands include

- Larger land requirements for equivalent service than wet ponds and other systems, especially if intended to serve quantity as well as quality control purposes;
- Relatively high construction costs;
- Delayed efficiency until plants are well established;
- Uncertainty in design, construction, and operating criteria is a drawback actually plaguing competitive methods as well; and
- Public concern about nuisances that can develop with runoff constructed wetlands if care is not taken in siting, design, construction, and operation.

Sizing Calculations and Expected Performance. Strecker et al. (1992), in a full literature review of both natural and constructed wetlands to control runoff pollution, considered more than 140 papers and reports and assembled detailed information on 18 U.S. locations. Median pollu-

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tant removals in constructed wetlands were 80.5 percent for total suspended solids (TSS), 44.5 percent for ammonia-nitrogen (NH_3-N), 58.0 percent for total phosphorus (TP), 83.0 percent for lead (Pb), and 42.0 percent for zinc (Zn). Coefficients of variation (ratio of the standard deviation to the mean) for these contaminants ranged from 27.7 to 56.1 percent, showing both substantially higher and lower performance than the median levels. Pollutant reductions in constructed wetlands overall were higher than in natural ones, attributed to the specific design features and more intensive management.

Schueler (1992) recommends wetlands designs based on the overall literature. He estimates the performance of wetlands designed as he recommends as shown in Table 8.6. He considers these efficiencies to be provisional pending monitoring of the new systems.

Table 8.6—Projected long-term pollutant removal rates for wetlands constructed.

POLLUTANT	REMOVAL RATE (%)[a]
TSS	75
TP	45[b]
TN	25[c]
BOD, COD, TOC	15
Pb	75
Zn	50
FC	2 orders of magnitude

[a] Lower by an unknown amount for pocket wetlands.
[b] 65 percent in pond/marsh system.
[c] 40 percent in pond/marsh system.
Source: Schueler, 1992.

Several ways to arrange constructed wetlands, based on runoff quality and quantity control requirements, are to

- Place a runoff quantity control device on-line and a constructed wetland off-line to treat all runoff up to a certain volume;
- Construct a wetland with a permanent pool zone for treatment and a fluctuating storage zone and discharge control sized for peak runoff rate control; and
- Construct a wetland only for treatment in situations where quantity control is not required.

The first arrangement benefits from the fact that most pollutant mass loading over time is transported by runoff from the more frequent, smaller storms, and the first flush from the less frequent, larger storms. This arrangement is recommended where runoff quantity control is required because (1) the relatively shallow depths needed to maintain wetlands are somewhat inconsistent with the large storage volume needed for quantity control, and (2) large surges of water can damage the wetland.

Basic sizing decisions involve the pool storage volume (V_P), surface area, depth contouring (plus fluctuating storage volume, if runoff quantity control will be provided)—the same dimensions required in sizing a wet pond. At this point, constructed wetland technology has established no procedures to determine volume based on desired performance efficiencies and pollutant removal mechanisms. Accordingly, pool storage volume should be sized the same for wet ponds (see previous explanation).

Schueler (1992) illustrates four design concepts to configure constructed wetlands in the Mid-Atlantic area. To establish the wetland surface area (A_W), start by selecting a trial mean depth (D) from the following approximate ranges (after Schueler, 1992):

Shallow marsh	0.30-0.45 m
Pond/marsh	0.60-0.85 m
Extended-detention wetland	
permanent pool	0.25-0.30 m
extended-detention zone	1.0 m
Pocket wetland	0.15-0.40 m

Using the trial mean depth, calculate surface area by $A_W = V_P/D$.

After determining satisfactory basic dimensions, allocate depths to the different wetland zones according to the design concept. Schueler (1992) recommends the following zones to obtain diversity in structure and treatment capabilities:

Deep areas —30-180 cm deep, no emergent vegetation—forebay, micropools, deep water pools and channels
Low marsh—15-30 cm below normal pool
High marsh—0-15 cm below normal pool
Irregularly inundated zone—above normal pool

Schueler also supplies approximate depth allocations for the various zones and design concepts.

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Design Recommendations. Identify and adopt a natural wetland that performs water quality control well and use it as a reference model. Natural wetlands control water quality because of their structure. Therefore, the elements of this natural structure must be recreated in a wetlands. Natural wetlands tend to have a more complex structure than do most runoff treatment systems. This complexity allows a range of mechanisms to operate and diverse pollutants to be treated. The result is relatively high efficiencies, compared to competing alternatives. Structural complexity can be created with high marsh peninsulas and islands.

A structurally complex system is more expensive and difficult to construct than a simple one. In some cases, we may need to dispense with a few features of an ideal system. In addition, a complex design may not be faithfully constructed. Therefore, design personnel should be in the field to interpret the design and guide construction.

A constructed wetland must have enough time to develop before it is put in full service. Attempts to short-circuit ecological processes by over-management will probably fail.

1. Site Selection

Evaluate a prospective site carefully before making a selection. Table 8.7 summarizes the major considerations that should be analyzed. While an analysis requires gathering significant data, it is essential.

A viable constructed wetlands depends on an adequate and steady water supply. A water budget should be carefully constructed to ensure that water is available and inputs at least balance outputs throughout the year:

$$I + P + D + S > O + E + R \qquad [11]$$

where:
- I = Surface inflow;
- P = Precipitation;
- D = Groundwater discharge;
- S = Wetland storage at beginning of calculation period;
- O = Surface outflow;
- E = Evapotranspiration; and
- R = Groundwater recharge.

(All units are in terms of volume or water depth over the wetland surface.)

Table 8.7—Considerations in selecting constructed wetlands sites.

CATEGORY	CONSIDERATIONS
Land use and general	Land availability Existing site use and value Site problems (e.g., previous dumping, utility lines) Adjacent land use and value Connection to wildlife corridors and potential for adjacent areas to be biological donors Public opinion Accessibility for construction and maintenance Ability to control public access according to project objectives
Environmental and regulatory	Federal, state, and local laws and regulations Avoidance of archaelogical and cultural resources Avoidance of critical wildlife habitat areas
Hydrology and water quality	Water supply reliability Low potential for disruptive flooding Water supply of adequate quality to sustain biota Low potential for adverse effects on downstream waterbodies and adjacent properties and their water supplies Need for lining to retain water or avoid groundwater contamination
Geology	Flat or gently sloped topography Adequate soil development Sufficient depth to bedrock Soil characteristics consistent with pollution control objectives Suitability of site materials for construction

Source: R.R. Horner.

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Estimate the water budget during site selection and check it after the preliminary design. In areas with pronounced seasonal drought (e.g., most of the western United States), calculate the balance for the dry period. Groundwater terms are difficult to establish, but a hydrogeologist familiar with the location should estimate them as closely as possible. Since natural wetlands often dry below the soil surface, permanent standing water is not necessarily needed to have a viable wetland. Washington State research has found that plant community richness declines substantially when drying extends longer than two months, compared to wetlands with shorter dry periods (Azous, 1991). Hence, the water balance should at least confirm that drying will not exceed two months.

2. Vegetation

Experience with wetlands creation, restoration, and construction projects shows that the plant community develops best when the soils harbor substantial vegetative roots, rhizomes, and seed banks. Development is enhanced when volunteer vegetation can enter from nearby donor sites. However, volunteers cannot be relied upon completely and should be supplemented by transplanting. While vigorous resident and volunteer stock may provide most of the vegetation, transplanting is still a wise strategy, as confirmed by most of the literature.

Hydric soils that contain vegetative plant material used to establish new wetlands are called wetland mulch. Ample use of this mulch enhances diversity and speeds plant establishment, but its content is somewhat unpredictable and donor sites are limited. Also, guidelines for extracting, handling, and storing the material are limited. In addition, exotic, opportunistic species might overtake more desirable natives—watch for this problem when obtaining material.

Potential donor sites include wetland soils removed during maintenance of highway ditches, swales, sedimentation ponds, retention/detention ponds, and clogged infiltration basins; during dredging; or from natural wetlands scheduled to be filled under permit—although these soils are best used for mitigating the loss. The upper 5.9 in (15 cm) of donor soils are best obtained at the end of the growing season and should be kept moist until installation. Establishing repositories for mulch reclaimed in maintenance operations is being explored. Despite the potential of wetland mulch and volunteer recruitment, transplanting is still the most reliable method and provides instant partial cover.

Wetland plant nurseries have sprung up recently in many places in the nation to provide material. The following list of general selection principles was compiled from Garbisch's (1986) recommendations for creating wetlands and from the comprehensive constructed wetlands literature:

- Base selections more on the prospects for success than on specific pollutant uptake capabilities. Plant uptake is an important mechanism only for nutrients, much of which are released upon the plants' death; nutrient removal is more the result of chemical and microbial processes than of plant uptake.
- Select native species; avoid natives that invade vigorously.
- Use a minimum of species adaptable to the various elevation zones; diversification will occur naturally.
- Select mostly perennial species; give priority to those that establish rapidly.
- Select species that are adaptable to the broadest ranges of depth, frequency, and duration of inundation (hydroperiod).
- Match the environmental requirements of plant selections to site conditions. Consider especially hydroperiod and light requirements.
- Give priority to species used successfully in constructed wetlands and commercially available species.
- Avoid specifying only species foraged by wildlife expected to use the site.
- Establish woody species to follow herbaceous species.
- Plant to achieve objectives other than pollution control.

Although selection based on pollution control capabilities is not recommended, considerable information on pollution control has been compiled. Kulzer's (1990) summary of plant capabilities for pollutant removal suggests that the most versatile genera, with species throughout the country, are *Carex*, *Scirpus*, *Juncus*, *Lemna*, and *Typha*.

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Specific guidance for constructing wetlands is contained in Schueler (1992) and for creating wetlands in Garbisch (1986). The course manual by Horner (1992a) also incorporates this guidance on constructed wetlands.

3. Design Features

While size alone does not guarantee good performance, adequate size is necessary. If the layout permits water to traverse the wetland too fast, the theoretical hydraulic residence provided by the volume will not be achieved. The following features will help keep the flow from short circuiting the wetland.

Shape and configuration

- Create at least two distinct cells by restricting the flow to a narrow passageway between high marsh features.
- Make the wetland relatively wide at the inlet to help distribute the flow.
- Maximize the distance between the inlet and outlet.
- The effective length-to-width ratio should preferably be 5:1, and 3:1 at a minimum.
- The longitudinal slope—parallel to the flow path—should be less than 1 percent.
- The wetland should be carefully constructed to have no lateral slope—perpendicular to the flow path—to avoid concentrating the flow in preferred channels, which reduces actual residence time and risks erosion.
- Side slopes should be gradual (e.g., 5:1 to 12:1, horizontal to vertical) as in natural wetlands. In no place should the side slope be greater than 3:1.

Forebay

- Specify a relatively deep (3.93 to 5.9 ft/ 1.2 to 1.8 m) zone placed where influent water discharges. This forebay traps coarse sediments, reduces incoming velocity, and helps to distribute runoff evenly over the marsh. The forebay should be a separate cell set aside by high marsh features.
- Provide maintenance access for heavy equipment (14.76 ft/4.5 m wide and maximum 5:1 slope) directly to the forebay. The forebay bed should be hardened to prevent disturbance during clean out.

Flow channeling

- Create sheet flow to the maximum extent possible.
- Where flow must be channeled, use multiple, meandering channels rather than a single straight one.
- Open water areas should be interspersed with marsh rather than connected along the flow path.
- Minimize velocity in channels to prevent erosion.

Outlet area

- Place a micropool 3.93 to 5.9 ft (1.2 to 1.8 m) deep at the outlet.
- Install a reverse-sloped pipe 11.81 in (30 cm) below the permanent pool elevation. This outlet design avoids the clogging characteristic of constructed wetlands (Schueler, 1992).
- Install a drain capable of dewatering the wetland in 24 hours to allow for maintenance. Control the drain with a lockable, adjustable gate valve. Place an upward-facing inverted elbow on the end of the drain to extend above the bottom sediments.

Soils

- Medium-fine textures—such as loams and silt loams—work best to establish plants, capture pollutants, retain surface water, and permit groundwater discharge.
- Circumneutral pH (approximately 6 to 8) works best to support microorganisms, insects, and other aquatic animals.
- A relatively high content of highly decomposed organics (muck) is favorable for plant and microorganism growth and metal and organic pollutant adsorption. Muck soils are better than peats (less decomposed organics), which produce somewhat acidic conditions, are low in plant nutrients, and offer plants relatively poor anchoring support.
- Vegetation becomes established more quickly and effectively in constructed wetlands when soils contain seed banks or rhizomes of obligate and facultative wetland plants. Obtain soils that offer these resources.

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- Soil characteristics recommended for specific pollution control objectives are
  - *Control of metals*—high cation exchange capacity; and
  - *Control of phosphorus*— high exchangeable aluminum and/or iron.

Liner

- An impermeable liner is required when infiltration is too rapid to sustain permanent soil saturation, when there is a substantial potential of groundwater being contaminated by percolating runoff, or both. Infiltration losses are small at most sites with USDA SCS class B, C, and D soils. Also, sediment deposition is likely to seal the bottoms of constructed wetlands. Therefore, a liner will likely be needed only in class A soils.

Emergency spillway

- An emergency spillway is required when the wetland will be used for runoff quantity control and for any other situation in which runoff might enter from a larger storm than the largest storm the facility is sized to handle.

Buffer

- A buffer should be provided around the wetland both to separate the treatment area and the human community and, if wildlife habitat is an objective, to reduce the animals' exposure to light, humans, pets, and other factors.

- The minimum buffer width should be 26.25 ft (8 m), measured from the maximum water surface elevation, plus 16.4 ft (5 m) to the nearest structure.

- If possible, preserve existing forest in the buffer area. At least 75 percent of the buffer should be forested to repel geese and provide better protection and habitat.

Avoiding Problems

- Mosquitoes, a rare but potential problem, can be prevented with diverse habitats that support predatory insects. Mosquitofish (*Gambusia*) can control mosquitoes in permanent ponds, but use caution in introducing the fish in non-native areas. Check with the state fish and wildlife agency before taking any action.

- Avoid aesthetic problems by carefully establishing construction and with vegetation. The buffer and tall emergent vegetation conceal water level fluctuation, films on the water, and other factors.

- Constructed wetlands are inherently safer than deep ponds, but deep zones may still be a hazard to children. Avoid this danger by creating gradual side slopes, a shallow marsh safety bench (16.4 ft/5 m wide) where the toe of the side slope meets any deep pool, concealing outlet piping and locking access. Fencing should only be needed on the embankment above large outfalls.

- Discourage nuisance waterfowl by maintaining the buffer largely in forest (at least 75 percent) and avoiding turf grass around the wetland. Maintain a variety of depths, especially high marsh not favored by geese and mallards, and educate citizens by placing signs to discourage feeding.

- Undesirable plant monocultures can be limited through structural diversity and a range of depths, especially in shallow areas. Plant a diverse native selection shortly after constructing the wetland.

- Metals and organics in toxicant accumulations are tightly bound in sediments and do not become mobilized over long periods. However, maintenance creates the problem of spoils disposal. Spoils that pass hazardous waste tests can be safely land-applied or placed in a landfill (Schueler, 1992). Applying spoils on-site saves disposal costs.

Landscape Management

Landscape management (Schueler [1987] uses the term urban forestry) signifies such practices as preserving trees during construction, replanting trees, and landscaping helpful to urban runoff management. One aspect of landscape management, maintaining vegetated buffers adjacent to waterbodies, advances the principle of minimizing the impervious area directly connected (by "hard" drainage facilities) to receiving waters.

Areas established using landscape management techniques can produce runoff volumes 30 to 50 percent less than conventionally developed sites (Schueler, 1987). Evidence suggests that

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even low density residential development can produce runoff rivaling impervious areas when lawns replace natural vegetation and topsoil is removed close to relatively impermeable underlying layers.

The effectiveness of vegetated areas in capturing pollutants depends on the water's residence time before it enters the receiving water. Buffers and other landscape management spaces are often too small to provide the nine-minute residence time specified in the earlier discussion of biofilters, considered a minimum for water quality control. Of course, landscape management can still provide significant benefits, even without the ideal residence time.

While a riparian buffer guidance handbook by Heraty (1993) also provides recommendations for landscape management forestry programs, complete guidance is not yet available.

Infiltration Practices

Infiltration is the only structural technique that reduces both the peak runoff rates and runoff volumes from urban development. Infiltration reduces contaminants in runoff when runoff percolates in a soil column in which physical and chemical mechanisms operate. Infiltration devices that receive runoff at the surface also treat water through plant uptake and processes in surface soils. Unfortunately, these practices have the highest failure rates among all alternatives. Success requires great care in site selection, design, operation, and maintenance. Types of infiltration devices are

- Infiltration basins, also known as retention ponds;
- Infiltration trenches;
- Perforated pipes;
- French drains, also termed downspout infiltration systems; and
- Porous pavements.

An infiltration basin (see Figure 14.10) impounds water in a surface pond until it infiltrates the soil. Excess runoff discharges on the surface. An infiltration trench receives runoff in a shallow excavated trench that has been backfilled with stone to form a below-grade reservoir. Water then enters the underlying subsoil according to its infiltration rate. A perforated pipe, or underground trench, distributes runoff into the subsoil. French drains, consisting of pervious material such as gravel, disseminate inflowing water into the surrounding soil. These drains are usually used in small-scale applications, such as roof drains from homes and other small buildings. Porous pavements permit precipitation to drain through coarse-graded concrete, asphalt, or specially cast paving blocks with a pervious opening. The coarse-graded pavements can be used on roads, although they are subject to clogging; paving blocks are appropriate only for paved areas with very light or no traffic.

Recent studies and observations have documented extensive infiltration system failures. Schueler et al. (1992), in reviewing Mid-Atlantic region reports, found that 50 to 100 percent of infiltration basins had failed within five years of construction; up to 50 percent had failed almost immediately. The five-year failure rates for trenches and porous pavements were approximately 50 and 75 percent, respectively. Overwhelmingly, clogging by sediments brought in with runoff caused the failure. Microorganism growths in poorly drained soils and oils in runoff can also cause failure (Horner and Horner, 1990). This poor operating experience led Schueler et al. (1992) to advise against using infiltration basins and porous pavements and to use trenches only with careful geotechnical investigations and aggressive pretreatment protection and maintenance.

A study in Washington's Puget Sound found that successful infiltration basins were built on deep to excessively drained soils and not near seasonal high water tables or low spots in drainage catchments (Klochak, 1992; Gaus, 1993; Hilding, 1993; Jacobson, 1993). However, these basins risk groundwater contamination because metals retention was little to none in one soil type and incomplete in two others (Gaus, 1993). Most instances of poor infiltration were caused by water tables rising too near the surface. Vegetation was apparently not associated with infiltration, although plants can filter pollution, aerate soil, and improve the appearance if maintained properly.

Soil is the most critical consideration in specifying infiltration systems. Systems are generally built in the native soil; but when native soil is inappropriate, a soil system can be constructed with media like sand, peat, or a combination.

Infiltration systems normally convey most runoff directly into the soil to eventually enter the groundwater. However, an underdrain system can be installed below the infiltration system to collect water that does not percolate well through a restrictive subsoil layer. After being collected, the water can be widely distributed to increase the percolation potential. If the grade permits, it can be discharged on the surface, after being treated while passing through the upper soils. Constructed soil systems usually require underdrains. While these systems could be considered filtration practices, this guide considers them under infiltration, reserving the filtration category for units constructed in boxes and generally having a conventional surface discharge.

The most crucial issues in using infiltration devices, in addition to soil suitability, are avoiding clogging and the potential to contaminate groundwater. Infiltration facilities should be constructed in medium textured soils. They are generally unsuitable for clay because of restricted percolation and gravel and coarse sands because of the risk of groundwater contamination, unless effective pretreatment is provided. An impermeable soil layer close to the surface may need to be penetrated. If the layer is too thick, underdrains, and possibly imported soil to provide sufficient treatment depth, may be required (Entranco Eng. 1989). As a minimum measure to prevent clogging, infiltration facilities should require a pretreatment device to settle larger solids and reject runoff from eroding construction sites.

Among the various runoff treatment options, only soil infiltration systems have been reliable in removing soluble phosphorus (Minton, 1987). This result likely applies to other relatively soluble pollutants as well. Reduction depends principally on how effectively the system prevents runoff from directly entering surface water. Reduction can be complete if surface effluent is absent and percolating water cannot get to surface water through interflow in the unsaturated zone or via rapid transit of groundwater in the saturated zone. In other circumstances, dissolved pollutant reduction is incomplete but is still higher than with any other treatment method.

Expected Performance

This manual classifies performance of soil infiltration systems as follows:

- Natural soil column infiltration basins, trenches, and perforated pipes with and without underdrains;
- Underdrained systems with selected filtration media—sand and peat-sand; and
- Porous pavements.

■ *Natural Soil Systems.* In a natural system without underdrains, the system's hydrology (directness of connection with surface water) determines how much runoff is captured and how efficient the treatment. Alternative design rules for infiltration basins and their estimated runoff reductions and pollutant removals (Schueler, 1987) are to store and infiltrate either (1) 0.5 in (1.27 cm) of runoff per impervious acre contributing, (2) the runoff resulting from a 1-inch rainfall event, or (3) the two-year frequency runoff volume. Table 8.8 estimates pollutant removals.

With the first rule, Schueler estimates that 40 to 50 percent of the runoff volume would be captured in the soil over the long term. This would rise to 65 to 75 percent with the second rule, depending on the soil and the amount of impervious area (the NURP database used to make the estimates

Table 8.8—Estimated long-term pollutant removal rates (percent) for infiltration basins.

POLLUTANT	SIZED BASED ON		
	0.5-IN RUNOFF/IMPERV. ACRE	RUNOFF FROM 1-IN RAIN	2-YEAR STORM RUNOFF VOLUME
Total suspended solids	75	90	99
Total phosphorus	50-55	60-70	65-75
Total nitrogen	45-55	55-60	60-70
Metals	75-80	85-90	95-99
Biochemical oxygen demand	70	80	90
Bacteria	75	90	98

Source: Schueler, 1987.

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represents catchments with 11 to 27 percent imperviousness). The third rule would likely raise the degree of volume reduction to appropriately 90 percent. Schueler cites Maryland estimates that widespread application of the first or second rule would maintain summer baseflow levels within about 90 percent of predevelopment conditions.

In developing a management plan for phosphorus-limited Lake Sammamish, Washington, Entranco Engineers, Inc. (1989) estimated potential reduction of particulate phosphorus at 100 percent and soluble phosphorus in natural basins at 75 to 90 percent. Estimates for an underdrained system with 3 ft (0.91 m) of soil were 80 to 100 percent for total phosphorus and 50 to 85 percent for soluble phosphorus. These estimates are uncertain because backup data was lacking.

▮ *Underdrained Systems with Artificial Media.* A number of underdrained sand and peat-sand media configurations installed and tested differ in the layering of sand of various grain sizes, peat, and gravel. Meyer (1985) also proposes a layer of crushed limestone to precipitate phosphorus. Horner and Horner (1990) review design and performance considerations for a side-wall filter (in contrast to a basin draining through the bed) not yet built. These devices have only been extensively employed in Austin, Texas. Reported levels of pollutant reduction percentages were

Total suspended solids—60 to 80 percent;
Total phosphorus—20 to 90 percent, with most reports above 60 percent;
Nitrogen, soluble phosphorus—inconsistent in a sand-peat filter to 96 percent in a sand filter;
Metals—30 to 100 percent depending on metal and medium;
Chemical oxygen demand—40 to 90 percent;
Organics—inconsistent, but approximately 85 percent when operating well; and
Bacteria—40 to 100 percent.

In Bellevue, Washington, a large soil filter system draining to Lake Sammamish has recently been constructed to serve a housing development. The system—which includes pretreatment with catch basins, grass swales, oil/water separators, and detention—is expected to capture more than 99 percent of the total suspended solids, 50 to 95 percent of the phosphorus, and 90 to 95 percent of the copper in urban runoff from developed portions of the site (Diessner et al. 1991). The system's performance is now being monitored.

▮ *Porous Pavements.* Schueler (1987) distinguishes between porous pavements providing full and partial infiltration. The latter involves some type of collection system to drain surface runoff that cannot be infiltrated. Schueler estimates potential pollutant captures at 80 to 99 percent for total suspended solids, total nitrogen, chemical oxygen demand, zinc, and lead and 65 percent for phosphorus, although the actual capture would again depend on soil infiltration.

Denver's Urban Drainage and Flood Control District (1993) recommends only the modular block type of porous pavement system. The design, consisting of perforated concrete slab units underlain with gravel, is specified for use only in low traffic areas like airports, parking lanes, and driveways, and paved paths without traffic.

Site Selection, Sizing, and Design

Since all infiltration systems rely on the ability to discharge water through the soil or an equivalent artificial medium and have the same general problems, most design aspects are similar, except for media specifications for artificial systems. The following guidance is applicable to all types, with additional information on artificial media where necessary. Reference sources provide more specific detail.

▮ *Site Selection for Natural Soil Systems.* Needs differ, depending on whether the infiltration system is intended for quantity control alone or for quality and quantity control. While quantity control is best achieved with a rapid percolation rate, this rate could be too fast to provide sufficient contact with the soil for pollutant capture. If the runoff is quite contaminated, if the groundwater table is relatively close to the surface, or both, rapid percolation risks groundwater pollution. Therefore, the safest practices are to

- Specify a maximum and a minimum percolation rate to protect groundwater and attain pollutant capture objectives, or
- Require runoff pretreatment to meet water quality objectives before the pretreatment effluent is infiltrated for quantity control.

Infiltration authorities recommend the following criteria to reduce the substantial potential for failure, safeguard groundwater, and achieve the desired urban runoff management benefits:

- The bed of the infiltration facility should be at least 3 to 5 ft (0.91 to 1.52 m) from the

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seasonal high water table, bedrock, or relatively impermeable soil layer (5 ft is conservative and warranted, unless seasonal water rise is carefully determined; 3 ft is minimum).

- With any application, the percolation rate should be at least 0.3 to 0.5 in/hr (0.76 to 1.27 cm/hr); 0.5 in/hr is conservative; 0.3 in/hr is minimum.
- With any application, the soil should not have more than 30 percent clay or more than 40 percent clay and silt combined (Wash. Dep. Ecol. 1992).
- When the infiltration facility will provide all runoff treatment (except perhaps presettling of solids) and when it will drain to groundwater (i.e., there are no underdrains), the percolation rate should not be greater than 2.4 in/hr (6.10 cm/hr) (Wash. Dep. Ecol. 1992). This, and the preceding guideline, effectively makes only loams, sandy loams, and loamy sands eligible for installing water quality infiltration systems.
- The facility should not be constructed in fill material or on a slope of greater than 15 percent.
- Baseflows should not enter infiltration facilities. The contributing catchment must be relatively small, or any permanent or intermittent flows must be diverted. Schueler et al. (1992) recommends that infiltration basins serve 2 to 15 acres (0.81 to 6.06 ha) and specified catchments be no larger than 5 acres (2.02 ha) to drain to trenches (Schueler, 1987).

Infiltration basins frequently lack good data on the soils and associated hydrogeology (Klochak, 1992; Gaus, 1993; Hilding, 1993; Jacobson, 1993). Using regional soil survey data is always very risky, and specific on-site soils investigation must be performed. Since infiltration generally occurs below the preconstruction grade level, soils and hydrogeologic observations and tests must be performed at the final grade level. Even measurement at a single location within the prospective facility location can be inadequate to characterize the soil and its new percolation rate. Hence, measurements should be repeated at several points. Finally, techniques often used to establish percolation rates (e.g., single-ring infiltrometers) have been found lacking—a double-ring device is an improvement. Standard percolation tests should also be performed in excavated holes.

Sizing Calculations. Several possible bases are used to size infiltration devices. One is to select one of Schueler's (1987) sizing rules and a maximum allowable drain time. Schueler recommends a maximum of 72 hours, except for 48 hours in marginal soils. The Washington Department of Ecology (1992) adheres to the latter time. Another way is an approach based on Darcy's law, which expresses flow through a porous medium. The resulting equations for the surface area (A_s) and infiltration system volume (V_i) are

$$A_s = V_r / f_d \cdot i \cdot t \qquad [12]$$

$$V_i = \text{Inflow rate} - \text{Outflow rate} = V_r - f_d \cdot i \cdot A_s \cdot t \qquad [13]$$

where:
- V_r = Design storm runoff volume (ft^3);
- f_d = Percolation rate (ft/hour = inch/hour/12);
- i = Hydraulic gradient (ft/ft) = $(h + L)/L$;
- h = Height of water over infiltration medium when full (ft);
- L = Depth to water table or impermeable layer from infiltration medium surface (ft); and
- t = Time to drain from full condition (hour).

The design runoff volume can be established as discussed for wet ponds. With the difficulty in getting good percolation rate values, the Washington Department of Ecology (1992) recommends a conservative approach of making several on-site measurements at the infiltration medium level, adopting the minimum of those rates, and multiplying by a safety factor of 0.5. Better measuring techniques would allow dispensing with such conservatism—or at least dropping the safety factor.

Design Recommendations. The following recommendations are important to avoid past failures of infiltration systems:

- Construction runoff should never be allowed to enter an infiltration device.
- Banks and other areas must be thoroughly stabilized to prevent erosion into the device.

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- At a minimum, pretreatment should be used to capture most of the runoff solids directed to an infiltration device. A recommended arbitrary removal criterion is 80 percent of total suspended solids.

- The facility should be at least 50 ft (15.24 m) from any slope greater than 15 percent and at least 100 ft (30.48 m) upslope and 20 ft (6.1 m) downslope of any building.

- The outlet orifice design must be consistent with the infiltration capacity (e.g., to avoid collecting more water than can infiltrate in 48 hours).

- After final grading, the bed should be deeply tilled to provide a well-aerated, highly porous surface texture.

- Plant a basin with grasses appropriate for conditions, and maintain the grass for both performance and appearance.

- The guidelines for wet ponds—introduction of flow at low velocity and with uniform distribution, side slopes, the emergency overflow, and safety—also apply to infiltration basins.

- Since constructed artificial soil systems are in their infancy, the following guidelines are subject to further testing (Horner and Horner, 1990):

  - A layered media structure seems to perform best. Most common are three layers, each about 1 to 2 ft (0.30 to 0.61 m) thick, separated by filter fabric. The upper layers have generally been various textures of sand or peat-sand mixtures. A crushed limestone layer has also been used for phosphorus reduction and pH adjustment.
  - Fibric peat is preferred over sapric peat because of the latter's poor hydraulic conductivity.
  - Surround the underdrain pipe with gravel or crushed rock.

Inspection and maintenance are also important for failure-prone devices like infiltration systems. Chapter 14 provides inspection checklists and maintenance standards.

Filtration Practices

Sand Filters

Sand filter chambers, similar to those used for many years in potable water and industrial treatment, have recently been introduced in urban runoff management. They differ from those described under infiltration practices by being installed in a box and having a surface effluent, instead of being a soil amendment with an underdrain system. These units are most appropriate in less than 5-acre (2.02-ha), mostly impervious catchments.

Figure 8.6 illustrates a design (Shaver, in press) being installed in Delaware, Maryland, and Virginia that consists of a sedimentation chamber followed by a filtration chamber.

▌*Sizing Calculations and Expected Performance.* Design criteria are still under development. Shaver (in press) recommends sizing the sedimentation and filtration chambers each at 540 ft^3 (15.29 m^3) per contributing acre. He further recommends a surface area for each chamber of 360 ft^2 (33.45 m^3) per acre and a sand depth of at least 18 in (45.72 cm).

Based on monitoring of three similar systems in Austin, Texas, the following pollutant removal efficiencies percentages are expected (Shaver, in press):

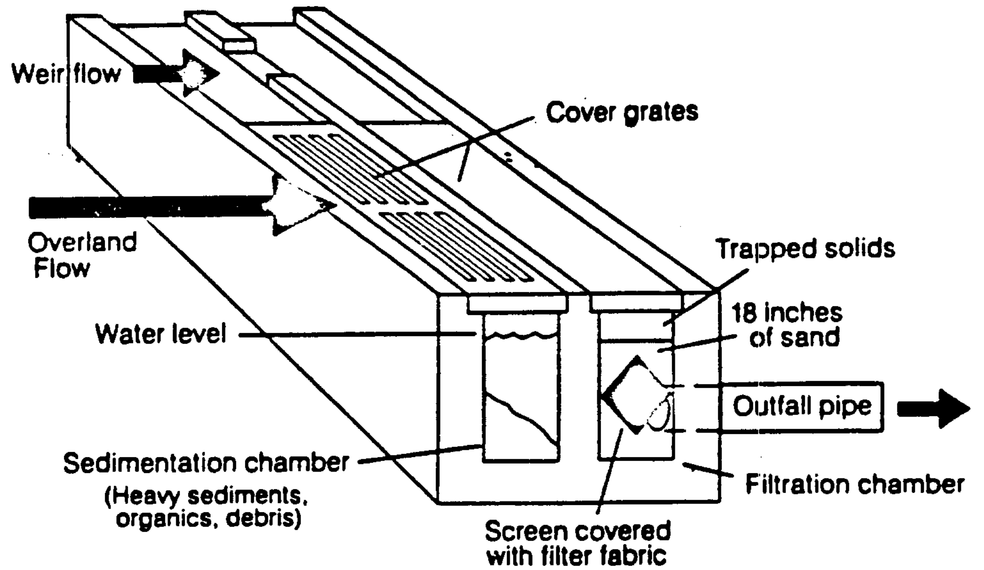
Total suspended solids	75 to 87%
Total phosphorus	19 to 61%
Total nitrogen	31 to 44%
Ammonia-nitrogen	43 to 77%
Nitrate + nitrite-nitrogen	-79 to - 5%
Lead	71 to 88%
Zinc	49 to 82%
Copper	33 to 60%
Chemical oxygen demand	45 to 68%
Fecal coliform	36 to 37%

▌*Design Recommendations.* Shaver's (in press) additional recommendations are

- Restrict the drainage area for any one filter to 5 acres (2.02 ha), which should essentially all be impervious.

- Make the outfall pipe from the sand chamber no larger than 6 in (15.24 cm) outside diameter, so that a minimum of 12 in (30.48 cm) of sand covers it. If a larger conveyance is needed, use more than one pipe.

Figure 8.6—Sand filter design.



Source: Shaver, in press.

Leaf Compost Filters

W and H Pacific (1992) has developed and tested a leaf compost filter in the Portland, Oregon, area. Monitoring 13 storms showed influent event mean concentrations to be reduced, on the average, by the following:

Total suspended solids	95%
Turbidity	84%
Chemical oxygen demand	67%
Total phosphorus	41%
Total Kjeldahl nitrogen	56%
Nitrate-nitrogen	34%
Ammonia-nitrogen	42%
Zinc	88%
Copper	67%
Total petroleum hydrocarbons	87%

Soluble phosphorus consistently increased across the filter. Work is now underway to improve the medium's anionic exchange capability (Stewart, pers. commun.). The device has not been independently tested, nor have design criteria been published.

Catch Basin Filters

Fiberglass (MacPherson, 1992) and activated carbon (Hutter, pers. commun.) filters intended for small-scale installations (e.g., catch basins) have recently been introduced on the market. Neither has been independently tested, but MacPherson reported concentration reductions of 90 percent for total suspended solids, 87 percent for lead, 77 percent for zinc, and 86 percent for copper. Specific design criteria have not been issued, but the fiberglass filter has been tested in flows up to 1 cfs, and the activated carbon filter is specified for use up to 0.13 cfs.

Series Treatment Combinations

Any treatment practices previously discussed can be combined in series arrangements, or treatment trains. This takes advantage of the capabilities of each and creates redundancy to increase the probability of capturing pollutants. The effectiveness of such systems will not be additive, however, because the first device in the series will trap the fractions easiest to remove, making subsequent reduction harder. For example, if two practices can individually capture 50 percent of a pollutant, leaving 50 percent present, the overall efficiency of a series of the two is not likely to be $0.50 + 0.50 \cdot (1 - 0.50) = 0.75$. Horner (1992b)

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proposes an equation for the performance of a series of two devices:

$$E_s = 1 - X \cdot (1 - E_1) \cdot (1 - E_2) \quad [14]$$

where: E_s = Series efficiency (fraction pollutant remaining);
X = "Penalty" representing the performance reduction in the second device because of its harder removal task ($X > 1$);
E_1 = Efficiency of first device if alone; and
E_2 = Efficiency of second device if alone.

However, information was insufficient on series studies to establish X from actual data. Using this equation and an assumed $X = 1.25$, E_s for the previous example is 0.69 (69 percent) instead of 0.75.

The literature contained four performance studies of treatment trains. In one report—phosphorus removal—Meyer (1985) describes an infiltration basin design with a sand/crushed limestone underdrain filter coupled to a constructed wetland. He expected 90 percent removal of dissolved phosphorus, but no performance data have been found. Oberts and Osgood (1991) report on a detention pond that discharges into a series of six constructed wetland chambers. The system reduced total phosphorus by 79 percent and dissolved phosphorus by 57 percent in the pond, and an additional 32 and 15 percent, respectively, in the wetland. Overall system efficiencies—77 and 48 percent, respectively—were lower than the pond alone because of flows to the wetland that did not pass through the pond. The pond was believed to be so efficient because of well-distributed inflow, low-dissolved-to-total-phosphorus ratio, and phosphorus complexation by organics.

Wulliman et al. (1989) discusses a system consisting of a pond, wetland, and infiltration basin that was planned to split detention pond effluent between the wetland and infiltration basin. Modeling predicted overall 52 to 87 percent phosphorus reduction, but performance data have yet to be reported. Holler (1990) reports on a wet pond-filter (soil, limestone, and sand) system. The average wet pond reductions of both total phosphorus and orthophosphate-phosphorus were 77 percent, while the filter yielded orthophosphate and further reduced total phosphorus by only 16 percent, for an overall system total phosphorus efficiency of 85 percent.

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CHAPTER 9

Industrial Activities Runoff Management

Several federal programs provide a basis for national urban runoff management. They are briefly summarized in the following paragraphs.

Clean Water Act

In 1972, amendments were made to the Federal Water Pollution Control Act, referred to as the Clean Water Act (CWA). These amendments prohibited the discharge of any pollutant to navigable waters from a point source, unless the discharge was authorized by a National Pollutant Discharge Elimination System (NPDES) permit. The program's initial thrust was to treat discharges of industrial process wastewater and municipal sewage. These discharges were easily identified and recognized as significant sources of receiving system degradation. With control of these discharges, attention has turned to the problems of other less visible pollution sources.

National Urban Runoff Program

From 1978 through 1983, EPA conducted a comprehensive study of urban runoff—the Nationwide Urban Runoff Program (NURP)— which provided a better understanding of the nature of urban pollutants from various urban land uses. It consisted of 28 projects conducted by local government agencies across the country under the review and coordination of EPA. NURP, a landmark effort, developed quantitative data on levels of pollutants generated from urban land uses. The study focused primarily on monitoring runoff from residential, commercial, and industrial land and clearly presents information on the magnitude and spectrum of pollutants encountered in the urban environment. The NURP study results are contained in three volumes; the executive summary (volume 1) should be required reading for individuals involved in stormwater management (U.S. Environ. Prot. Agency, 1983).

Water Quality Act of 1987

The 1987 amendments to the CWA, or the Water Quality Act of 1987, contains provisions that significantly increase efforts to address water quality in urban runoff. Section 319 created a state framework to address nonpoint source pollution not covered by NPDES permits. Section 402(p) expanded the existing NPDES program to include stormwater.

Section 402(p) lists five types of runoff discharges required to obtain a NPDES permit prior to October 1, 1992 (CFR November 16, 1990, issue):

- A discharge related to a permit issued prior to February 4, 1987;
- A discharge associated with industrial activity;
- A discharge from a municipal separate storm sewer system serving a population of 250,000 or more;
- A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000; or
- A discharge determined by the EPA administrator or a state to violate a water quality standard or significantly contribute pollutants to U.S. waters.

In addition to these activities, the 1987 CWA amendments require EPA to develop regulations governing runoff from additional sources. The five listed items are commonly called Phase 1 of the NPDES stormwater program. Additional sources will be addressed under Phase 2, which have not yet been finalized.

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November 16, 1990, Rule

On November 16, 1990, EPA issued permit application requirements for stormwater discharges associated with industrial activities. The regulations identify 11 industrial categories (EPA Region 3 Pollution Prevention Plan Development Workshop) which include

- Heavy manufacturing
- Light manufacturing
- Light industries (only through exposure of material or products to runoff)
- Recycling facilities
- Transportation facilities (vehicle maintenance, equipment cleaning, airport deicing)
- Construction projects (over 5 acres [2.023 ha] in size)
- Steam electric power generating stations
- Hazardous waste treatment, storage, and disposal facilities
- Mining/oil and gas

Design Considerations

The industrial activity category *excludes* from NPDES requirements runoff drained from areas located on industrial lands that are separate from the plant's industrial activities, such as office buildings and accompanying parking lots, *as long as that drainage is not mixed with runoff from industrial areas.* Most older industrial sites, by the nature of their drainage systems, will have mixed runoff. Industrial activity includes only runoff discharges from all areas where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to runoff.

Permit Application Requirements

To obtain an application for an NPDES permit required for industrial activities, the following information must be prepared for individual permits. Group applications or industry-specific general permits may have different requirements. Contact individual states or EPA regions for specific requirements.

- A site map indicating drainage areas served by outfalls, drainage and discharge structures, paved areas, buildings, storage areas, structural control measures to reduce pollutants, materials loading, and access areas.
- An estimate of the impervious surface area, the total area drained by each outfall, and materials treated within the last three years.
- A certification that all outfalls that should contain runoff discharges from industrial activity have been tested or evaluated for the presence of nonstormwater discharges. This can be accomplished through
  - Visual inspection of storm drain inlets and outfalls—flow observations, stains, sludges, or other unexpected conditions;
  - Review and validation of pipe locations, connections, and flow directions from available construction plans, which must be field verified;
  - Dye tests to identify flow direction, since many situations, particularly older plants where drainage systems have been gradually added or replaced, will not have accurate plans and storm drain inlets; and
  - TV line surveys where illicit connections are suspected but their sources cannot be discovered.
- Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility within the past three years.
- Quantitative data based on samples collected during storm events including
  - Total suspended solids
  - Total dissolved solids
  - COD
  - BOD_5
  - Oil and grease
  - Fecal coliform
  - Fecal streptococcus
  - pH
  - Total Kjeldahl nitrogen
  - Nitrate plus nitrite
  - Dissolved phosphorus
  - Total ammonia plus organic nitrogen
  - Total phosphorus

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Pollution Prevention Plan

A pollution prevention plan is required in EPA's stormwater general permits and has been incorporated within most state general permits. The pollution prevention concept is also appropriate for individual permits and can include efforts relating to all phases of site use. Essential components of a pollution prevention plan are as follows:

- **Reduction of pollutants at the source.** Areas that can be expected to generate waste can include
  - Vehicle or equipment fueling areas
  - Vehicle and equipment maintenance areas
  - Painting operations
  - Vehicle and equipment washing
  - Loading and unloading areas
  - Aboveground liquid storage tanks
  - Industrial waste management areas and outside manufacturing
  - Outside storage of raw materials, by-products, and others
  - Salt storage facilities

  These areas should be individually inspected and considered for actions or modifications to existing plant operation to reduce their pollutant contribution. An example of effective control of waste generation can be as simple as covering the activity so the material does not mix with rainfall and run into the storm drainage system. During an inspection, check the following items:
  - Corroded drums or drums with plugs or openings (potential to fill with rain water and overflow)
  - Corroded or damaged tanks, tank supports, and tank drains
  - Torn bags or bags exposed to rain water
  - Corroded or leaking pipes
  - Leaking or improperly closed valves and valve fittings
  - Leaking pumps and hose connections
  - Broken or cracked dikes, walls, or other physical barriers designed to prevent stormwater from reaching stored materials
  - Windblown dry chemicals
  - Improperly maintained or overloaded dry chemical conveying systems

- **Recycling.** All of the following materials may be recycled either at the industrial facility or sent off-site for recycling:
  - Spent solvents
  - Paint thinner
  - Degreasers
  - Used oil/oil filters
  - Antifreeze
  - Cleaning solutions
  - Automotive batteries
  - Hydraulic fluid

- **Treatment of runoff.** This category includes segregating the activity to prevent runoff from draining untreated into a storm drain inlet. Segregation may be accomplished by installing a berm to prevent untreated flow into a storm drain or divert the flow into a runoff control practice. A berm alone is not adequate, however, unless evaporation is greater than rainfall. Otherwise the bermed area must have an outlet structure to drain the accumulated runoff. In these situations, use visual and possibly chemical analysis to determine if a controlled release will provide for water quality protection. The specific industrial activity may require using structural water quality controls. Controls include the following:
  - Detention basins—extended detention both dry and wet
  - Infiltration practices —use caution to prevent groundwater contamination
  - Filtration practices

- **Disposal through approved method.** Use this category when other options are unavailable or impractical. For example, in an area with water quality problems, dispose of runoff through the sanitary system. However, consider these points:
  - Temporary storage of the runoff until the sanitary system can accept the flow;
  - The nature of the pollutant being discharged into the sanitary system; and
  - Whether the wastewater treatment plant can accept and treat the pollutant being discharged.

Historical Problem Areas

Episodic Nature

The episodic nature of runoff presents a unique problem in addressing water quality concerns through the historic NPDES approach. In that program, outfalls have a controlled rate of discharge so monitoring and sample analysis is consistent. Urban runoff is generated by rainfall, which is variable in volume, time, intensity, duration, and direction. The episodic nature of rainfall presents problems in considering a specific site. The existing drainage system's capacity may be limited for larger storms and may cause backed up runoff to flow into an adjacent system or to flow overland off-site. To determine the level of storm the system can accommodate, the existing conveyance system must be evaluated.

Another problem with urban runoff versus the historic NPDES program involves monitoring. Because runoff does not always occur at a convenient time, collecting the samples at the appropriate time may be difficult. Results will also depend on the dry period between storms when pollutants accumulate. The longer a dry period lasts, the greater the potential for water quality problems in the initial runoff.

Other Pollutant Sources

The problems associated with historic point source discharges are fairly well understood. Less recognized is how pollutants from urban sources affect the quality of urban runoff. Pollutants that are generated from various land uses are described in Chapter 2.

One possible major source of pollutants is atmospheric deposition from wind blown or borne particulate or materials—often from adjacent properties. Another possible means of pollution mobilization is acid rain, which mobilizes metal contacts. One of the studies referenced in the NURP final report, the study on the Jones Falls watershed in Baltimore, Maryland, documented this concern. Watershed monitoring showed elevated levels of copper, possibly from copper downspouts of most area homes mobilized by acid rain. In Alexandria, Virginia, rain gages near the Capitol Beltway demonstrated a linear relationship of high acidity from fossil fuel combustion by automobiles (Warren Bell, city engineer, personal communication). In many areas of the United States, nitrogen is a major pollutant. Excess nitrogen in rainfall contributes to elevated levels of nitrates or runoff acidity.

Another pollutant source is from specific industrial activities. One electrical generating site in Maryland currently uses fuel oil. The operation is relatively clean; however, significant coal dust covers the state from previous coal use. The runoff pH is very acidic and can mobilize available pollutants (e.g., metals).

Another significant pollution source relates to disturbed areas or areas without ground cover. Many industrial sites have large areas of bare dirt caused by neglect or high traffic volume. This dirt is transported in urban runoff. In one plant, suspended solids loading in monitored outfall was due to general site instability from a lack of effective ground cover.

Age of the System

In many older industrial sites, storm drain pipe systems are undocumented, undersized, partially crushed or rusted, have unknown gradients, or the present plant staff is unaware of the system's location. Flow drainage areas, pipe capacities, and runoff flow path that exceeds the existing pipe system can all cause water quality problems.

In addition, the slope of overland flow may not be in the same direction as pipe flow. Generally, the NPDES permit requirements do not consider the size and flow capacity of the runoff drain system in conjunction with its drainage areas and how frequent the system is bypassed by larger runoff flows. This situation may result in significant discharges at locations where flow is not expected. Situations like these need to be carefully examined for modernization.

Lack of Site Space

Many small industrial sites are surrounded by existing development that could limit structural water quality control practices. These sites may have difficulty installing structural controls. The following section considers this problem. In many industrial sites with limited space, existing storm drains flow into or across the property from adjacent industrial sites. Runoff control problems are compounded when extraneous flows with degraded water quality are considered.

Recommended Approach

Many EPA documents discuss in detail individual site analysis for pollution prevention and rank an approach for dealing with a problem, regardless

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of size of the site. The individual industry also can adopt a proactive approach with master planning. This approach involves determining the system's ability to convey runoff flows and its flow capacity. All land areas contributing urban runoff should be identified, including off-site areas draining onto the property. An accurate site elevation plan should be generated since visual inspection, often provided under the NPDES requirements, may be inaccurate.

After completing the inventory of drainage areas, identify the complete storm drain system along with pipe sizes, slopes, inverts, and inlet sizes. Gathering this information often necessitates walking the entire site, since many older sites have poor drainage system records.

The inventory should detail the existing land use, including pervious areas along with their cover conditions. Identify soils through the appropriate USDA SCS soil survey and conduct a hydrologic study, using local rainfall data, to determine the runoff rates and volumes for various storm conditions. Since storm drain systems are normally designed to handle peak runoff from a 10-year storm, consider initial storms in the 2-, 5-, and 10-year range to estimate storm drain capability.

Ideally, a geographic information system can incorporate information identified through these initial steps and future site intentions or actual modifications. This allows the plan to evolve along with site use. A GIS system is a valuable tool for any industry expanding or modifying a site, since alternative scenarios can be considered.

After delineating existing site information, consider consolidating outfalls to minimize monitoring requirements. Older sites often allow outfall consolidation with little site modification. Available analytical techniques can compute typical pollutant loadings for similar urban areas to ascertain expected pollutant types. This analysis, in addition to gaining information on potential sources of pollutant loads from the pollution prevention plan, is important if outfall water quality sampling necessitates additional structural control practices.

With the final site plan and an estimate of runoff rates, volumes, and quality at various outfall points, alternative water quality control practices can be considered, especially if monitoring data necessitates additional site control. Water quality estimates and site characteristics provide some guidance on the type of runoff practice appropriate for a specific drainage outfall. Therefore, a preliminary estimate of the type of practice for a given area and a rough estimate of the practice size can be developed and placed on the master plan.

Areal extents of possible management areas are important if future site expansion or modification is intended. Identify potential runoff management areas to reserve in case future management measures are necessary. If those areas are not reserved through the master plan, the industry may have difficulty complying with future regulatory requirements. Master site planning also assists the industry in making other land use decisions.

Programmatic Considerations

Permits

The NPDES stormwater program for most nonstorm use discharges does not necessarily fit the traditional point source compliance approach. The nationwide approach has been to rely on general permits so that permitting authorities can handle the large number of additional permits necessitated by the 1987 CWA amendments.

Issuing general permits is appropriate to initially implement the program and also can be part of municipal NPDES stormwater permits. But states should recognize that this program requires a long-term commitment. Eventually, state representatives should visit each site covered by an NPDES stormwater permit, evaluate its approach to site control, and determine if the pollution prevention plan provides adequate site control. Under permit authority and municipal stormwater regulations, industrial sites need to be visited initially by technical staff, probably an engineer, to evaluate the pollution prevention plan's technical merits. If the plan is adequate, an inspector can make follow-up site visits. These inspections should be conducted annually to ensure that control measures are a continual part of the site operation. Permitting is not the end result of the program—therefore, site monitoring is essential for program success.

Enforcement

To emphasize the program's importance to the regulated community, enforcement mechanisms must be in place and functioning. Since the NPDES program relies on issuing permits, the regulated community must recognize its responsibilities under the law. Enforcement procedures must

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be developed, circulated to the regulated industries, and implemented.

These procedures should be simply stated and have graduated, progressive enforcement. They should spell out state and federal legal authorities and enforcement options, including penalties provided by the CWA.

Staffing

The NPDES should have at least two, and ideally three, separate functions in addition to typically regulatory functions (data entry, program management, support). Functions include technical assistance and runoff strategy review, periodic inspections, and educating the regulated community about pollution prevention strategies, approaches, and practices. An understanding and awareness of the types of practices will increase industry's willingness to implement those practices. Functions vary in their staffing needs, depending on the number of industries needing NPDES permits. While many states have assigned only one staff member to implement the entire program, that is not nearly adequate to ensure proper program implementation.

Technical assistance must be provided by staff trained in runoff management and pollution prevention. Ideally, assistance should come from engineers trained to review and guide the industry in the structural and hydrologic aspects of specific designs. The engineer must know pollution prevention strategies, from source reduction and recycling to individual runoff management practices, along with their strengths and limitations. This professional should also conduct workshops for industry representatives and design consultants on effective on-site water quality control. Since the industry is not required to submit pollution prevention plans for review, an engineer or technician should visit individual sites to ensure that the plans have been adequately developed and implemented.

Once a pollution prevention plan is endorsed, an inspector can make subsequent inspections. Again, the number of inspectors is determined by the number of sites to be visited. Inspections made periodically ensure that the pollution prevention plan is implemented and the structural controls are maintained and functioning. Periodic inspections remind the industry to operate the program as long as the site is being used.

Education, a factor frequently ignored, is important to the program's success. Education ensures that everyone involved understands the program's underlying rationale and uses acceptable approaches and design standards. Education also ensures communication between industry and the regulatory agencies and reduces the we/they mindset. Education of adjacent property owners may also improve communication and awareness of pollution prevention activities that an industry is undertaking. If resources are limited, education should be the single most important function emphasized.

Example Site

Delmarva Power and Light, an industrial site in Maryland, determined that a runoff management master plan would assist its efforts to comply with NPDES requirements and in overall site development.

The site, an existing electrical generating facility called the Vienna Power Plant, covered approximately 25 acres (10.11 ha) and had eight large stormwater outfalls covered under NPDES permits. Some 8 acres (3.24 ha) of bare soil contributed dramatically to the suspended solids loading.

The site's master plan presented expected loadings for various pollutants under existing site conditions. New design plans reduced outfalls to four. The plans also recommended site stabilization and runoff management practices for the proposed outfalls, in case pollutant discharges necessitated implementing practices. Pollutant loadings with runoff management practices were also developed so that the site owners could understand the expectations of water quality control versus existing conditions. Table 9.1 demonstrates the results.

Total output of sediments is estimated at approximately 125,000 lb (56,700 kg) per year. After planting vegetation, the concentration of suspended sediments and the total amount of runoff was significantly reduced, resulting in an annual sediment load of approximately 29,000 lb (13,154 kg). Erosion from the site has thus been reduced by about 96,000 lb (43,546 kg) per year. Implementation of on-site runoff controls could further reduce the suspended solids output by another 10,000 lb (4,536 kg). Site stabilization from permanent runoff quality controls represents a significant reduction in the site's pollutant export.

The outfall areas were prioritized for runoff quality control, with site stabilization the highest

Table 9.1—Annual pollutant loads (in pounds).

	EXISTING SITE CONDITIONS	OUTPUTS AFTER MANAGEMENT	TOTAL REDUCTIONS
Total P	84	63	21
PO_4	48	33	15
Total N	610	478	132
NO_3	177	136	41
TKN	433	361	62
COD	16,737	12,896	3,841
BOD	2,193	1,712	481
Zinc	32	23	9
Lead	33	23	9
Copper	8	6	2

Source: Chris Athanas, Ph.D. & Assoc. 1992.

priority. Individual outfalls and the areas draining to them were considered for additional runoff management. One area that had consolidated four original outfall points is being treated by a constructed wetland to ensure reduced pollutant discharge. Management controls have been designed for other outfall points in case monitoring requires additional controls. While these practices may never be needed, the owner has set aside areas for possible use as vegetated swales, infiltration trenches, or sand filter systems.

The master plan development cost $42,000, including detailed design plans for the constructed wetland.

Recommended Reading

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For NPDES guidance documents, contact Permits Division (see Appendix C).

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PART II

Institutional Issues

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CHAPTER 10

Governmental Strategies for Urban Runoff

The first part of this manual discusses urban runoff management problems caused by changes in land use. Problems include changes in hydrology, erosion and sedimentation processes, and the nature and amount of materials that runoff picks up from the land surface and conveys downstream. State and local governments have implemented a variety of programs to address these problems. Programs have traditionally focused on preventing or minimizing flooding to protect homes, buildings, property, and lives of citizens. Consequently, drainage ordinances and programs have been established just about everywhere.

Part II covers institutional approaches to prevent, mitigate, or correct runoff problems. No single solution or institutional framework is recommended to solve runoff problems around the country. Flexibility is needed to establish or refine programs, based on the area's existing legal authorities and institutional framework. However, no matter what a state or local government chooses to implement, it should consider certain issues or program components. As runoff management program objectives are broadened beyond the traditional drainage focus to encompass water quality protection, runoff reuse, and open space/recreation, existing programs must evolve and become more comprehensive.

Establishing Runoff Management Strategies

Program Goals

The goals of a runoff management program must be established when the program is initiated. Until recently, this was easy since programs typically dealt only with runoff quantity problems. Since the traditional focus has been on draining runoff away from improved property as quickly as possible, runoff management has been referred to as "drainage." The increasing awareness of runoff quality problems by citizens and elected officials and Clean Water Act requirements has forced state and local governments to broaden runoff goals. Today, program goals should include quantity, quality, erosion prevention and sediment control, good aesthetic values, runoff reuse, and open space/recreation.

Even the goals of runoff quantity management are changing. This broadening includes control of both peak discharge rate and volume, especially in closed basins and for discharges to estuaries. Peak discharge control, which limits postdevelopment discharges to predevelopment levels, is evolving from control of a single design storm to several design storms. To prevent stream channel erosion, controlling the peak discharge from a two-year, 24-hour design storm is becoming more common, along with controlling the peak discharge for flood control purposes, usually a 10-, 25-, or 100-year design storm. Some runoff management entities, such as the Suwannee River Water Management District and the Florida Department of Transportation, are requiring control of the critical storm. This storm creates the biggest difference between predevelopment and post-development peak discharge rates and/or volume. Analysis of design storms—ranging from a one-year, one-hour storm to a 100-year, 24-hour

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design storm—is required to determine the critical storm.

Another consideration of a runoff management program is whether it minimizes runoff problems from new development, corrects runoff problems caused by existing development and land uses, or both. While most programs address both goals, priority and allocation of resource decisions must be made to address each problem.

The program's philosophy is determined by which goals it addresses and in what priority. The two basic philosophies of runoff management are prevention and cure. Preventing runoff problems rather than trying to cure them is easier, less expensive, and more effective. Unfortunately, runoff frequently is the "orphan infrastructure," and few resources are devoted to runoff management until some type of crisis—usually flooding with property damage and even injury or death—occurs. Even then, these problems often are corrected with quick fixes that may actually contribute to or worsen problems downstream. As a result, local governments and other providers are spending most of their efforts curing rather than preventing. Chapters 11, 13, 15, and 16 discuss aspects of this topic in more detail.

Program Tools

Urban runoff management uses many tools to prevent or correct problems. Additionally, its broadening objectives are producing new tools and refining existing ones. The program's goals play a major role in selecting the appropriate tools.

Runoff tools can be separated into two types—nonstructural and structural controls. Nonstructural controls help prevent runoff problems, while structural controls help mitigate the problems. Until now, most runoff programs have focused on flood control and relied on structural controls. Additionally, several nonstructural controls require changes in property—e.g., growth management, land use planning, zoning—often a controversial topic. Nonstructural controls include source controls that limit the types and amounts of pollutants in runoff. Many of these involve controlling or modifying certain aspects of human behavior such as using fertilizers, pesticides, or household cleaners. These controls, too, are highly controversial.

In broadening runoff management goals, structural controls often require reconsidering the usual BMP design, less emphasis and use of certain practices, and changing preferred alternatives. To improve pollutant removal, detention ponds must be changed to increase residence time and minimize short-circuiting, and shallow littoral zones planted with appropriate native wetland plants. Dry detention, used widely for flood control, provides little pollutant removal benefits because of its short detention time, bottom discharge control, and paved channels. In many locations, codes require that street curbs and gutters be used with storm sewers to eliminate runoff ponding, even for short time periods. Many localities are eliminating this requirement to promote infiltration, decrease runoff volume, and improve pollutant removal. Localities are promoting the use of roadside vegetated swales, especially in low-medium density residential areas.

Another consideration is how runoff controls are combined and integrated into a development. Increasing emphasis is being placed on the "treatment train" concept, in which several types of runoff controls are used together and integrated into a comprehensive management system. This is especially true when a project uses a wet detention pond as the primary control but promotes it as a visual and recreational amenity. To help prevent the wet pond from turning into an eyesore, swales rather than storm sewers can be used, and vegetated littoral zones added. Increasingly, small off-line depressional storage areas are being integrated into site plans, usually as part of the site's required open space and landscaping. Chapters 7, 8, 12, and 14 discuss these topics in more detail.

Program Approaches

Runoff management has two primary approaches:

- The on-site, piecemeal approach; and
- The comprehensive watershed approach.

Program goals determine which approach a state or local government selects. Selecting an approach also depends on the types of tools to be used to prevent or solve runoff problems. Finally, selection depends on the political will of elected officials and their financial commitment to the program. The piecemeal approach, the most widely used, is typically preferred when a program

- Is single-goal oriented, especially if it focuses on flood control;
- Is aimed at managing runoff from new development;

- Is oriented primarily on structural controls;
- Is preventable in nature, especially from new development; or
- Regarding the impacts of new development, has limited financial resources that prevent it from developing a runoff master plan.

The watershed approach, which is gaining popularity, is preferred when a program

- Is multiple-goal oriented;
- Is aimed at curing existing runoff problems;
- Is oriented toward using nonstructural controls; or
- Has adequate financial resources, usually from a dedicated funding source such as a runoff utility.

Many programs around the country begin with a piecemeal approach and evolve into a watershed approach. While reasons for this evolution vary tremendously, it is often related to citizen pressure or changes in state or federal statutory or regulatory requirements, such as

- Increasing attention and pressure to reduce the water quality impacts of runoff discharges;
- Downstream flooding caused by the random location of numerous on-site systems;
- Reducing costs by promoting the use of nonstructural controls; or
- Recognizing the relationship between land use changes and stormwater problems.

Chapters 11, 12, 13, 15, and 16 discuss these topics in more depth.

Common Aspects of a Runoff Program

Establishing an urban runoff management program typically includes considering and resolving a number of needs or program elements.

Legal Authority

The program must have adequate state and local legal authority to accomplish its mission and use all its tools. Runoff programs generally protect the public's health, safety, and welfare. However, authority is needed to create, adopt, and enforce ordinances and regulations. Provisions must be made to establish performance standards and associated design criteria for various control measures. The state should grant statutory authority for local entities to set up dedicated funding sources, such as a runoff utility.

Administration

Administration is a major component of a runoff program, with its organizational location a key consideration. A number of other questions must be answered. Will the program be part of the state's environmental or water agency? Within the agency, will the program be a distinct entity or part of a larger program, such as wetland and floodplain management? What relationship does the runoff program have to the NPDES or the nonpoint source program? Locally, will the program be a distinct entity or part of public works or streets and drainage? Will its maintenance be the responsibility of a runoff utility, public works, streets and drainage, or parks and recreation?

Another administration consideration concerns the program's function. Will the program have separate administrative, planning, permitting, engineering, and operation/maintenance groups? Who will evaluate and monitor the system's performance? Who will manage program finances and legal needs? Who will conduct public education programs?

Planning

Effective runoff services and infrastructure should not be haphazard—often the normal method of operation. Planning is an essential program element to maximize cost-effectiveness and help meet goals. A runoff master plan based on a community's land use plan should be developed to provide a long-term map for capital improvement and operation/maintenance needs, particularly when addressing both runoff quantity and quality. Typically, a runoff plan covers a 20-year period and is broken down into five-year phases. Developing a plan helps determine the capital improvement costs, provides an implementation schedule, and identifies funding needs.

Capital Improvements

Designing and constructing runoff conveyances, storage, and treatment facilities is expensive, especially without a long-term plan. Engineering

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expertise is essential. More and more frequently, runoff programs have interdisciplinary staffs of planners, modelers, biologists, and landscape architects. Decisions must be made about whether to maintain this expertise in-house or rely on outside consultants. Regional facilities should meet additional needs such as open space, recreation, and public education.

Operation and Maintenance

For maximum benefits, structural controls must be properly maintained and operated. Policy questions include whether a local government should accept ownership of runoff facilities, especially for residential development; which facilities to own (e.g., those that provide service for both private and public lands); and, if ownership is not accepted, how to assure that systems are maintained and operated properly. In deciding whether to accept ownership of a runoff system, a local government must consider the type of facility and its maintenance needs. Today, development projects often incorporate runoff systems as green space or landscaping. Such areas need extensive, regular maintenance such as mowing to keep them aesthetically pleasing. In such cases, the local government must determine whether it wants to be subject to citizen complaints about the site's appearance.

Another consideration is how to handle material removed from runoff conveyances, especially runoff treatment systems. One question is whether such substances are considered hazardous or toxic waste. Tests performed on these materials generally indicate that they are not hazardous or toxic waste, so waste can be used for landfill cover. However, some very specialized runoff controls, such as oil/grease separators, may contain materials requiring special disposal.

Regulation

Generally, a runoff program includes regulations and a permitting program. Local governments must decide if the legal expertise required to develop, interpret, and enforce regulations should exist within the program or in another area. Permitting programs require staff with good public communication and interaction skills plus excellent, broad-based technical skills. Staff must apply and interpret complex technical rules and review site plans that will raise land use planning, hydrology, soils, geology, and engineering concerns. The site must be inspected regularly to assure that permit conditions are being met. Enforcement must be a priority to assure that regulations are followed. Enforcement can include many tools including stop work orders, administrative fines or tickets, and even prison. Governments must decide if enforcement will be conducted by general program staff or by specialized law enforcement personnel.

Monitoring and Evaluation

Regular evaluation procedures help determine whether the program is achieving its goals and being administered in an efficient, cost-effective manner. Procedures can include actual environmental monitoring such as water chemistry, biological communities, and sediment chemistry. Monitoring program objectives must be clearly decided when initiating the program. Decisions must be made about whether monitoring will be part of the runoff program or whether another agency or government will perform these tasks. Regular administration evaluations assure that regulated parties are treated consistently, equitably, and efficiently.

Education Programs

Since everyone who lives or works in a watershed contributes to its runoff problems, governments must undertake public education programs. Programs should be directed at the regulated community to help it understand the regulations and to increase compliance and efficiency in the permitting process. Plan reviewers, inspectors, designers, and contractors may need special training, and even certification programs. Education programs can often be conducted with professional associations such as the state engineering society, state bar, or general contractors association.

Educating the public about runoff programs, their purposes, and how every citizen must be a part of the solution is a crucial and continuing need. Citizens must understand how everyday activities contribute to runoff problems. Simple pamphlets inserted into utility bills, booklets, videos, and displays at local events have been used successfully. Special programs such as "stream (lake, bay) watch," "adopt-a-stream (lake, bay)," and "eco-neighborhoods" are proving successful in encouraging citizens to buy into programs. Youth group involvement in programs such as storm sewer stenciling is also highly effective.

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Technical Assistance

Runoff and watershed management programs rely on cooperation from many levels of government, the private sector, and citizens. As runoff programs become more comprehensive, new and complex problems arise. States and local governments need to provide technical assistance and take advantage of technical assistance offered by the federal government, other states, local governments, or private concerns. In many cases, a problem or control technique has already been addressed.

Good Science

One of the inherent needs of a runoff or watershed management program is sound, scientifically defensible information. This information is needed to develop regulations, BMP design criteria, accurate monitoring and evaluation techniques, and a better understanding of the relationships between land use changes and impacts on aquatic resources. Unfortunately, budget constraints at all levels of government have led to decreases in funding for essential scientific studies and research. To solve runoff problems, especially those caused by existing drainage systems, the nation must make a financial commitment to develop new control technologies, refine existing controls, and improve our understanding of the actual effects of intermittent discharges on aquatic systems and their biota.

Funding

As with any activity or program, adequate financial resources are essential to achieve program objectives. Legislators and local governments can enact the best laws and ordinances, but if resources are inadequate for implementation, legislation will not achieve the desired results. While protecting the environment ranks high in citizen polls, environmental programs do not fare well at budget time. One reason, of course, is intense competition for limited resources. Public health, safety, and welfare concerns such as crime, medical care, and education receive priority over environmental programs. For this reason, innovative alternative funding sources must be found for runoff and watershed management programs. State dedicated funding sources might include special fees on certain products such as cement, asphalt, oil, fertilizer, pesticides, or water; additional documentary stamp fees; or even specialized property or sales taxes. Locally, runoff utilities are the most widespread and equitable dedicated funding source. Additional funding sources can include permit, inspection, and impact fees.

Other Sources

U.S. Environmental Protection Agency. 1992. State and Local Funding of Nonpoint Source Control Programs. EPA 841-R-92-003. Off. Water, Washington, DC.

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CHAPTER 11

Regulatory Strategies for New Development

An overall governmental or institutional strategy for effective management must include several key program components, including the development, promulgation, and enforcement of regulations. These regulations are necessary to technically define the goals of the runoff management program and to insure that they are achieved.

This chapter focuses on the regulations typically required to address the runoff management impacts of new land development by implementing permanent structural facilities or control measures. The chapter discusses key regulatory needs or roles necessary to establish effective facility design, design review, and construction inspection programs for permanent runoff control practices.

Finally, the chapter reviews the numerous federal programs that directly and indirectly affect a state or local runoff management program, reflecting the growing federal role in runoff. This summary, which includes both positive and negative aspects of the programs, can serve as a reader's guide to the extensive and confusing array of federal programs that affect local runoff management issues.

Facility Design

After establishing the goals of a runoff management program for new land development, strategies to achieve them must be defined. As described in Chapter 8, strategies can use structural and nonstructural controls, either separately or, preferably, in combination. Program regulations ensure that these strategies are properly implemented through specific regulatory needs or roles. In using structural controls or facilities, regulations must ensure proper facility design. To help achieve this, the following regulatory needs should be addressed.

Performance and Safety Standards

The regulations must establish a facility's performance and safety standards. Performance standards involve the outflow characteristics required to comply with the regulations—and achieve the overall program goals. Examples of requirements are (1) that the peak rate of runoff discharged by the facility after site development should not exceed a certain level from a specified range of storm events, and (2) that an extended detention time must be established for frequent storms to promote pollutant removal, with a specified removal rate.

The inherent risks of water impoundment by structural facilities require that safety standards be established to ensure acceptable risks from the facility's presence and operation. Requirements range from emergency spillways that safely convey the runoff from extreme storm events through the facility to safety measures that facilitate both normal and emergency maintenance activities.

The regulations should also address long-term maintenance by specifying who is legally and physically responsible. The regulations should also provide procedures to conduct periodic facility inspections and to notify the responsible party of the maintenance need. They should also provide enforcement powers to compel those recalcitrants who ignore such notification. Finally, the regulations must address the possibility that the facility might not be maintained or be abandoned and provide for the possibility of government ownership and maintenance.

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Because facility performance, safety standards, and regular maintenance are so vitally important, regulations should be promulgated through official and legally binding forms—laws, ordinances, resolutions, and official regulations. These avenues will ensure that the regulations are not changed arbitrarily but only by informed consensus and official action.

Computational Methods and Data Sources

Unlike performance and safety standards, the details necessary to design and construct structural runoff management facilities are best promulgated in documents with flexible formats such as handbooks, manuals, and guidelines. This flexibility is due to several factors:

- The site-specific nature of runoff and the structural facilities used to manage it;
- The relative accuracy and varied suitability of the computational methods currently used (see runoff and soil erosion estimating techniques in Chapter 1); and
- The constantly evolving body of knowledge and experience on all aspects of structural runoff facilities.

Beneficial changes to the standard methods and details can more easily be made in handbooks and manuals to respond to the specific needs of the site and facility. These informal publications also recognize the designer's professional discretion and legal responsibility. In addition, new and enhanced methodologies, technologies, materials, and data can be incorporated into the facility design process, eliminating the time-consuming and bureaucratic procedures of modifying existing laws, resolutions, and ordinances. In fact, these documents should acknowledge and encourage designers to develop and use improved techniques and features.

Regulatory discretion for design aspects such as computational methods and structural details requires competent and responsible personnel to design, oversee, and approve the facility. The next section provides more information on facility design review.

Regulations are required so that runoff management program goals can be achieved by safely constructing structural management facilities. Those promulgating design regulations must distinguish between standards and requirements fundamental to the program's goals and objectives and those that should be flexible to respond to scientific and practical improvements in runoff management. Regulations should not be subject to change without informed and official deliberations. In any case, competent and responsible personnel and an open attitude toward program enhancement are vital.

Facility Design Review

The second role of runoff management regulations is to provide an objective and thorough design review process. This is particularly true if discretion and flexibility have been incorporated in the facility design standards. Since discretion demands knowledge and responsibility, the program must include provisions for a timely, thorough, and objective design review prior to construction. The following guidelines are recommended:

Legal Responsibilities

Before developing review procedures and requirements, the legal ramifications of the design review process and implied by approval of the design should be addressed. In seeking the advice of legal counsel, clearly state the objectives of the review process. Make clear that, unless otherwise stated, the facility's designer is ultimately responsible for the performance, safety, and longevity of the structural facility—not the design reviewer, whose interests and authority are limited by the overall runoff program.

Because of the liability issues, designs should be supervised, approved, and certified by a licensed professional such as an engineer or architect. Seek legal counsel in all legal aspects of a runoff management program. Issues might include the extent of certification required on documents and computations submitted for approval, the time limit of the approval, and the extent of changes allowed before resubmission is required.

Minimum and Recommended Requirements

Regulations should establish both minimum and recommended submittal requirements for facility designs seeking approval. Minimum submittal requirements ensure that those conducting the design reviews have enough information to perform their task. Minimum requirements also ensure that the application process is fair and allow applicants to accurately budget the time, effort, and expertise needed for approval. This accuracy helps establish fair and adequate review fees.

Recommended or optional submittal requirements can help more complicated projects or designs. Optional requirements include preapplication meetings between the designer and reviewer during the design process to address more complex project features. If used properly, these meetings can save considerable design and review time and lead to more effective structural facilities. This is particularly true if the preapplication meeting—and the entire design review procedure—operates in an open and cooperative manner and all design aspects, including the need for and type of facility selected, are objectively reviewed.

A comprehensive design review procedure should include a process to review and appeal denials and rejections. This process should include decision-review meetings between applicants, designers, and reviewers. These meetings can often resolve problems promptly and efficiently; save time, effort, and emotions; and preserve support for the runoff program.

Wherever feasible, regulations should establish maximum time limits for design reviews. While time limits can sometimes be onerous to individual reviewers, developers, and applicants, they allow both the reviewing agency and the applicant to better budget staff time and expenses. Time limits also provide the reviewer an incentive to obtain the required design information from the applicant. Programs that establish maximum time limits must also clearly define what constitutes a complete submittal, and allow the reviewer adequate time to determine completeness. The program should also allocate adequate time for logging, filing, notification, and other administrative procedures.

Level of Review

The design review process also entails deciding the level of review to conduct. This could range from a reviewer's simple check of plans, data sources, and computational arithmetic to a comprehensive and independent analysis of the proposed structural facility. Often, a combined approach is best, with the reviewer making arithmetic checks of standard or less critical design computations and independent computations of more critical aspects. The proper mix of review techniques depends on the legal responsibilities of the review process, the specific aspects of the design being reviewed, and the implications of design error and/or facility malfunction.

Self-Examination and Monitoring

This aspect of the design review process, including time spent by review personnel and the problems encountered, will help identify shortcomings, inefficiencies, and deficiencies in the process. This could include the extent of required submittal data, staff knowledge and training, and various administrative procedures. In many instances, the self-monitoring process can be used to identify deficiencies in the knowledge and/or abilities of the applicant or designer. These deficiencies can then be addressed through techniques ranging from more descriptive application forms and instructions to seminars and workshops on design, submittal, and review procedures and requirements.

Interaction and Dialogue

A truly effective design review process includes some interaction and dialogue with the design community that it oversees and facility construction and maintenance personnel. Such interaction—formally at regularly scheduled meetings and workshops or informally through professional or trade organizations—can help identify and correct review practices and specific facility requirements that are causing design, construction, or maintenance difficulties. The complexity of runoff processes and the growing scope of the programs intended to manage it make such a proactive approach to problem identification and resolution vital to the success of any regulatory program.

Facility Construction Inspection

Once the runoff facility design has been developed, reviewed, and approved, the facility must actually be put into service through construction. The importance of this point, however obvious or simple, should not be overlooked. Until a structural control measure is constructed and begins functioning, it has absolutely no effect on runoff and solves no runoff need or problem. Too frequently, facility design or review procedures become ends in themselves. The program goals are not realized by the production of a set of plans

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stamped "approved," but through construction and operation. Therefore, not only should the regulatory aspects of structural runoff facilities be focused on producing an effective, safe, efficient, and durable facility, they should also be focused on getting it constructed.

The same is true for construction inspection programs. The primary focus must be on constructing effective, safe, and durable structural facility. The return on investment is not realized until the project is constructed and functioning.

Legal Issues

In many ways, the regulatory needs of a construction inspection program are similar to those for facility design review. Prior to program start-up, all legal aspects and implications of the program must be thoroughly reviewed and accepted. This includes satisfactorily addressing the legal implications of the inspection process and the approvals it produces. All involved must understand that, unless otherwise stated, the ultimate responsibility for safe and proper construction rests solely with the builder, not with an inspector who has limited program interests and authority.

Construction Inspection and Reporting

A formal construction inspection and reporting procedure includes provisions for preconstruction and project start-up meetings, inspection schedules, documentation and dissemination of findings and observations, periodic progress and problem solving meetings, and postconstruction documentation and certification. As with preapplication meetings during the design review process, preconstruction meetings can be key to efficient and productive construction. These meetings can provide all parties an opportunity to familiarize themselves with the various procedures, personalities, and potential problems before construction begins and in the relatively calm environs of a meeting room rather than the immediate and highly-charged atmosphere of a construction site.

The regulations should provide a clearly defined role by describing the construction inspector's responsibilities and authority and suggest periodic review meetings to address problems and plan construction phases. The regulations should also require that the as-built drawings of the facility be subject to the review and approval of the inspecting agency. Finally, the regulations should provide certification procedures to officially designate the project's completion. This designation helps contractors and owners, who may need to terminate construction performance bonds and other sureties, and design review and construction inspection agencies.

Interaction

An effective construction inspection program includes interaction and interchange among facility designers, builders, and maintenance personnel. This interaction can take place formally at regularly scheduled meetings and workshops or informally through professional or trade organizations. It allows difficulties in design, construction, or maintenance to be identified and corrected. The complexity of runoff processes and the growing scope of management programs make proactive problem identification and resolution vital to success.

Federal Programs Affecting Runoff Management

Since passage of the 1972 Clean Water Act, a variety of agencies have introduced numerous federal programs to manage and protect water resources. Many of these programs directly affect runoff management by reducing its impact on aquatic systems, not only at the federal level, but also at state and local levels. Unfortunately, some of these programs—especially older ones—have single focus goals and/or legal mandates. These often conflict with the multifaceted environmental protection goals of more recent programs, particularly those that seek the holistic ecological goals of watershed management. Attaining runoff and watershed management goals will depend, in part, on modernizing existing laws and programs to make goals more consistent with those of more recent laws emphasizing environmental protection. The success of this modernization process, in turn, will depend upon how well we can integrate existing laws into watershed-based runoff management programs.

Before we can undertake such a process, we must understand each of the various federal programs that affect the development of local, state, and even federal runoff management programs and regulations. The following section lists the numerous federal programs that can affect, adversely or beneficially, the management of runoff and other nonpoint sources of pollution.

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U.S. Environmental Protection Agency

Clean Water Act

■ **Section 104, Water Quality Cooperative Agreements.** Supports programs and projects for the prevention, reduction, and elimination of pollution. Some eligible activities include special water quality studies, investigations of pollution control techniques, river corridor watershed management planning, and pilot and demonstration projects. Special programs funded through Section 104 include

- **Near Coastal Waters.** Improves the environmental conditions of near coastal waters through a watershed management approach. Eligible activities include developing and implementing regional strategies in targeted areas.
- **State Wetlands Program.** Increases the ability of state programs to protect wetland resources. Eligible activities include developing new state wetland protection programs or refining existing programs, watershed protection demonstration projects, state wetland conservation plans, and section 404 program assumption assistance.
- **Wetlands Protection Program.** Receives funding for activities in targeted watersheds such as advance wetland identification, public education, and enforcement.
- **Assessment and Watershed Protection Support.** Provides very limited funding for watershed planning priorities, regional targeting, and monitoring in support of section 305(b) reports.
- **Section 104(g).** Encourages the establishment or enhancement of small community outreach programs.

■ **Section 106, Water Pollution Control.** Administers programs to prevent, reduce, and eliminate water pollution. This is the primary federal grant funding source for state water quality management programs. Eligible activities include nearly all aspects of the prevention and abatement of surface and groundwater pollution—planning; monitoring; permitting; enforcement; and training, public education, and technical assistance.

■ **Section 205(j)(1).** Authorizes water quality management planning programs by states. Eligible activities include identifying pollution control methods to protect and restore waterbodies and monitoring programs conducted statewide or in targeted watersheds. Funded by a 1 percent set-aside of the state's Title II grant funds, it is being replaced by section 604(b).

■ **Section 303, Water Quality Standards and Implementation Plans.** Requires states to develop, adopt, and enforce water quality standards that are at least as stringent as those adopted by the EPA and that will protect, maintain, and restore the chemical, physical, and biological integrity of all waters. It requires the regular review and, if needed, revision of water quality standards; the establishment, allocation, and enforcement of total maximum daily loads for certain waterbodies; and a continuous state water planning process.

■ **Section 304, Information and Guidelines.** Requires EPA and the states to establish water quality criteria and effluent guidelines for a wide variety of substances, especially hazardous and toxic ones. It requires states to develop a list of waters needing control strategies for toxic and other pollutants.

■ **Section 305, Water Quality Inventory.** Requires EPA to biennially report to Congress on the environmental quality of the nation's water resources and identify waters that do or do not meet their designated uses. States develop State Water Quality Assessment reports (305(b) reports) and submit them to EPA, which uses the information as the basis for its report.

■ **Section 314, Clean Lakes Program.** Establishes projects and programs to control pollution sources to lakes and to protect and restore the quality of lakes. Eligible activities include identification and classification surveys of all publicly owned lakes, state lake water quality monitoring and assessment, and public education. Lake restoration projects typically include three phases: a diagnostic/feasibility study; a restoration/protection implementation program; and postrestoration monitoring.

■ **Section 319, Nonpoint Source Program Implementation.** Supports activities that implement the states' EPA-approved nonpoint source management plans. These include basic program implementation tasks that help institutionalize the program within a state; watershed nonpoint source management program implementation within targeted watersheds; nonpoint source control practice installation at demonstration sites; and groundwater nonpoint source assessment and management programs.

■ **Section 320, National Estuary Program.** Authorizes development of comprehensive conservation and management plans, usually over a five-year period, for specific legislatively designated estuaries. It does not provide funding to implement approved plans, although other CWA funds (e.g., 319, Title II and VI) may be used.

■ **Section 402, National Pollutant Discharge Elimination System.** Establishes regulatory programs for point sources of pollution but exempts most agricultural activities. This program was originally designed to reduce pollution from point sources such as domestic and industrial wastewater discharges. This program now includes certain runoff discharges from specific industrial activities, including construction sites, and runoff discharges operated by local governments with a population over 100,000.

■ **Section 404, Permits for Dredged or Fill Material.** Establishes a regulatory program to control the discharge of dredged or fill material into navigable waters (wetlands). This program is administered by the U.S. Army Corps of Engineers, using permitting guidelines developed in coordination with EPA. The section allows a state to administer the program, with EPA having veto power.

■ **Section 604, Title VI Water Quality Management Planning.** Requires each state to reserve 1 percent of the State Revolving Loan Fund grant for water quality management planning activities required by section 205(j) and 303(e). Eligible activities include projects to determine the nature, extent, and causes of water quality problems; to identify cost-effective and acceptable point and nonpoint source controls; and to develop implementation plans.

Federal Safe Drinking Water Act

■ **Section 1443, Underground Injection Control.** Establishes federal and state programs to protect groundwaters from these sources. It provides grants to states to fund all types of related activities.

■ **Section 1442, Wellhead Protection.** Provides technical assistance and funding to states and local governments designing and implementing wellhead protection programs. Eligible activities include delineation of wellhead protection areas; identification, mapping, and sampling of contamination sources; public education; and development of ordinances.

U.S. Department of Agriculture

■ **Agricultural Conservation Program (ACP).** Administered by the USDA Agricultural Stabilization and Conservation Service (ASCS), ACP is designed to control erosion and sedimentation and encourage voluntary compliance with federal/state requirements to solve point and nonpoint source pollution. It provides financial assistance to individuals in all U.S. counties to implement conservation practices. Recently, water quality improvement has received special emphasis. However, allowable BMPs and funding amounts are set by county and state committees, which are usually dominated by agricultural interests.

■ **Conservation Reserve Program (CRP).** Administered by the USDA ASCS, CRP is intended to return certain agricultural lands—which are highly erodible or otherwise critical in protecting and restoring water quality—to a conservation use, typically as grass or forests. Farmers receive payment per acre to conserve these lands for a contracted period, typically 10 years.

■ **Wetlands Reserve Program (WRP).** Administered by the USDA ASCS, WRP is intended to restore and protect farmed or converted wetlands. Farmers receive direct payments and conservation planning and technical assistance to install necessary restoration practices on areas they agree to maintain under a conservation easement.

■ **Resource Conservation and Development Program (RC&D).** Administered by the Soil Conservation Service, RC&D encourages and improves the capability of state and local entities in designated rural areas to plan, develop, and implement programs, typically in targeted critical areas.

■ **Soil and Water Conservation.** Administered by the USDA SCS, this program provides technical assistance to the public through total resource planning and management to improve water quality and natural resources and reduce pollution sources. USDA SCS also publishes detailed soil surveys for each county and provides a variety of useful natural resources management information.

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■ **Watershed Protection and Flood Prevention (Small Watershed Program, PL-566 Program).** Administered by the USDA SCS, it provides technical and financial assistance to state agencies and local governments to develop and implement plans that protect, develop, and use land and water resources in small watersheds. Recently, this program has been broadened to emphasize protecting and restoring water quality, especially from flooding, erosion, sedimentation, and use/disposal of water problems.

U.S. Department of the Interior

■ **National Water Quality Assessment Program.** Administered by the U.S. Geological Survey, it addresses a wide range of major water quality issues, with special emphasis in the next few years on pesticide impacts on water resources. The program will include nationwide surface and groundwater quality monitoring and assessment.

■ **Water Data Program.** Administered by the USGS, it consists of four water quality monitoring networks, the most important of which is the National Stream Quality Accounting Network (NASQAN). Data on stream flow and height, lake stage and storage, groundwater levels, well and spring discharge, and the quality of surface and groundwaters is collected and stored in National Water Data Storage and Retrieval System (WATSTORE).

■ **Federal State Cooperative Program.** Establishes a partnership for water resources investigations between the USGS and state and local agencies. This program is the foundation for much of the planning, development, and management of the nation's water resources.

■ **Coastal Wetlands Planning, Protection and Restoration Program.** Administered by the U.S. Fish and Wildlife Service, it provides funds to acquire coastal lands or waters and to restore, enhance, or manage coastal wetland ecosystems. Projects must provide for the long-term conservation of these lands and waters.

■ **Land and Water Conservation Program.** Administered by the National Park System, it was established to create and maintain a national legacy of high quality recreation areas. It provides funding for federal acquisition of authorized national park, conservation, and recreation areas and to state and local governments to help acquire, develop, and improve outdoor recreation areas.

Federal Highway Administration

■ **Federal Aid Highway Program.** Assists state agencies in developing and improving an integrated, interconnected transportation system. Funds may be used for planning, research and development (including BMPs), restoration, roadside beautification, and wetland mitigation. It provides funding for erosion and sediment controls needed to minimize highway construction impacts but not typically to treat and manage highway runoff. However, the Surface Transportation Program authorizes funding for highway runoff quality controls and for mitigating damage to ecosystems, habitat, and wildlife.

U.S. Army Corps of Engineers

Civil works projects are specific line-item congressional appropriations in the biennial Water Resources Development Act. They provide help to communities for a variety of water resource problems including flood control, coastal and shoreline erosion, environmental restoration, and water quality management. Projects must include mitigation of unavoidable environmental damages and must also consider environmental restoration through opportunities created with projects.

The following programs have great potential to adversely affect aquatic systems and impede runoff management to protect or restore water quality:

■ **Small Flood Control Projects.** Pursuant to section 205 of the Flood Control Act of 1948, the Corps is authorized to reduce flood damages through projects not specifically authorized by Congress. However, the Corps is restricted to making improvements to natural water courses—typically structural, such as bank hardening or dredging—and cannot consider watershed runoff improvements.

■ **Snagging and Clearing for Flood Control.** Pursuant to the Flood Control Act of 1937, it allows the design and construction of flood control measures that typically increase drainage and decrease water quality.

National Oceanic and Atmospheric Administration

■ **The Coastal Zone Management Act of 1972.** Allows states to prepare and implement comprehensive management programs for coastal re-

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sources that balance competing demands on resource protection, protection of public health and safety, provision for public access, and economic development. States with federally approved programs receive federal grant funds to develop and implement a wide variety of coastal resource management initiatives.

- **Section 6217, Coastal Nonpoint Pollution Control Program.** Jointly administered with EPA, which is responsible for establishing minimum nonpoint source management measures. States with federally approved coastal zone management programs must develop and implement nonpoint source control programs to restore and protect coastal waters and must comply with the minimum nonpoint source management measures.
- **National Estuarine Research Reserve System.** Establishes and manages a national system of reserves representing different coastal regions and estuarine types. The reserves serve as field laboratories and public education centers.
- **National Marine Sanctuary Program.** Identifies areas of the marine environment of special significance and provides authority for comprehensive and coordinated conservation and management. It also provides for research and monitoring activities and public education.

Information Sources

Further information on these programs can be obtained from *Watershed Protection: Catalog of Federal Programs* (EPA-841-B-93-002), a 1993 publication of the U.S. Environmental Protection Agency's Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 1991. Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity. EPA 505/8-91-002. Washington, DC.

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CHAPTER 12

Site Planning and Other Nonstructural Management Practices

In the long run, preventing runoff problems is easier and much less expensive than correcting problems later through expensive infrastructure construction and resource restoration. This chapter presents a variety of effective management practices that can be used to prevent runoff problems. These preventive controls, called nonstructural management practices or best management practices, include regulatory practices, such as buffer zones or limits on impervious areas, and source controls, such as public education, growth limitations, and protection of sensitive areas to reduce runoff pollution sources. Unlike structural controls, which address runoff problems on a particular site, nonstructural controls are used throughout an entire community, watershed, or special protection zone.

Most nonstructural BMPs are associated either with land use changes or with educating citizens to encourage a change in lifestyle activities. Accordingly, local governments primarily develop and implement nonstructural management practices and programs, although state and regional agencies can join the implementation team. Recently, federal agencies and programs have begun to emphasize pollution prevention activities.

The nonstructural management practices tool box contains a large number and variety of nonstructural BMPs. An urban runoff management plan for the Santa Clara Valley in California, for example, includes more than 100 potential nonstructural BMPs. Local governments and other users of nonstructural measures should screen BMPs to determine those most appropriate for a given area.

Historical Problem Areas

In most parts of the United States, many state and local governments have been discouraged from implementing programs to control or regulate land use and development. This reluctance developed because of an abundance of easily developed land and a lack of understanding about the negative impacts of growth and development on natural resources. With real or perceived concerns about potential property rights questions and sensitivity about restricting a person's use of private property, governments have proceeded cautiously in establishing land use controls, setting specific development design or performance requirements, or restricting citizen activities. Currently, eight states have implemented statewide growth management programs, and many state and local governments have instituted various types of zoning, permitting, or other programs that restrict activities or new development. However, developing and implementing these programs is frequently controversial.

Many source controls involve changing citizens' lifestyles or activities. Every citizen who lives in, works in, or visits a watershed contributes to urban runoff problems through everyday activities. Whether traveling in a motor vehicle on a paved or unpaved road, using fertilizers or pesticides, using household cleansers, or walking the family dog, each individual contributes pollutants to the watershed. Educating citizens to encourage

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a change in habit is difficult. First, we must convince citizens that runoff is a pollution source, that their everyday activities contribute to this pollution problem, and finally that changing their ways helps prevent pollution.

Site Planning and Other Nonstructural BMPs

Institutional Framework

Local governments are typically the public entity responsible for reviewing and approving development plans. Local governments influence and guide urban development, depending on state laws and local ordinances, by identifying where and how development should occur through local land use plans and associated policies. These plans and policies are implemented through specific ordinances and mechanisms known as land development codes or regulations, which establish the legal basis for reviewing and approving development plans, monitoring implementation, and enforcement. Many nonstructural management practices—limits on site clearing and impervious areas, landscaping, buffer zones, and others—can be incorporated into local land development codes. (See Chapter 11 for summary of regulatory programs.)

Development plan review by local government addresses a wide range of public policy concerns including traffic circulation, safety, health, landscaping, tree protection, and public services. Plan review and approval protects natural resources, especially water resources, by addressing potential water quality degradation sources such as construction, runoff, and septic tanks. Plan review should also include preservation of critical areas and wildlife habitats. Local governments can prevent problems and solve existing and potential problems by implementing a comprehensive site plan review process. Effective development reviews lead to more efficient use of land, water, and cultural resources and can help eliminate or reduce difficulties experienced by landowners.

In developing regulations, local governments need to screen various nonstructural management practices to determine those most beneficial in a particular area or situation. Screening methods should include criteria specific for the watershed's conditions and for the goals of the watershed program. Typical criteria include

- **Pollutant control and effectiveness.** This criterion should be from pollutants of primary concern or known pollution problems. Consider reliability and longevity of the controls along with siting and design constraints.

- **Control acceptability.** Controls should be accepted by the public and by public agencies responsible for implementing and maintaining BMPs.

- **Technical and economic feasibility.** Some BMPs may require considerable technical expertise, staffing, and financial resources. Cost considerations should include planning, design, construction, operation, and maintenance.

- **Legal authority and considerations.** Local land development codes must provide adequate legal authority to implement and enforce requirements. Evaluate risks or liabilities that may occur in implementing control measures.

- **Existing government framework.** Governments vary greatly around the country. The roles, powers, and duties of multiple levels of local and regional governments greatly influence the effectiveness of a potential nonstructural BMP, especially one that relies on widespread implementation.

Although local governments have unique requirements and steps in the development review process, certain elements common in most procedures include

- **Comprehensive plan amendment.** In most cases, proposals for land development should conform to the local government's adopted land use plan and map. If the proposed development is not consistent with the plan, an amendment to the local plan or map may be necessary.

- **Rezoning.** Once the development and local plans are consistent, an official change in the site's designated zoning may be necessary.

- **Development plan review and approval.** Through this process, plans for land improvements, buildings, and related activities are reviewed for compliance with local land development regulations. This review can include multiple steps such as subdivision

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approval (e.g., conceptual, preliminary, and final plat). The process usually involves preparing a site plan, especially for commercial, industrial, and multifamily developments.

- **Engineering plans.** This step includes preparing and receiving final approval of designs for utilities, wastewater management, runoff management (including erosion and sediment control), roads, and building construction.

- **Building permits and approvals.** Necessary federal, state, regional, and local permits should be obtained before beginning construction. In many areas, no land clearing is allowed until certain permits such as clearing and grading, erosion/sediment control, and runoff management are obtained.

Planning with Nature

The United States' rich and diverse environment has a tremendous variety of natural systems, with many well suited to urban development. However, many systems have low tolerances for intensive development and, if radically altered, can no longer perform their basic functions. A main purpose of site planning is to encourage the use of comprehensive design principles that preserve the integrity of the natural environment. In this sense, site planning is a preventive measure and, frequently, a neglected element of land development.

Natural systems provide unique and beautiful environments that attract visitors and residents alike. These systems also supply, transport, cleanse, and store water; assimilate and filter wastes; modify and moderate the climate; provide storm protection and dampen floodwater; produce food; oxygenate and purify the air; recharge aquifers; build land; and provide recreational and economic opportunities. Perhaps the greatest benefit provided by natural systems is their self-maintaining capability. When used within their tolerance levels, natural systems provide a variety of services efficiently, dependably, and at no cost to humans. This self-maintaining capability is in direct contrast to most constructed systems that require money and energy to maintain. Like any other complex system, natural systems can operate efficiently only as long as their ecological integrity is maintained. If essential components are damaged or destroyed, or if the system as a whole is overstressed, the natural biological processes will break down and the system will fail. Therefore, economic sense dictates that each system fulfill its proper function and maintain peak efficiency by thoughtful, insightful resources management.

Principles of Runoff Management

The following principles should be used to develop a site plan:

- Preventing problems is much more efficient and cost-effective than attempting to correct problems after the fact. Sound land use planning decisions based on the site planning principles discussed later in this chapter are essential as the first, and perhaps the most important, step in managing runoff problems. All new development plans (e.g., subdivisions, shopping centers, industrial parks, office centers) and redevelopment plans should incorporate nonstructural management practices, including source controls, along with a comprehensive runoff management system.

- Every piece of land is part of a larger watershed. Since we all live downstream, a runoff management system for each development project should be based on and support a plan for the entire drainage basin.

- The runoff management system should mimic and use the features and functions of the natural runoff system, which is largely capital, energy, and maintenance cost free. Every site contains natural features that contribute to runoff management under existing conditions. Depending on the site, existing features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control runoff velocity, extend the concentration time, filter sediments and other pollutants, and recycle nutrients.

Each development plan should carefully map and identify the existing natural system. Use natural engineering techniques to preserve and enhance the natural features and processes of a site and to maximize the economic and environmental benefits. Natural engineering is particularly effective when the runoff system is integrated into a site's landscaping, open space and recreational areas, or in "blue-green" developments using permanent lakes and cluster tech-

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niques. Engineering design can and should be used to improve the effectiveness of natural systems, rather than negate, replace, or ignore them.

■ The volume, rate, timing, and pollutant load of runoff after development should closely approximate the conditions before development. To accomplish these objectives, two overall concepts must be considered: (1) maintaining the perviousness of the site to the greatest extent possible; and (2) slowing the rate of runoff. Give preference to runoff management systems that use BMPs to maintain vegetative and porous land cover and include on-site storage mechanisms. These systems promote infiltration, thereby reducing, filtering, and slowing runoff.

■ Maximize on-site runoff storage. Storage provisions can reduce peak runoff rates; aid in groundwater recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion, and sedimentation; and provide water for other beneficial uses. Where practical, the blue-green development approach should be employed, since it inherently provides storage, environmental protection, and enhanced community amenities.

■ Runoff should never be discharged directly into surface or groundwaters. Runoff should be routed over a longer distance, through grassed conveyances (swales), wet ponds, vegetated buffers, and other practices that increase overland sheet flow. These practices increase infiltration and evaporation, allow suspended solids to settle, and remove pollutants before they reach downstream receiving waters and groundwaters.

■ Plan, construct, and stabilize runoff management systems, especially those emphasizing vegetative practices, before development. This principle frequently is ignored, causing unnecessary off-site problems, extra maintenance, regrading, revegetation of slopes and grassed waterways, and extra expense to the developer. Construct and stabilize the runoff management system, including erosion and sediment controls, at the start of site disturbance and construction activities.

■ Design the runoff management system beginning with the project's outlet or point of outflow. The downstream conveyance system should contain sufficient capacity to accept the discharge without adverse downstream impacts such as flooding, streambank erosion, and habitat destruction. Downstream conveyance systems may need stabilization, especially near the system outlet. Another common problem is a restricted or submerged outlet. This can cause runoff to back up and exceed the storage capacity of the collection and treatment system, resulting in temporary upstream flooding. This situation may lead to hydraulic failure of the runoff management system, causing resuspension of the pollutants and/or expensive repairs to damaged structures or property. In such circumstances, more than one outlet or an increase in the on-site storage volume may be needed.

■ Whenever possible, follow the topography to construct the components of the runoff management system. This step will minimize erosion and stabilization problems caused by excessive velocities and slow the runoff, allowing for greater infiltration and filtering.

■ Runoff, a component of the total water resources, should not be casually discarded but used to replenish those resources. Runoff is a misplaced resource, with location and timing determining whether it is a liability or an asset. Given the water quantity and quality problems facing our nation, we must consider runoff an asset. Treated runoff can potentially provide many beneficial uses such as irrigation of farms, lawns, parks, and golf courses; recreational lakes; groundwater recharge; industrial cooling and process water; and other nonpotable domestic uses.

■ Whenever practical, integrate multiple-use temporary storage basins into the management system. Too often, planned facilities are conventional, unimaginative, aesthetically unpleasing ponds. Recreational areas (e.g., ballfields, tennis courts, volleyball courts), greenbelts, neighborhood parks, and even parking facilities provide excellent settings for temporary runoff storage. Such areas are not usually used during precipitation, so runoff ponding for short durations will not impede their primary functions.

■ Design storage areas with sinuous shorelines. Curves increase the length of the shoreline and create greater development opportunities, especially in using the blue-green concept of permanent lakes. The increased shoreline also provides more space for the growth of littoral vegetation to provide greater pollutant filtering, more diversified aquatic habitat, and greater attractiveness (aquascaping).

- Retain vegetated buffer strips in their natural state or create strips along the banks of all waterbodies. Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a floodplain during high water periods. They also provide a pervious strip along a shoreline to accept sheet flow from developed areas and help minimize the adverse impacts of untreated runoff.

- Maintain the runoff management system. Failure to provide proper maintenance reduces the system's pollutant removal efficiency and hydraulic capacity. Lack of maintenance, especially to vegetative systems requiring harvesting or revegetating, can increase the pollutant load of runoff discharges. The key to effective maintenance is to assign responsibilities to an established agency or organization, such as a local government or homeowners association, and to regularly inspect the system to determine maintenance needs. An even better tactic is to design a system that is simple, natural, and as maintenance free as possible.

The Site Planning Process

Site planning requires determining specific uses for definitive land areas and planning development to achieve a community character and an amenable quality of life. To achieve this end, assemble and analyze all pertinent site information—social, ecological, cultural, economic, political—to determine the project's ultimate design or feasibility.

Site planning can help preserve the site's integrity and diverse natural systems. Assessing the opportunities and constraints imposed by a site's features helps avoid or minimize potential problems and hazards, decrease construction and maintenance costs, and attain a community character that produces an amenable quality of life.

Innovative development techniques, such as planned unit or cluster developments, are extremely well-suited for site planning. Not only do these techniques reduce costs, they also allow greater flexibility and can incorporate natural and cultural resources into the development plan. These techniques foster a harmony between the development and existing natural systems, creating opportunities for amenities such as open space, recreation, and beauty not commonly found in developments.

Site plan contents will vary, depending on state requirements and local ordinances. However, site plans typically include a development plan and a street and utility layout. Most important, a site plan includes plans for grading, soil erosion and sediment control, runoff management, and landscape. Development and infrastructure plans created in harmony with the site's constraints and opportunities greatly influence their effectiveness in protecting site and watershed resources. Coordinate these elements to assure a logical sequencing of events. For example, a sediment basin in the erosion and sediment control plan can become a permanent runoff detention basin. Additionally, all initial and final elevations in the grading plan should be consistent with facilities in both the erosion and sediment control plan and the runoff management plan.

Developing a site plan requires a careful step-by-step analytical approach, which often includes the following steps:

- **Conduct a site evaluation.** Assess existing natural and cultural features and determine suitability for the proposed development activity.

- **Develop site maps.** These allow visual inspection and analysis of site features and their relationship to the alternative site development plans.

- **Collect additional information.** This is needed to finalize conceptual plans.

- **Review site plan goals.** Goals should properly address requirements of state and local laws, ordinances, permitting regulations, comprehensive plans, and land development codes.

- **Develop and integrate the individual components of the site plan.** Each component should include goals, desired performance, design considerations for chosen BMPs, operation and maintenance needs, costs, and scheduling.

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Conducting a site evaluation is the heart of the site planning process. It includes collecting and analyzing the information to prepare a final development plan in harmony with both the natural and cultural communities. The following section discusses this process in more detail.

Site Evaluation

Site selection is the most critical stage of the development process. Developers must begin planning for a new project before the land is purchased to evaluate the suitability of potential sites. Usually a developer lacks the luxury of choosing an ideal location but must rely on what is available at a price that can return a reasonable profit. Whether the project begins with a site or an idea, the site's physical characteristics and location in the community will determine the feasibility of the concept. Site selection and evaluation must consider two important factors:

- The opportunities and constraints the site brings to the proposed development—elevation, hazards, soil types, water table elevation, runoff management, and
- The community impact, especially in adjacent and downstream areas.

In analyzing the site and its surroundings, include all natural, cultural, and aesthetic features that affect it and illustrate the information graphically (site maps). These features influence final site selection and provide clues to site personality that will help establish and select guidelines for later development. The following steps are useful in selecting a site or analyzing one already selected:

- Collect basic data for surface and subsurface features. Analyze and interpret aerial photographs, maps or charts, previous environmental and cultural resource studies, and field surveys. Much of this information can be obtained from local planning departments as a result of local government comprehensive planning efforts.
- Organize and present the basic data graphically. Recent advances in the technology and application of computerized geographic information systems facilitates mapping and analysis.
- Analyze and interpret maps singly and in combination. Identify critical areas needing preservation or special treatment; evaluate appropriate locations for buildings, roads, and utilities; and prepare alternative conceptual development plans.
- Interpret maps for planning decisions. Contact representatives of state and local government agencies for various jurisdictional determinations where appropriate.

Table 12.1—Site selection, analysis, and planning factors.

NATURAL FACTORS	
Climate	Solar orientation, wind, precipitation, and humidity
Geology	Bedrock and surficial
Physiography	Geomorphology, relief, and topography
Hydrology	Surface and groundwater
Soils	Classification of types, limitations, and capabilities
Vegetation and wildlife	Plant communities and habitats
Critical areas	Identification and protection
CULTURAL FACTORS	
Existing land use	Ownership of adjacent property and off-site nuisances; projected future land use of site and adjacent property
Traffic and transit	Vehicular and pedestrian circulation on or adjacent to site
Density and zoning regulations	Legal and regulatory controls
Socioeconomic	Market analysis, suitability
Utilities	Wastewater, stormwater, water, gas, steam, electricity, and telephone
Historical and archaeological	Historic buildings, landmarks, and archaeological sites
AESTHETIC FACTORS	
Natural features	Location, protection, views
Spatial pattern	Views, spaces, and sequences

Source: Livingston et al. 1988.

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■ Prepare composites map. These illustrate the general and specific development limitations and opportunities of the whole or part of the selected site.

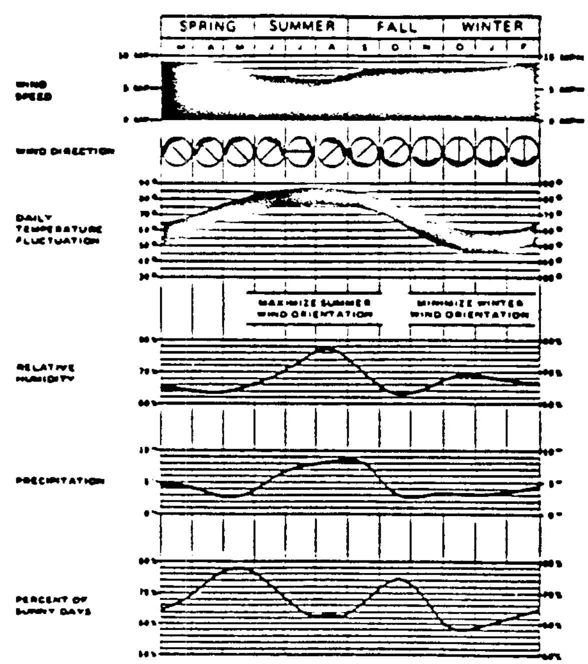
A number of important natural, cultural, and aesthetic factors should be considered in site selection, analysis, and planning (Table 12.1). The remainder of this chapter discusses each of these factors, along with design or development guidelines.

Natural Factors

Climate

Planning Considerations. The chief climatic control factors are latitude, physiography, temperature, and proximity to waterbodies. Climate is usually characterized within well-established probabilities. However, site planning must be concerned with extremes as well as averages. Floods, droughts, hurricanes, and coastal storm surges should all be considered during the development planning phase. Precipitation and temperature are major factors affecting vegetation. Proper building orientation can ameliorate hot and humid climates by taking advantage of shade and prevailing breezes. In colder climates, building orientation and positioning help reduce cold winds and provide solar reflection and heating. A summary of a site's climatic data (Figure 12.1) can help plan an environment for living.

Figure 12.1—Sample summary of site's climatic data.



Source: Simonds, 1978.

Design Guidelines

■ Arrangements, materials, and conformation of site plans and structures should be designed according to the climate and the site's microclimate—variations to the climate due to on-site factors such as water and trees.

■ Sites along lake shorelines and ocean coastlines, especially along the Gulf of Mexico and the Southeast Atlantic, are vulnerable to storms—including hurricanes—with high winds and storm surges. Coastal developments should preserve the remaining protective sand dunes, ensure that floor levels of structures are above flood levels, and carefully consider the potential effects of an intense storm or hurricane to minimize property damage and personal injury.

■ Use open patterns in hot and humid climates to take advantage of prevailing summer winds.

■ Take advantage of the cooling provided by waterbodies and shade trees when locating housing.

■ Shield heat-prone paved surfaces, such as streets or parking areas, in the shelter of structures that provide shading.

Sources of Information

■ **U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Asheville, North Carolina.** This agency collects and compiles climatological data for many areas throughout the country. The amount of information varies, but most stations record daily temperatures and precipitation. Some stations have detailed monthly reports and an annual summary that tabulates records from stations statewide. Most major libraries receive these publications.

Geology

Planning Considerations. Although a site's underlying rock structure is used much less frequently than the surface soil layers, it is of critical importance. Surveying and analyzing subsurface

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geological conditions provides essential information that might affect development. This is especially true for karst areas that have thick formations of easily dissolved limestone, creating a high number of sinkholes.

The subsurface geology is a source of raw materials, a reservoir for water and waste disposal, and gives the land backbone—allowing it to support heavy structures. It also contains important mineral deposits. Improperly analyzing and using this resource can result in jeopardized water supplies, ineffective disposal systems, and damaged buildings and roads. Knowledge of subsurface geology is also needed to answer questions about the weight-bearing capacity, availability of potable water, physical limitations, suitability of the site, and infiltration potential on runoff control. An area's surface physiography is a direct result of its geology.

Development Guidelines

- Karst topography has important implications since sinkholes can form at any time. Therefore, geologic mapping and evaluation completed prior to design should consider all environmental factors that affect design and construction. This preliminary feasibility study should consider adverse geologic conditions (i.e., location of sinkholes and other limestone formations) and the economics of grading and other land modifications.

- Potential sinkhole formation should be evaluated. Roadways, structures, sewage lagoons, landfills, and runoff systems should not be located in areas likely to develop sinkholes.

- Recent evidence indicates that vast dendritic underwater networks connect many sinkholes, allowing rapid transmission of pollutants through this underground river system. Extreme care is needed to prevent introducing runoff/pollutants into groundwater, a major source of fresh water.

Sources of Information

- **Department or bureau of geology.** Most states have a geology department or bureau within a state resource management agency. This department will often have environmental geology maps and reports that provide basic data to create and execute sound programs for waste disposal, water resources and land management, building and highway construction, geologic hazards identification, and mineral extraction. Many departments also publish numerous in-depth studies for small areas, but site-specific investigations may still be needed.

- **Universities.** Many universities have geology departments with studies useful to the planner or developer.

- **U.S. Geological Survey.** This agency publishes many types of technical reports and maps useful in determining a site's geological characteristics.

- **Well Logs.** These records, prepared by well drilling contractors, identify the type of material and depth of various subsurface formations. Many states require these logs.

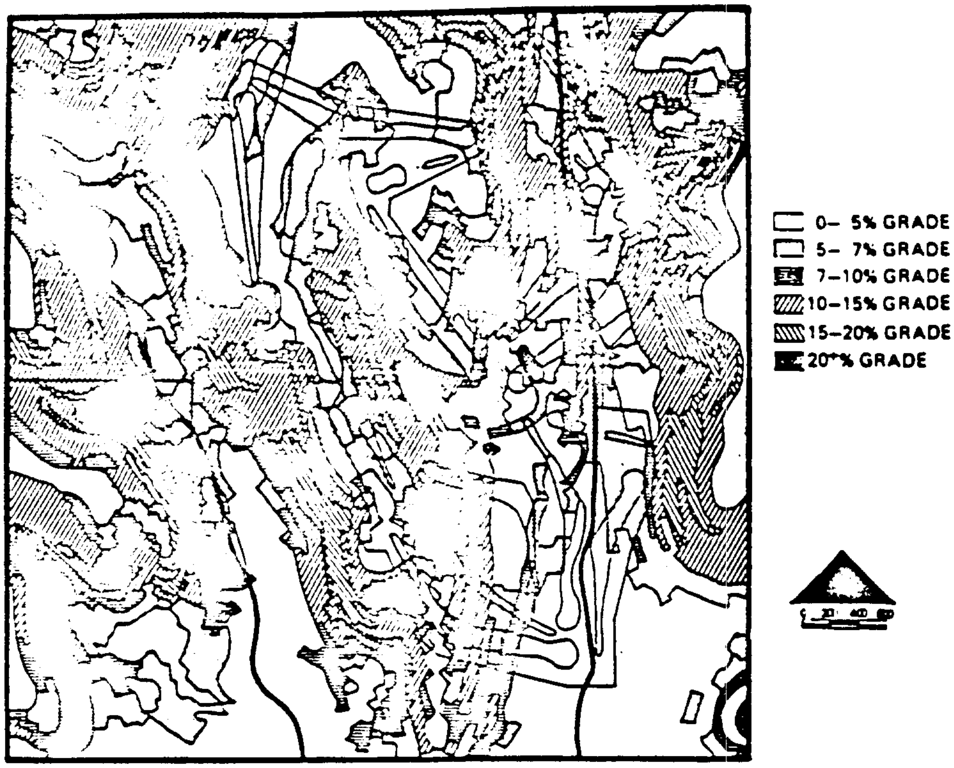
Physiography

Planning Considerations. Physiography is the study and description of landforms or irregularities of the earth's surface. Knowing the original topography, drainage, and vegetation of different landforms is important to minimize potential development problems and hazards in siting/design of building and grounds.

States generally have several major physiographic divisions, which can be further broken down into major landforms. These landforms and divisions are combined and described by the USDA SCS's major land resource areas (MLRAs). An MLRA is a land area characterized by particular soil patterns, including slope and erosion, climate, water resources, and land use. The Agricultural Handbook (U.S. Dep. Agric. 1976) describes each MLRA in the country.

The most important physiographic element to the developer is site topography. Topographic information is critically important because hills and valleys, plateaus and ridges, height, and slope degree all affect the area's ecology and suitability for development. Topography influences the type and cost of development, controls the direction and rate of water runoff, influences the overall utility layout, adds variety to the landscape, influences the weather and climate, and affects the types of vegetation and wildlife. A slope analysis (Figure 12.2) performed on hilly sites determines the best land uses for various portions. Moderately sloping sites are preferable to steep or level land. Improvement costs rise sharply on slopes over 10 percent, unless they are specially planned and treated. Preserving the area's natural amenities—trees, terrain, and views—can significantly reduce development costs.

Figure 12.2—Slope analysis for hilly site.



Source: Rubenstein, 1980.

Development Guidelines

- Obtain a topographic site survey before purchase. A thorough topographic survey will provide such physiographic data as the elevation, amount, and direction of slope, ridges, and valleys; location of rivers, lakes, sinkholes, and wetlands; outline of wooded areas, rocky areas, or outcroppings; and scenic vistas.
- Preserve the natural topographic features. This step involves preserving floodplains, streams, sinkholes, and other waterbodies by building well back from their edges, thereby creating common open space along shorelines.
- Let the topography guide the land use plan. A community designed in harmony with nature benefits from the services provided by nature, uses the natural landscape rather than creating a new, artificial landscape, and requires less time, effort, and expense.
- Control or prevent development on steep slopes, highly erodible soils, and areas with threatened or endangered species.
- Place roads parallel to the contours on ridges to minimize the need for cut and fill. Stabilize cut and fill banks with minimum maintenance materials to prevent continuing erosion problems.
- Use cluster development when sites contain steep slopes or other physiographic characteristics that would increase development costs or disrupt the natural systems.

Sources of Information

- On-site inspection. This visit is the cheapest, most thorough, and most reliable source of information. However, the inspector must be knowledgeable and experienced.
- U.S. Geological Survey. Topographic quadrangle maps are reliable for actual to-

pography, but the scale and contour interval are usually too large to be useful for smaller properties. The maps also show location of urban areas, constructed structures, highways, railroads, waterbodies, and other physiographic features.

■ **USDA SCS.** Detailed soil surveys, which include aerial photographs, delineate general slopes, wet areas, and other sensitive areas.

■ **Aerial photographs.** These photos can help one get the feel of an area, although thorough, accurate interpretation usually requires the services of a professional. Aerial photographs may be available from a state transportation or revenue department, regional planning commission, county tax assessor's office, or private firms authorized to sell aerial photographs.

■ **Local registered land surveyors.** These professionals can supply and interpret site topographic maps.

Hydrology

Planning Considerations

■ **General hydrology.** This science explores the behavior and properties of water in the atmosphere and on and under the earth's surface. The movement and exchange of water between the earth and atmosphere is called the hydrologic cycle. Although most areas receive adequate annual precipitation, a large portion is returned to the atmosphere by evaporation from land and water and by transpiration from plants. Continued growth and development create more impervious surfaces, which increase urban runoff, much of which is then discharged to surface waters that ultimately flow into the sea. This represents a tremendous loss of valuable fresh water. To avoid water shortages and prevent lowered water quality, water management must become a primary factor in decisions affecting land use, population distribution, and the protection of our country's natural resources.

■ **Surface waters.** Surface runoff varies from place to place, depending on the timing and amount of precipitation, soil, topography, and nature of underlying rock formations and on whether the waters are lakes, estuaries, or coastal. Stream density is low where water, moving downward to the aquifer, is enhanced by thin or porous soils overlying the limestone. In other areas, stream density is high. In some systems, especially broad swamps or floodplains, the water moves slowly in broad bands. Some streams are almost entirely spring-fed and have a well-sustained flow. The flow of other streams consists largely of runoff or groundwater inflow. Flow varies greatly, with little or no flow during dry periods and high flows and floods during wet periods.

■ **Wetlands.** One of the country's most valuable resources, wetlands provide a natural way to manage and store water and maintain water quality. As extremely productive ecosystems, wetlands are vital fish and wildlife habitats. They provide a variety of benefits—such as cleaning water to maintain water quality, storing and dampening floodwater, recharging aquifers, modifying the climate, and providing recreational, educational, and aesthetic values—with no cost or maintenance. Unfortunately, many wetlands have been drained or altered so that they no longer provide these benefits. Development should not destroy or alter remaining wetlands; it should preserve or, where feasible, restore them by using their services (e.g., wastewater treatment, runoff management).

■ **Floodplains.** Flooding is a natural characteristic of all rivers, but one of unknown probability. Floodplains formed naturally as waterbodies exceeded their normal levels during periods of high precipitation. Because floodplains provide a place for floodwater storage and detention and reduce floodwater velocities, they function as nature's safety valve. Before humans changed the landscape, there were floods but no flooding problems. But since we began to encroach upon floodplains, problems have occurred, waterbodies have become degraded, and injuries and damages have escalated. Floodplain planning and management reduce these economic losses and the need to build expensive structural runoff management systems.

Floodplains also perform valuable environmental functions including wildlife habitat; recreational, aesthetic, and scientific needs; open space; groundwater recharge; water quality maintenance; and sediment control.

Development in floodplains usually reduces, modifies, or eliminates their ecological functions. It also places an economic burden on the general public, which must reestablish these functions through costly public works projects and pollution abatement controls such as runoff management systems.

■ Groundwater. This is one of the country's most valuable, and in many places abundant, resources. Many areas are underlain by thick, porous, and permeable layers of sedimentary rock that serve as prolific groundwater resources and yield tremendous quantities of fresh water. These underground reservoirs are called aquifers. The two main aquifer types depend on their geologic development condition. One type is the nonartesian or unconfined aquifer, not covered by an impervious layer, the upper surface of which is sometimes referred to as the water table. Withdrawal requires pumping or directly using exposed surface water. This surface aquifer is usually recharged by local precipitation and is vulnerable to contamination from overlying land uses.

The other type is the artesian aquifer, confined above by a less porous or impermeable layer and under sufficient hydrostatic pressure to cause the water to rise over the containing layer to outlets such as springs or sinkholes. The potential for aquifer contamination is present where connections or inlets are made from the land's surface to the artesian aquifer, either naturally or artificially.

Because artesian aquifers supply many people with drinking water, sinkholes and other inlets to the groundwater system must be protected from pollution. Many areas have maps that depict the approximate altitude of the top of the rock or sediment that composes a particular aquifer. These maps can determine where the aquifer rock is exposed at or near the land surface. Development in such areas must be carefully planned to prevent aquifer contamination.

Many aquifers are recharged in areas where the aquifer's hydrostatic pressure head is lower than the water table. These areas should be protected by special development review requirements—such as the Wellhead Protection Ordinance—to ensure that the recharge potential is not diminished (i.e., by limiting impervious surface area) and that inappropriate land uses, which employ potentially polluting substances, are not allowed within the area.

In coastal areas, special care must be taken to prevent salt water intrusion into the aquifer. In these areas the aquifer's permeable limestone is shielded against upward intrusion of salt water by relatively impermeable beds of clay and marl but not against lateral encroachment of seawater. Such encroachment can result from overdrainage by canals or from overpumping the aquifer. Proper planning and water management are becoming increasingly important in protecting our nation's supply of potable groundwater.

General Design Guidelines

■ Postdevelopment runoff from the site should approximate the rate of flow, volume, and timing of runoff that would have occurred following the same rainfall under predevelopment conditions to preserve riparian areas and streambanks.

■ Thoroughly map all waterbodies, recharge areas, and natural water retention/storage areas as part of the topographic survey. This survey determines existing drainage patterns, delineates wetlands protected by law, defines the area of floodplains in which special building regulations may apply, and identifies vital recharge areas. Depending on the size and type of development, some delineation, description, and engineering evaluation of the surrounding watershed may be appropriate.

■ Preserve the existing natural runoff management system. When incorporated into the area's overall runoff management plan, natural systems provide water quality and storage benefits more efficiently and less expensively than a constructed system. The natural runoff system components may also provide open space and recreational opportunities.

■ Restore and rehabilitate degraded wetlands. Reestablishing the natural hydrology and integrating the wetlands into a final component of the site's runoff management system realizes many natural benefits of wetlands, including runoff pollution removal through retention and detention.

■ Lands that contain waterbodies should be developed using techniques such as planned unit developments or clustering. In planned communities, sensitive areas such as flood-

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plains and wetlands are preserved to provide their natural functions, including runoff pollution control. Additionally, planned developments can reduce site development costs and provide residents with an enhanced quality of life.

- Preserve or restore natural shorelines and stabilize shoreline vegetation. In the natural state, shorelines are relatively erosion-resistant and represent an equilibrium of many forces. The irregular convolutions fulfill important functions such as holding soils, reducing surface runoff and erosion, percolation, filtering runoff, and providing food and habitats for aquatic organisms.

- Avoid alteration of natural stream channels. Disturbances can devegetate and destabilize the stream channel and bank, causing loss or alteration to the habitats of aquatic animals.

- Plan water-related developments to maximize the land potential and still protect natural resources such as riparian habitat. In Figure 12.3, Plan B allows for scenic vistas from the highway, maintains part of the shoreline for public use, provides public and private access, and increases property use, thereby increasing the developer's potential return.

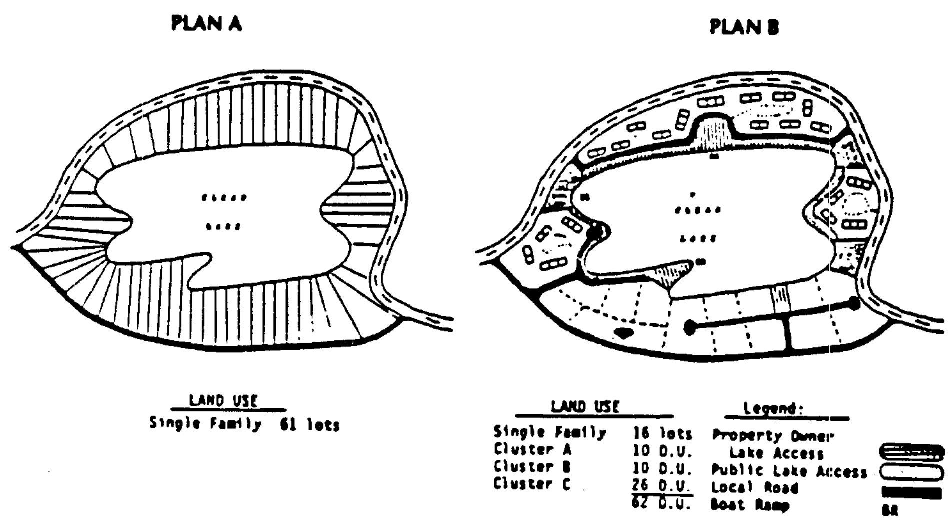
- Establish buffer zones, either fixed or variable—the size depends on soils, slopes, and floodplain—along all waterbodies. Buffer zones protect adjacent developments from the water and protect the water from the developments.

- Vegetated filter strips that filter runoff before it reaches the water should be left in a natural state or reestablished if clearing has occurred. Alternatively, a swale and berm system can be set back from the shoreline. This system slows and filters runoff from the development and can be used as a recreational area (e.g., jogging trail) during dry periods.

- Waterfront property frequently has steep slopes as it descends to the water. Areas without natural vegetation can be terraced, increasing potential use and reducing runoff and erosion. This is especially effective when a swale and berm system is incorporated into the terrace system.

- Do not remove shoreline vegetation to create a sandy beach. Removing vegetation destroys roots that stabilize soils and eliminates the natural filter and habitats for aquatic animals. If shoreline vegetation has already been removed, local native plant varieties suitable for the site conditions can be

Figure 12.3—Plan to maximize land potential and protect natural resources.



D.U. = Dwelling units
Source: Livingston et al. 1988.

replanted. Access to water is best accomplished via boardwalks, decks, or pier structures. If a sandy beach is essential, remove vegetation only on a small part of the shoreline—less than 20 percent or as allowed by state or local regulations.

■ To minimize maintenance and reduce nutrients introduced into the waters, maximize the use of native plants in landscaping, especially those requiring little water (xeriscape). Avoid using introduced varieties and lawns requiring fertilization, especially in waterfront areas.

■ If on-site wastewater disposal systems are used on waterfront properties, place them as far as possible from the water, preferably in front yards. Base minimum setback requirements on soil, geology, hydrology, groundwater, and other characteristics that influence environmental effectiveness and safety. Alternative on-site disposal systems, such as aerobic units, may be required in some areas to protect the environment from nutrient and pathogen loadings. In other areas, site conditions may make on-site systems unreliable and likely to cause adverse health and environmental impacts.

■ Groundwater recharge areas should have low-density development with limited impervious surface. To augment the recharge ability of a developed area, retain runoff onsite and allow it to infiltrate. If possible, treated wastewater should be recycled and allowed to percolate into the soil (i.e., use treated effluent to irrigate lawns, open spaces, or golf courses).

■ In areas with high water tables, avoid contaminating the groundwater. Use on-site disposal systems only with 4 ft (1.22 m) of suitable soil between the drainfield bottom or percolation pond and the water table to ensure that the effluent is properly filtered.

■ Fill should not be placed within the 100-year floodplain, as this increases flood heights and velocities. It also moves sediment into receiving waters, causing associated problems. In addition, locate only low-intensity land uses (i.e., open space, recreation, silviculture, and agriculture) with appropriate best management practices within the floodplain.

Information Sources

■ **U.S. Geological Survey.** With offices throughout the country, the USGS maintains a highly diversified database on water resources, ranging from hydrologic record networks to interpretive investigations of water resources.

■ **State departments or bureaus of geology.** These agencies may publish the results of local geological, hydrogeological, or water resources investigations.

■ **Water management districts or boards.** Some states have established regional water management (watershed) districts or boards with broad responsibilities to protect and manage water resources. They often conduct scientific investigations and administer certain types of water planning, management, and regulatory programs.

■ **State environmental protection, water quality, health, or natural resources agencies.** These agencies have a variety of resource management information and data, including pollution source permitting information. Agencies usually offer technical assistance, as well.

■ **USDA SCS.** With offices in nearly every county, USDA SCS provides technical assistance, conservation planning, and implementation services to local landowners. It also publishes detailed soil surveys that identify soil types and locate vegetation and waterbodies.

■ **Local governments.** Many city and county governments have water resources departments with considerable knowledge of local hydrology and water quality and quantity conditions.

■ **Regional planning councils or councils of governments.** These agencies often review and approval large developments and prepare and coordinate implementation of regional water management plans or programs. They usually serve as clearinghouses for planning and technical information and publications.

■ **U.S. Environmental Protection Agency.** EPA regional nonpoint source coordinators can provide resources and technical information. Regions work with state, federal, regional, and local agencies on pollution control efforts.

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Soils

Planning Considerations. In many instances, major soil-related problems are discovered after a site has been selected, with construction well under way or completed. These problems can cause construction delays and increase the project's total cost. By consulting a soil survey during the planning process, alternative designs can be prepared and sites selected. Knowing soil types, topography, and surface drainage patterns is beneficial in planning and designing almost any type of land development project; it is essential for erosion control planning.

With soil maps and accompanying supporting data in soil surveys, developers can determine the soil conditions in proposed construction areas. Modern soil surveys provide great savings of time and money and result in improved designs, more effective planning, and more accurate preliminary cost estimates.

A USDA SCS detailed soil survey is especially valuable in determining a site's suitability for a particular land use. These surveys contain aerial photographs that map soil classifications and other information. Detailed soil surveys also contain interpretations of soil characteristics, information on the soil suitability for selected urban uses such as wastewater treatment, community development, transportation facilities, recreation development, and water management. However, interpretations do not replace specific on-site investigations for engineering design and construction. Interpretations should be used primarily for land planning, evaluating land use alternatives, and planning site investigations prior to design and construction. Important soil properties and characteristics include permeability, infiltration, seasonal wetness and the water table, depth to bedrock, texture, shrink-swell potential, erodibility, and slope. Variations in soil properties affect the soil's ability to support heavy loads, serve as a medium for wastewater or solid waste disposal, percolate rainwater, hold its shape and slope after excavation, or grow vegetation.

Important soil characteristics needed for planning include

- **Erodibility.** This is the major soil consideration for erosion and sediment control. An erodibility factor (K) indicates the susceptibility of different soils to the forces of erosion. A soil survey report lists the K factor for each soil type within the survey area. These K factors are used in the Universal Soil Loss Equation to determine soil loss from an area over a period of time due to splash, sheet, and rill erosion. K factors can be grouped into three general ranges:

0.23 and lower	low erodibility
0.23 to 0.36	moderate erodibility
0.36 and up	high erodibility

Soil particle cohesiveness varies with different layers of the same soil, causing varying degrees of erodibility at different depths. Therefore, excavation depth must be considered in determining soil erodibility on a construction site.

- **Permeability.** Permeability is a major factor influencing erosion. Soil permeability is the quality that enables soil to transmit water or air. Deep, permeable soils are less erodible simply because more rainfall soaks in, reducing surface runoff. Permeability, which varies with different layers, must be considered when excavating. Antecedent soil moisture conditions also affect soil permeability.

The hydrologic soil group (HSG) is a direct indication of the soil's infiltration rate. Soils are grouped into four hydrologic soil groups, according to their infiltration and transmission rates:

A. Soils with high infiltration rates even when thoroughly wetted—low runoff potential.

B. Soils with moderate infiltration rates when thoroughly wetted.

C. Soils with slow infiltration rates when thoroughly wetted.

D. Soils with very slow infiltration rates when thoroughly wetted—high runoff potential.

- **Texture.** Soil texture refers specifically to the proportions of clay, silt, and sand smaller than 2 mm (.08 in) in diameter contained in a soil mass. Soil texture is a primary factor in erodibility and is reflected in the erodibility factor. Erodibility increases with greater silt and very fine sand content and decreases with greater sand, clay, and organic matter content. Soils with high clay content are generally more resistant to detachment; but once detached, clay particles are easily transported. These clays and silts are very difficult to settle out once they get into the water column, sometimes necessitating the

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use of coagulating agents to prevent their discharge into conveyances or receiving waters.

- **Shrink-swell potential.** Certain soils have clays that shrink when dry and swell when wet. In this situation, special foundations are required to allow for this variation. Identify these soils by consulting the soil survey and take the necessary precautionary steps.

- **Flood hazard.** Although soil survey information does not replace hydrologic studies, it does estimate where floods will likely occur. The hazards of flooding and ponding for various soil types are rated in soil surveys, and flood-prone areas are shown on survey maps.

- **Soil reaction (pH).** Soil survey information includes the pH of the individual soil layers. This factor is used to plan vegetation on disturbed areas, especially critical slopes.

- **Wetness.** Soil surveys have many types of data available including natural soil drainage, depth-to-seasonal water table, and suitability of winter grading for various soils. With this information, engineers can determine such things as seasonal limitations on using heavy, earth-moving machinery and estimating flood hazards or damage to underground structures due to soil wetness.

- **Depth to bedrock.** Soil surveys indicate bedrock types and where bedrock will be encountered at a depth of less than 5 to 6 ft (1.52 to 1.83 m). This information is helpful in determining location, time, and cost of excavation.

- **Slope.** Soil surveys record slope ranges and identify areas where cuts and fills are needed. The longer and steeper the slope, the greater is the potential for soil loss due to increased velocity of surface runoff.

Soil surveys are also helpful in interpreting the effect of soil properties on various land uses. For example, an interpretation may determine that soil can be used as topsoil, road fill for highway subgrade, or sand and gravel. The interpretations also show soil limitations for such purposes as building foundations, highways, streets, roads, parking lots, pipelines, underground utility lines, and septic tank absorption fields.

Often the survey will provide adequate information; sometimes it may only provide warnings or indications of soil-related problems likely to be encountered. In this case, a more in-depth, on-site investigation may be needed.

Design Guidelines

- Use the detailed soil survey or map the soils to help develop the land use plan. Knowledge about the location of wet soils, high water tables, clay soils, erodibility, and slope can help prevent many problems.

- Use USDA SCS and/or Soil and Water Conservation District expertise to develop a conservation plan that minimizes erosion, sedimentation, flooding, and nonpoint source pollution. The USDA SCS has soil, plant, and water resource data; technical information; and standards and specifications for BMPs that apply to most local areas.

- Follow the USDA SCS's "seven principles of erosion and sediment control":

1. Plan the development to fit the site's topography, soils, drainage patterns, and natural vegetation.
2. Minimize the extent and duration of the area exposed at any one time.
3. Apply erosion prevention control practices to minimize erosion and on-site damage.
4. Apply perimeter control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.
5. Keep runoff velocities low and retain maximum amount of runoff on-site.
6. Stabilize disturbed areas immediately after final grading.
7. Implement a thorough maintenance and follow-up program.

Information Sources

- **USDA SCS and Soil and Water Conservation District.** USDA SCS generally has a state office along with regional and county/district offices and detailed soil surveys for many counties. It continues to map soils in those areas without soil surveys. In addition, the USDA SCS/district provides technical assistance in conservation planning and other issues to local landowners. The state office usually publishes a directory of USDA SCS offices and staff.

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Vegetation and Wildlife

Planning Considerations. As more people become urbanites, the value of plants and animals in a development increases. Aesthetically, landscaping and its accompanying wildlife provides residents with a sense of well-being and enhances the quality of life. The living resources in a well-planned development can effectively bridge the gap between the created and the natural environment.

Plants and animals also prevent and solve environmental problems in a development. For example, the variety and abundance of plants and animals in an area are important indicators of natural conditions and can interpret a site's constraints and opportunities (Table 12.2). Vegetation and wildlife also provide many other benefits (Table 12.3).

The importance of vegetation as an economic incentive has risen greatly in recent years.

Table 12.2—Vegetation indicators of site conditions.

ABSENCE OF PLANT COVER	SPARSE HERB AND SHRUB COVER	THICK HERB AND SHRUB COVER	BRUSH AND SMALL TREES	BLADE AND REED PLANTS	HIGHLY LOCALIZED TREE COVER
Bedrock at or near surface	Bedrock near surface	Recently logged or burned	Landslide/fire, flash flood scars	Organic soil, standing water	Wet depression, steep, organic soil
Active dunes	Recent, sterile soils/dunes, fill	Too wet for trees	Old field or woodlot regrowth	High-ground water table	Slopes in agricultural areas
Recent human use, cultivation	Recently disturbed (fire, flood fallow)	Managed grazing	Shale/clay substrate	Springs, seepage zones	Flood-prone areas
Recent fire	Active slope or erosion	Organic soil	Organic soil		
Recent loss of water, cover		Old field regrowth	Moisture deficiency		

Source: Marsh, 1978.

Table 12.3—Benefits of plants and animals in a development.

	VEGETATION	WILDLIFE
Recreation	Exercise trails Nature trails Tree climbing, swings	Bird watching Nature photography Fishing
Environmental	Absorb carbon dioxide Produce oxygen Protect watershed (filter runoff and reduce runoff speed) Screen wind, rain, sun Cool air Buffer noise Wildlife habitats	Recycle and redistribute nutrients Propagate vegetation Control pest species Preserve genetic stock
Aesthetic	Screen incompatible land use activities Provide attractive, diverse scenery Influence walkways	Provide enjoyment of wild animals

Source: Marsh, 1978.

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Table 12.4—Comparison of specific site effects.

VEGETATION AND WILDLIFE AREAS	6,000-ACRE PLANNED DEVELOPMENT	6,000-ACRE UNPLANNED DEVELOPMENT
Acres of semimature woodland developed[1]	8	35
Acres of mature woodland developed[2]	35	90
Miles of tree-lined roads incorporated into developed areas	1.3	.9
Miles of tree-lined roads widened	0	1.3
Acres of wildlife habitat developed	10	235
Number of interruptions in wildlife corridors	0	4

[1] Clearing semimature woodland at $650 per acre would cost $5,000 in the planned community and $23,000 in the sprawl community.
[2] Clearing mature woodland at $1,600 per acre would cost $56,000 in the planned community and $144,000 in the sprawl community.

Source: Quennel, 1972.

More developers are incorporating existing vegetation into site plans because of the high costs of land clearing and landscaping. The initial cost per acre may be higher when working around trees and other natural areas. However, because the total number of acres cleared and the amount of landscaping is smaller, the total cost is reduced. Table 12.4 compares the cost of a planned and an unplanned development.

Residential preference surveys identify parks and green spaces as important reasons to choose one neighborhood over another. Realtors have found that wooded lots consistently bring higher prices than those without vegetation. For example, in residential areas, a mature shade tree may have an estimated value of $1,000 to $3,500; other plantings may improve the real estate value of an average lot by $3,000 to $7,000.

Resource Inventory. The diversity in landforms and climate has produced a variety of habitat types that contain different combinations of plants and animals. Investigating a site's biological communities is essential to understanding the site's importance to the integrity of the ecosystem. Identifying and assessing plant and animal resources is an important part of site planning. Species could be identified and mapped, along with other site inventories such as hydrologic, physiographic, geologic, and soil surveys. Ultimately, these parameters must be considered together to develop a land use plan that balances ecological constraints and benefits with intended uses.

Vegetation. Natural vegetation is an important resource and habitat for wildlife. Inventory vegetation using a quality rating scheme from aerial photos and/or data from field surveys. Where the site is small (100 acres [40.47 ha] or less), interpreting photos may be as time consuming as field surveys. The following factors should be considered in analyzing a site's vegetation:

1. The number of distinct plant communities and their distribution;
2. The uniqueness of each plant community;
3. The presence of subareas that have recently been disturbed (e.g., clear cutting, cultivating, grazing, burning, bulldozing);
4. Accessibility of the area; and
5. Correlation with the site's physiographic features.

The inventory is used to document what plants occur naturally on the site, identify the forces and processes controlling their distribution, and determine where to find certain plants or plant groups. If the site has been environmentally degraded or overtaken by exotic species, readily determining the natural vegetation and environmental relationships may be impossible. Consult with local botanists, state foresters, and other

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trained professionals or examine historical records and photos to establish types and distribution of native vegetation.

■ **Wildlife.** Local wildlife can be inventoried directly by taking a population census or indirectly by assessing the quality of local habitats. Habitat analysis is the simpler approach, as the analysis can be performed from secondary sources (e.g., aerial photography). Consider the following terrestrial ecosystems factors in the analysis:

1. The number and types of plant communities per unit area,
2. The number of forest or woodland openings,
3. The presence of water,
4. The presence of movement corridors,
5. The size of the area, and
6. The variety of the wildlife appropriate to the habitat.

The value of wetland areas that support a rich variety of wildlife primarily depends on water quality. As with terrestrial ecosystems, perform separate habitat analysis for species requiring different habitats.

To take a population census, seek the help of trained wildlife observers. Census methods range from direct observation to analysis of indirect evidence. Regardless of the method, survey wildlife populations at several points in time to account for natural environmental fluctuations.

Special consideration must be given to endangered species and their critical habitats. Agencies such as the U.S. Fish and Wildlife Conservation Service, the State Department of Natural Resources and the State Committee on Rare and Endangered Plants and Animals list endangered species. However, state statutes will usually specify which organization's list is officially recognized.

▮ *Design Guidelines.* The resource inventory and site surveys should examine basic structural, functional, and locational patterns. If the area is in a natural state, these elements probably work effectively to support the living community. If the area is a constructed landscape, the natural systems may be degraded and work marginally, if at all. In either case, the plan should aim for compatibility between natural and constructed environments. A degraded natural system can be strengthened or even fully restored by a carefully planned development. For example, ditched and drained wetlands can be revitalized by introducing pretreated runoff.

The following principles will help developers plan for wildlife and vegetation, in consultation with local biologists familiar with the areas:

■ **Transition zones.** This zone between two habitats—such as the area between two forests or between a forest and a waterbody—is extremely important to wildlife. It supports wildlife not found in either habitat. Often the transition zone provides an exclusive habitat for a very selective, sometimes endangered, species or community of species.

■ **Water.** Proximity to water enhances an area's ecological productivity. Swamps, marshes, and bogs support a rich variety of plants and animals—many of which are valued as game species. Saltwater wetlands are important breeding grounds for fish and crustaceans.

■ **Alternative habitats.** Other habitats where wildlife may relocate have potential impacts, especially on endangered species.

■ **Timing of construction.** Construction should be timed to avoid critical periods in vegetation and wildlife reproduction, especially for threatened or endangered species.

■ **Choice of plantings.** Wildlife existence, both in number and quantity of different species, depends on habitat availability. Choice in planting or preserving specific habitats can effectively encourage certain wildlife species. When transplanting, include varying age classes of trees and shrubs. Select native species, especially those that require little fertilization, pesticides, or water, instead of troublesome exotic species.

■ **Animal-plant interactions.** Developments that reduce the wildlife that some plants depend on for reproduction may eventually eliminate these plants. For example, berry-producing plants depend on birds for seed propagation, and furry mammals often help distribute thorny seeds.

■ **Exotics.** Exotic species may compete with native varieties and eventually become nuisances. Sites with communities of exotic species may be good areas to develop and reestablish native communities.

Table 12.5—Comparison of six community types.

PROTOTYPE	COMMUNITY DESCRIPTION*	IMPACTS TO VEGETATION AND WILDLIFE
Type I: Planned Mix	20 percent of each of the following — single-family conventional, single-family clustered, townhouses, walk-up apartments. 2,000 units of each type. Neighborhoods are contiguous; large areas of open space are preserved.	Less species disruption where significant tracts of land are preserved as permanent open space.
Type II: Combination Mix	50 percent planned unit developments with contiguous and related land uses; 50 percent sprawl pattern. Housing mix same as Type I.	Greater disruption than in Type I. Open areas can be retained.
Type III: Sprawl Mix	Random, leapfrog development with many small lots vacant. Housing mix same as Type I.	Similar to Type I. Leapfrog development pattern bares only small pockets of undisturbed area.
Type IV: Low Density Planned	75 percent of dwelling units single-family clusters; 25 percent conventional, single family. Contiguous neighborhoods, but low density with vacant lots. Open spaces preserved, land uses comprehensively designed.	Low density development decreases amount of open land preserved in natural condition. Careful planning can protect areas of special significance as species habitats (i.e., woodland, swamp).
Type V: Low Density Sprawl	Most prevalent form of current development. 75 percent of dwelling units are conventional single-family; 25 percent are clustered single-family dwellings. Small percentage of passed-over land.	Virtually no land will be left totally undisturbed, thus eliminating habitats and causing a disruption in ecological balance.
Type VI: High Density Planned	10 percent of dwellings clustered single-family; 20 percent townhouses; 30 percent apartment; 40 percent high-rise apartments. Housing types are mixed with contiguous neighborhoods. Planned open spaces, related land uses.	Adverse effects lessened through careful planning to conserve special habitats and through high density development that preserves large tracts of undisturbed land.

* All communities contain 10,000 dwelling units
Source: Quennel, 1972.

■ **Fish.** Fish population in lakes and streams is closely tied to water quality and habitat. A decrease in dissolved oxygen concentration below 5 parts per million or major changes in flow character—including temperature changes caused by removing shade trees—may eliminate valuable game fish. Excessive runoff loadings—e.g., nutrients, metals, sediments—will increase aquatic plant problems and eventually cause fish populations to shift towards more "trash" species.

■ **Coastal vegetation.** Coastal vegetation along sandy and estuarine beaches protects inland areas against wind and waves. Dunes and mangrove areas provide physical barriers against high tides, wind, and waves. Marshes act as sponges, absorbing water during storms and high tides.

■ **Natural stormwater systems.** Modified natural stormwater systems reduce habitat for frogs, snakes, and salamanders. Preserve and incorporate natural areas into a comprehensive runoff management plan. This plan should incorporate a "treatment train" of runoff management practices, along with natural and landscaped areas, into a multipurpose amenity for the development plan.

■ **Compare planning approaches.** Land development has often disturbed natural cycles and flows of energy, producing undesirable economic and environmental effects. Table 12.5 describes six community development prototypes.

Structural Considerations

■ Runoff management areas should double as open space, landscape, and wildlife habitats. Because edge conditions are important, designs that maximize edges will be most successful in drawing and keeping wildlife. Plant native plants such as canes, marsh grasses, and riparian shrubs around basin edges. Many of these plants have beautiful flowers, allowing a designer to aquascape the shoreline to enhance visual amenities and increase property values.

- Direct roads away from high quality natural habitat areas, especially wetlands.
- Networks of waterways can be effective in interweaving the constructed landscape with wild areas.
- Maintain proper water level in wetlands with spreader swales and outlet control structures.
- Disturb the smallest area possible, retaining the maximum natural vegetation.
- Avoid clearing, scraping, leveling, and constructing seawalls and buildings on beaches and dunes.
- Construct observation blinds and interpretive nature trails through natural areas to provide recreation and enjoyment of wildlife.

Nonstructural Considerations

- Confine planted lawns and grass mowing to small areas to enhance seedling and wildflower growth and increase buffer effects.
- Retain wildlife corridors that connect habitats and water areas.
- Help protect and maintain areas with rare and unique natural features, including endangered species.
- Use open space, blue-green design space, and green space. They serve as recreational areas, wildlife buffer zones, and increase the aesthetic appeal.
- Where large-scale planned development is the predominant pattern, improved site design and landscaping makes it easier to retain the natural ground cover.
- Leave a buffer zone of vegetation in its natural state along the shore of waterbodies and adjacent to wetlands.

Information Sources

- **State game and fish commission.** Information on various species and habitats is usually available from state agencies. Agencies may have a special nongame wildlife program to further wildlife conservation by detecting and preventing population declines in animal species before they reach the verge of extinction. Agencies usually have information to assist the developer in considering wildlife.
- **USDA SCS/District.** The USDA SCS publishes lists and guides to native vegetation species or those well adapted to local conditions. The USDA SCS operates plant material centers around the country to study plants to determine suitability for conservation use (e.g., erosion control).
- **State universities.** Frequently, a state designates a state agricultural school. The school may have several agricultural and environmental resource programs and typically will focus on three areas—teaching, research, and extension. Normally, a college of agriculture and school of forestry conduct university level instructional programs; the Agricultural Experiment Center conducts basic and applied research; and the Cooperative Extension Program disseminates information through extension directors in each county. Numerous publications on successfully growing plants are available from these offices.
- **Natural Areas Inventory.** This is a joint project between a state agency (e.g., Department of Natural Resources) and The Nature Conservancy to provide a detailed, computerized account of a state's native flora and fauna. The inventory could provide a planner or developer with information concerning natural communities for landscaping, restoration, or preservation.

Critical Area Identification and Protection

Planning Considerations. A primary objective in site planning is to identify and locate critical areas. Typically, these are environmentally sensitive areas that, because of their inherent characteristics or location, create certain constraints on development. These constraints usually include environmental concerns and often include economic considerations. The site planning process creates a development plan that minimizes disturbing critical areas and works them into the plan as natural areas and other amenities. Critical areas may include steep slopes, highly erodible soils, stream corridors, shorelines, wetlands, floodplains, native forests, karst geology, high groundwater tables, and other similar areas.

▌*Design Guidelines.* If possible, avoid developing critical areas. Use them instead as natural areas, open spaces, and parts of the runoff system. When designing guidelines for critical areas

- Avoid alteration or construction within natural drainageways, stream corridors, wetlands, floodplains, natural depressional storage areas, or on steep slopes.
- Maintain and protect dense vegetation adjacent to waterbodies and wetlands to serve as natural buffers and filter strips.
- Establish setbacks from all critical areas where no development is allowed.
- Preserve or limit the clearing of shoreline vegetation, which helps to stabilize the shoreline, filter pollutants, and provide habitat for fish and wildlife.
- Preserve porous soils to take advantage of infiltration capacity.
- Avoid disturbing highly erodible or unstable soils to minimize erosion and sedimentation potential.
- Preserve and incorporate the natural runoff management system.
- Protect and incorporate native forests to provide shade and wildlife habitat.

Cultural Factors

A site's suitability and a project's success are closely related to cultural factors that have a direct effect on future inhabitants. The following factors are important in gaining public acceptance of proposed projects.

Existing Land Use

▌*Planning Considerations.* The pattern of existing area land uses should be investigated to ensure compatibility. The developer should meet with adjacent property owners and local planning department staff to discuss the future development under consideration and if it will conflict with uses on the proposed site.

Investigate off-site nuisances—i.e., visual, noise, or odors—and safety hazards. Visually disruptive elements may include power lines, water towers, industrial complexes, highways, and junkyards. Possible noise disturbances include heavy automobile, rail or air traffic, or noise made by stadium crowds. Objectionable odors may originate in landfills, wastewater treatment facilities, and polluted waters.

In studying the site's location in relation to adjacent properties and the community, determine and assess all existing linkages. Linkages involve moving people, goods, communication, or amenities through an area. Inventory community facilities—shopping centers, schools, hospitals, employment centers, residential areas and recreation—determine if they can adequately serve the site. If not, make plans to improve them through future development.

Density—an important environmental, sociological, and legal element in most types of development—influences privacy, freedom of movement, and social contact among people. Local governments usually have zoning regulations concerning density standards to help maintain a certain quality of life. A project's permitability by the state environmental agency may also be related to density factors.

▌*Information Sources*

- **On-site inspection of the surrounding area.** Observation is the easiest way to determine the existing land use.
- **Local government planning or zoning departments.** Contact these agencies at the earliest planning stage to determine if the proposed development is acceptable. Many potential conflicts and delays can be avoided by discussing development plans with local officials during the conceptual design phase. Review local comprehensive plans and policies to ensure consistency with the proposed development.
- **Regional planning councils or councils of governments.** These agencies, frequently involved with long-term land use planning, should be contacted early in the development process, especially for large projects or those of regional significance.

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Traffic and Transit

▌ *Planning Considerations.* If the type and size of development is significant, investigate the adequacy of existing transportation facilities. This investigation should determine the relationship of traffic patterns, whether adequate roads exist or must be supplemented, and whether public transportation is available. Large projects may require a trip generation survey to determine the proposed development's effect on existing traffic patterns. The survey should consider traffic's origin and destination, its purpose, the time of day, and the traffic volume generated by inhabitants or project users.

The conventional gridiron street pattern produces an unsafe, unpleasant circulation system with arbitrary street dimensions, through traffic, visual monotony, and lack of neighborhood identity. A curvilinear pattern or clustering arrangement in residential developments minimizes through traffic, disruption of the natural terrain and landscape, and expenses associated with road construction and other improvements. Well-planned curvilinear and cluster planning developments reduce the length of roads, utility lines, and sewer and water mains. Compared to conventional development, clustering can reduce the total road and impervious surface area and the cost of roads by 14 percent and utilities by 33 percent.

▌ *Information Sources*

- **Local governments.** Consult with local authorities to determine any long-range transportation plans and improvements. Obtain copies of local land development regulations (e.g., subdivision, zoning, and land development codes) that contain specifications for street rights-of-way and construction. Some local governments will also have traffic count information.

- **State department of transportation.** This department schedules highway improvements and publishes them in a long-term construction plan. It also conducts traffic counts and analyzes the data.

Density and Zoning Regulations

▌ *Planning Considerations.* Communities use planning and zoning to effectively balance land uses such as recreation, conservation, residential, commercial, and industrial development. Establishing appropriate development densities and intensities—number of buildings per acre and building bulk versus remaining land on the lot—is a fundamental problem. As density and intensity of development increase, so does the stress on natural and financial resources. The goal of community planning and zoning is to minimize these stresses and ensure that public facilities—such as street, school, sewer, water, and runoff services—are adequate. Sound site selection and planning principles are indispensable in achieving this goal. Planning and zoning regulations also benefit the developer by protecting the housing market.

Some state legislatures have enacted local government comprehensive planning and development acts to assure responsible growth. These regulations usually requires local governments to develop comprehensive plans to address future growth. Plans are implemented by adopting land development regulations such as zoning ordinances and land development codes.

▌ *Information Sources*

- **State land planning agency.** This agency implements the growth management program and works with local governments to develop and approve local plans. Various types of planning information and technical assistance may be available.

- **Regional planning councils or councils of governments.** These agencies may have regional policy plans that serve as a foundation for local comprehensive plans and include policies to minimize the regional impacts of large developments.

- **Local governments.** Obtain specific regulations such as zoning ordinances, land development codes, local comprehensive plans, subdivision regulations, and housing codes before selecting a site and designing the project.

Socioeconomic Factors

▌ *Planning Considerations.* To determine a project's feasibility, study the community and its socioeconomic structure. Social factors broadly affect community facilities and services. New facilities may displace homes, businesses, or community activities. A new highway may sever an area's cohesion by creating physical or visual barriers that affect business, property values, and character. Stormwater facilities, especially regional systems, can be viewed as detrimental to an area or neighborhood. Local governments need to assure that such systems are attractive, properly maintained, and well-designed to include recreational opportunities.

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A market analysis can determine the socioeconomic feasibility of a project. Such studies help justify the need for the proposed development to local planning agencies. They also help ensure the developer a return on his investment. Generally, anticipate a building rate of 80 percent in 10 years, phasing development as demand warrants. Consider also the cost-effectiveness of rehabilitating income-producing historic structures listed in the National Register of Historic Places over new construction with the added benefit of investment tax credits.

Utilities

Planning Considerations. Every project should include provisions for six essential services—water supply, sewage disposal, solid waste collection, paved roads, runoff management, and utilities (electricity, telephone, gas). These services make a piece of raw land usable and shape its future resale value. Contact utility companies early in the site planning process to ensure that project needs can be met. Just as important, plan utility locations to minimize environmental disturbances on the site, and use appropriate erosion, sediment, and runoff controls during the installation of utilities to minimize adverse effects.

- **Potable water supply.** Water is probably the most critical basic need for community growth. Ensuring a continued, safe, adequate supply requires special planning. In addition to drinking water, most water systems provide fire protection, which requires high water pressure. If the area has no central water system, obtain information about the water quality for individual wells, the effect of many wells on the aquifer, and the potential for saltwater intrusion.

- **Sewage treatment and disposal.** In general, central wastewater treatment facilities should be provided for all lots under one-half acre (0.20 ha) and for any size lots not suitable for on-site disposal systems, either conventional or alternative designs such as aerobic units. Septic tanks should be used only on lots with proven adequate percolation rates, with slopes less than 12 percent, with bedrock and seasonal high water tables at least 4 ft (1.22 m) below the bottom of the drainfield, and with a distance of at least 200 ft (60.96 m) from any surface waters. Consider specific setback requirements for developments near water since the potential of these wastewater systems to degrade water resources depends on many variable, site-specific factors (e.g., soils, slopes, water table, geology, relative location).

- **Solid waste collection.** In rural areas, homeowners usually take refuse to a sanitary landfill or collection station. Urban subdivisions and commercial developments should include provisions for an authorized agent to collect solid waste to prevent litter and debris in runoff.

- **Streets and roads.** All roads should be built to county or municipal standards and dedicated to the local government for maintenance. In most cases, residential roads should be paved and include swales for runoff management. Storm sewers are needed only on more intensively developed projects; even then, swales could be a valuable component of the treatment train.

- **Runoff management.** The project should include a runoff management system that protects against flooding and ensures the water quality of receiving waterbodies. The system should meet local requirements (i.e., design storm) using the runoff management principles presented earlier.

Historic and Archaeological Resources

Planning Considerations. Thousands of recorded archaeological and historic sites, many listed on the National Register of Historic Places, demonstrate the nation's rich cultural heritage and colorful history. Many communities have historic structures of exceptional architectural quality and appeal. Many archaeological sites have high scientific and cultural value. As urban populations increase, so does the demand for more comprehensive protection of historic and archaeological resources. This demand should be considered in land development decisions.

Include an inventory of all historic and archaeological elements in development planning. Infrastructure planning is important because of the special requirements for preserving older buildings, streets, significant structures, and unique landforms. Architecture, landscape, and other design studies that affect the total environment should not conflict with existing cultural themes. On the contrary, development projects that blend into the cultural atmosphere can produce attractive and lucrative developments.

Historic structures and archaeological sites can have valuable and important community uses, while preserving their cultural value. Urban environments that are functional and offer a sense of community identity have many benefits for the developer, the residents, and the community.

▮ *Information Sources*

- **Local governments.** Consult local governments for assistance with identifying and restoring culturally significant buildings and other structures and sites. Many local governments have designated historic districts that impose special development regulations. A comprehensive plan may also be a valuable resource.

- **State government.** The state may have a bureau of historic preservation that records all existing historic and archaeological sites. It may also help evaluate an area's historic/archaeological significance and the impacts of development on significant sites.

Aesthetics

Aesthetic factors should also be analyzed on development sites. These factors can differentiate a "typical" development from one with extraordinary appeal and intrinsic beauty and value. A development with carefully considered and incorporated natural features and spatial patterns will have a greater appeal because of its community character.

Natural Features

▮ ***Planning Considerations.*** The landscape of the United States provides many sites with outstanding natural earth, water, and vegetation features. Incorporating mountains, rolling hills, oceans, lakes, streams, wetlands, forests, sinkholes, and springs into the development accents its architecture, reflecting the area's natural character rather than competing with it.

Spatial Patterns

▮ ***Planning Considerations.*** A site's spatial patterns include factors such as views or scenic vistas. Views, pleasing or objectionable, frequently bear heavily on a building's orientation. An outstanding view should be preserved or accentuated. Views must also be compatible with proposed activities and their relation to each other, because nuisances both on and off the site may disrupt them. Vegetation, slope, fences, or walls can screen objectionable odors, noises, or visual elements such as billboards, power lines, junkyards, or parking lots. Power lines can be placed underground, and parking lots can be depressed below grade and heavily landscaped.

Other Nonstructural Management Practices

Many of the varied nonstructural management practices and source controls available are good examples of common sense and a stewardship ethic. Nearly any technique that reduces the potential adverse impacts of our daily activities on a watershed's natural resources can be considered a nonstructural control. Following is a brief discussion of common nonstructural or source controls. Many can be incorporated into local land development codes, while others require a commitment of all residents for success.

Site Characteristic Practices

- **Buffer zones or critical area zones.** In these areas, special design and performance criteria may apply and a naturally vegetated zone is maintained. Land development codes often establish a minimum distance that the zone must extend from a sensitive feature, depending on a variety of site specific characteristics.

- **Setbacks.** Discrete distances—such as the distance between a septic tank and a well, shoreline, or stream—are established by state or local regulations and used to protect sensitive areas and meet environmental goals. Both setbacks and buffer zones can be protected by a variety of legal mechanisms including purchase, easements, or conservation easements.

- **Minimum natural area.** Some local codes specify a minimum portion (e.g., 20 percent) to be maintained in its natural condition, unless the site is already degraded, to preserve critical features and reduce overall development impacts.

- **Landscaping and tree protection.** Local codes often specify landscaping requirements (e.g., plant types and sizes) and protect certain trees, usually based on diameter and species, to reduce clearing. This protec-

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tion reduces erosion, sediment, and runoff problems. These requirements, together with any requirements for minimum natural area, must be carefully integrated to assure compatibility.

■ **Shoreline vegetation management.** Shoreline vegetation protects and enhances waterbodies. Clearing for waterfront development should be limited to a minimum. Developers, waterfront property owners, and local governments should practice aquascaping by establishing diverse, aesthetically pleasing native aquatic plants along shorelines of runoff ponds, lakes, streams, and other waterbodies. Restoring these watershed resources can reduce the need for more expensive structural controls.

Characteristic Practices of Natural Runoff

Minimize Impervious Surface Area

Limiting impervious area is the most effective way to preserve a site's predevelopment runoff characteristics. Local codes may specify the maximum proportion of impervious cover allowed (e.g., 75 percent). Techniques include

■ Reducing building setbacks, which reduces the lengths of driveways and entry walks. This technique is most applicable along low-use residential roads where traffic noise is not a problem.

■ Reducing street widths by eliminating on-street parking or reducing lane width is most applicable to residential neighborhood roads.

■ Reducing sidewalks to one side or combining them with bicycle trails/walkways that go through back yard easements or natural areas. Whenever possible, these trails should be made of pervious materials.

■ Using pervious pavement materials, such as pervious asphalt or pervious concrete, gravel, or combinations of geotextiles with sand, gravel, and sod. Take care when using pervious pavements to prevent clogging. Special design, preparation, batching, pouring, and finishing procedures, along with long-term maintenance needs, require that these pervious pavements be used appropriately.

■ Using alternative development designs, such as cluster development, to reduce the length of roads, sidewalks, and other impervious areas.

Preserve and Mimic the Natural Runoff System

Traditionally, runoff systems were built solely to convey runoff away from homes, buildings, and developed areas as quickly as possible, with little regard for its effect on downstream land or water resources. Techniques that promote infiltration by slowing and filtering runoff include

■ Routing roof runoff to pervious areas, such as lawns, grassy swales, or depressed landscaped areas. Prohibit connecting downspouts directly to storm sewers or discharging downspouts onto parking lots, driveways, or other impervious areas.

■ Protecting floodplains, wetlands, natural depressional storage areas, and highly pervious sites. Incorporate them into the final runoff management plan as part of the treatment train.

■ Using grassy swales instead of storm sewers as runoff conveyances, especially in residential developments. Swales, especially those with check dams or raised driveway culverts, encourage runoff capture and infiltration. Use public education to teach citizens that water standing in a swale for a day is not bad and to prevent citizens from altering or using swales to dispose of yard materials or other garbage.

■ Using depressional landscaping techniques that allow small areas, including landscaped islands within parking lots, to provide some storage and infiltration.

■ Placing storm sewer inlets in grassy areas instead of paved areas. For example, a successful treatment train within a shopping center parking lot consists of landscaped areas around the perimeter that includes a grassy swale adjacent to the curb line. Regularly spaced curb openings (curb cuts) allow runoff to flow off the parking lot into the swale. The swale conveys runoff toward a storm sewer inlet, raised about 6 in (15.24 cm) above grade, and then to a wet detention basin. Depressed landscape islands with curb cuts contain storm sewer inlets, also raised 6 in.

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Good Housekeeping Practices

Practices that reduce sources of potential pollutants in runoff should be undertaken by all watershed residents. Public education is vital to acceptance and use of these practices.

- **Street or parking lot sweeping.** Particles that accumulate along streets and on parking lots should be removed before they enter the runoff waste stream. Mechanical broom sweepers effectively remove particles larger than 400 μm but cannot remove smaller particles that contain the majority of street pollutants. Vacuum sweepers, more efficient in removing smaller particles, are ineffective on wet pavements. While street sweepers undoubtedly remove large quantities of solids and other materials from streets and parking lots, their effectiveness depends on many factors. Using street sweepers regularly in highly impervious areas like central business districts may be one of the only effective BMPs for a highly developed area. Research must determine if materials collected by street sweepers pose any environmental threats and how to dispose of this material.

- **Detecting and prohibiting illicit connections.** Illicit connections of sanitary sewers, industrial discharges, commercial floor drains, sump pumps, and basement drains greatly contribute to water quality problems caused by runoff. These often serve as conduits that introduce solvents, oils, and even toxic materials into runoff. Local governments should conduct regular investigations (i.e., smoke tests, dye tests, dry weather flow sampling) to detect and eliminate illicit discharges.

- **Proper handling, use, and disposal of fertilizers and pesticides.** Controlling the rate, timing, and method of chemical applications can minimize use and limit runoff contamination in a watershed. Many state agricultural agencies provide educational materials on the proper type and amount of fertilizers needed for a particular landscape. U.S. Department of Agriculture agencies provide fertilizer and pesticide management guidance in selecting the most environmentally safe chemical and minimum effective dosage.

- **Proper handling, use, and disposal of household chemicals.** A wide variety of cleansers, oils, solvents, paints, and other household materials pose certain risks to the environment. Some wastes are legally defined as hazardous or toxic and must be disposed of using stringent procedures imposed by federal, state, or local laws. Some states have established programs such as amnesty days that encourage citizens to safely and freely dispose of potentially hazardous household wastes. Citizens need to know how to safely use and dispose of many household materials including antifreeze, gasoline, waste motor oil, car batteries, old tires, floor or furniture polish, most cleaning products, chlorine bleach, paints, paint thinners, turpentine, mineral spirits, wood preservatives, weed killers, and roach and ant killers.

- **Proper solid waste management.** Solid wastes and litter that accumulate on the land are easily transported by runoff. Properly collecting and disposing of solid wastes—and recycling appropriate materials—can greatly reduce runoff pollutant loadings. Litter laws, adopt-a-road or shore programs, and econeighborhood programs are effective in encouraging citizens to "clean their own nests."

- **Proper disposal of pet wastes.** The wastes our pets leave behind can be a major source of bacterial loading to our waters. Requiring owners to properly dispose of animal wastes can help reduce these loadings and keep our waters open to recreation.

- **Recycling used waste oil.** Many gallons of waste oil are dumped into storm sewers for disposal. However, this oil can be recycled and used for many activities. Many states, local governments, and private companies have established used-oil recycling programs and centers.

- **Organic debris disposal.** As laws limiting the landfill disposal of yard wastes become more common, the proper management of grass, leaves, pruned branches, and other debris becomes increasingly important. Composting by homeowners or at collection centers reduces organic debris and associated pollutants from the runoff waste stream. Additional benefits include increased soil organic matter, resulting in improved water and nutrient holding capacity, and nutrients, which reduce the need for fertilizers.

Roofing or otherwise enclosing areas. Loading docks, storage areas for raw materials, wastes or final products, and equipment maintenance and storage areas are likely pollutant sources carried in runoff. Roofing or enclosing these areas so they are no longer exposed to rainfall or runoff will prevent oil, gasoline, fuels, solvents, hydraulic fluids, sediment, organics, nutrients, and other pollutants from entering runoff. However, since roofing increases impervious area, this effect should be mitigated.

Proper siting and storage of materials. Many commonly purchased and used materials can contribute to runoff pollution. For example, many businesses store and sell bags of fertilizer and pesticides from pallets in an open parking lot. These bags often tear or rip, allowing material to spill onto the paved surface. A storm sewer inlet directly downstream provides a direct conduit to transfer this material to a downstream waterbody. Such areas may need roofing. At a minimum, storm drains should not be located downstream. Aboveground storage and secondary containment may be necessary for materials and in locations vulnerable to groundwater contamination.

Waste reduction and prevention. Waste reduction usually involves using several integrated techniques to eliminate or reduce the amount of potentially hazardous materials used at a site. It may involve source reduction through good housekeeping, technology or process changes, or modification of input materials; recycling, reclamation, and reuse of materials; and treatment to reduce material toxicity.

Proper spill prevention and containment. Facilities that store or use certain types of potentially hazardous materials may be required to prepare a written plan outlining their approach to preventing and containing spills. These plans document the operational procedures and management approaches. Pollution prevention plans typically specify procedures for preventing pollution caused by storage and use areas, manufacturing processes, treatment systems, or shipping areas; emergency containment and cleanup procedures to be used in case of spills, leaks, or other discharges; inspection procedures and schedules; and methods to maintain inventories of potentially hazardous materials from the time the material is received or manufactured until it is treated and discharged or shipped out.

Storm sewer screens. Simple screens of chain link fencing placed at the outfall point of storm sewers capture cups, leaves, and other large debris. Of course, these screens must be regularly inspected and cleaned.

Operation/Maintenance Practices

Unlike traditional drainage facilities, urban runoff treatment systems are designed to capture and retain pollutants, especially solids. The accumulation of these materials can seriously impair the system's operation and greatly reduce its effectiveness, resulting in pollutant discharge and possibly increased flooding. Therefore, the long-term operation, maintenance and management requirements, and costs for a stormwater practice should be important considerations in selecting BMPs. Additionally, institutional frameworks must be created to assure that runoff systems are regularly inspected and maintained.

Stormwater System Operating Permits

One way local governments can reduce their liability for pollutants discharged from their runoff system is to assure that discharges are already properly managed. In states where new development must install on-site runoff management systems, a stormwater operating permit system implemented by the local government or stormwater utility can ensure that runoff facilities are maintained and operated properly. Operating permit systems typically require annual inspections of privately owned runoff facilities and certifications that all needed maintenance has been performed. Additionally, local governments can review the implementation of runoff pollution prevention plans required for industrial runoff sources discharging into the local system.

Storm Sewer Inlet or Catch Basin Cleaning

These inlet devices capture large debris, along with smaller sediment and organic materials. However, pollutants can be washed out if inlet devices become too full and rainfall occurs. Regular inspection and periodic maintenance (i.e., general vacuum cleaning) is essential for maximum environmental benefits. More frequent cleaning is required at certain times, such as when leaves fall.

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Highway and Utility Right-of-Way Maintenance

These activities involve materials that add to runoff problems. Shoulders and roadside swale systems should only be scraped or excavated if necessary to maintain the integrity and safety of roads. Vegetation should be mowed or maintained as necessary to keep areas stabilized and the use of nutrients and pesticides should be reduced.

Winter Road Management

In areas with snowfall and extended periods of freezing temperatures, special maintenance activities are needed on roads and bridges to keep them safely open to traffic. Since the late 1940s, road salt has been one of the most popular road deicers, with more than 11 million tons used annually. However, snow removal and storage along with salt application and storage can corrode bridges, roads, and vehicles and contribute to several adverse environmental conditions, including damage to roadside vegetation, stratification of ponds and lakes, increased chloride levels in surface and groundwaters and contamination of water resources. These effects can be reduced or prevented by

- **Carefully siting snow storage areas.** Runoff or seepage from the snow pile should not go directly into surface or groundwaters. Ideally, these areas will be served by BMPs that capture pollutants attached to the snow and soil particles.

- **Minimizing or eliminating the use of salt (sodium chloride).** Determine and use proper application amounts. Consider alternatives to salt, such as calcium magnesium acetate (CMA), calcium chloride, urea, sand, potassium chloride, magnesium chloride, or other substances. Each has advantages and disadvantages, both environmental and economic.

- **Proper salt storage.** Some 80 to 90 percent of environmental problems from salt come from careless or improper storage. Elements of a good salt storage policy include

1. Not locating salt storage areas near waterbodies or other sensitive features.
2. Storing salt in permanent roofed structures. If salt cannot be stored indoors, use an impervious liner and a waterproof cover.
3. Storing salt on an impermeable surface, not bare ground.
4. Routing runoff from the salt storage area to an appropriate runoff management system.

Public Education Practices

Many previously discussed structural practices—swales, retention areas, and detention lakes—require public education programs to be readily accepted and used. Programs concerning the following topics or activities have proven effective:

- **Storm sewer stenciling.** Stenciling storm sewer inlets with messages such as "Dump no wastes, drains to lake (bay, river)" can greatly increase public understanding of the relationship between pollution sources and receiving waters. These programs often are conducted by youth groups or civic associations.

- **Econeighborhood programs.** These programs designate econeighborhoods and secure residents' commitments to follow good housekeeping practices.

- **Education displays, pamphlets, booklets, and utility stuffers.** Educational materials cover a wide variety of everyday citizen activities that can adversely affect water resources. Citizens need to understand how their activities around the home and yard can contribute to water quality problems.

- **Public awareness.** Public information and education can reduce nonpoint source pollution by changing individual behavior and lifestyles. An information program that educates citizens can also encourage them to become part of the solution. This chapter and Appendix C provide numerous sources of information for public awareness programs.

Recommended Reading

Many excellent sources of information are available on the use of nonstructural runoff management practices. Numerous urban and planning textbooks provide relevant material. Federal, state, regional, and local agencies have produced many helpful booklets and brochures on the cor-

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rect use of household and yard chemicals and other materials—these are frequently available from Agricultural Extension Service offices.

Many state, regional, and local governments offer detailed best management practices manuals, several of which are referred to in other chapters. Additionally, local governments have model land development ordinances and codes. Regional planning councils and councils of governments often have model land development regulations.

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CHAPTER 13

Legal Authorities

A good runoff management program is founded on legal authority, design and implementation criteria, and adequate resources. This chapter is mainly concerned with legal authority.

The evolution of sediment control and urban runoff management programs has been gradual. In attempting to address local problems and concerns, several areas of the country have provided leadership. The runoff management issue has emerged from concerns over flood damage and public safety.

Historically, society has relied on water for transportation and commerce, necessitating significant development in areas adjacent to waterways. Over the last 200 years, the frequency and magnitude of flooding, the associated damages, and the potential for loss of life have inspired public efforts to reduce the adverse impacts. These efforts have naturally evolved into considering changes in upstream land use, since those changes affect impact on downstream flooding potential.

Early runoff management efforts relied on channelizing streams and constructing large regional detention facilities to control upstream peak discharge release rates and prevent increasing downstream flood frequency or elevation. Most early ordinances only controlled peak discharge rates from new development activities. Common criteria varied with policies to control the postdevelopment 10-year storm to the predevelopment 10-year peak release rate, and other similar variations.

Concerns about water quality and controlling sediment during construction were localized and occurred only when the magnitude of land development necessitated action. With the 1970s and the first Earth Day, the public gradually became aware, however grudgingly, of impacts beyond water quantity control. Approximately half the states have some form of erosion and sediment control laws, although few are aggressively implementing a program. Fewer states have implemented runoff management programs concerned with water quality. The problem in implementing comprehensive sediment control and urban runoff management programs for new development activities is not inadequate technology—the problem is a lack of commitment.

While most jurisdictions are familiar with the adage, an ounce of prevention is worth a pound of cure, many implement sediment control and runoff programs only after significant resource damage has been done. Many areas should implement effective programs now, before runoff impacts become so great that solutions are limited and costly. One major benefit of the 1987 amendments to the Clean Water Act and section 6217 of the Coastal Zone Act Reauthorization Amendment of 1990 is the increased national awareness of sediment control and urban runoff management needs and requirements. Still, state and local governments must recognize that these issues are important, even without federal initiatives. Efforts must be initiated to prevent existing water quantity and quality problems from intensifying.

Program Considerations

Identifying and Documenting the Problem

In initiating a sediment control and runoff management program, consideration must be given to identifying and documenting the problem. The impetus could be a water supply reservoir that is becoming fouled with nutrients or other pollutants, making drinking water treatment expensive.

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Most water quality programs—for example, Chesapeake Bay and Puget Sound—focus on downstream resource protection. The National Estuary Programs, the Clean Lakes Programs, and others provide examples of state, regional, and local government responses to documented problems.

Problems must be clearly identified and documented. For example, a resource problem in fisheries is a dramatic decline in clam landings over the last 10 years; the cause, however, is increasing development in contributing drainage areas. Another example is the dramatic decline in stripped bass landings in the Chesapeake Bay. The problem must be clearly defined before solutions are considered.

Prelaw Educational Efforts

Education is the key to garnering the necessary political support. To win support, the problem must be clear to the average individual. Individuals must buy in to the need and the personal impact of the proposal.

In Delaware, for example, individuals spent approximately six months on problem identification before beginning the sediment and runoff effort. The effort included documenting construction and degraded stream system problems with slides at public presentations to environmental groups, municipal leagues, Kiwanis clubs, engineering societies, and the general public.

Education should include the components of the proposal, the types of practices required, and the industries impacted. Supporters must clearly define the proposal and effectively respond to concerns. The proposal should answer all concerns; if not, it must be modified or the provision eliminated. A response should not transfer responsibility to another source or entity.

To succeed, the proposal and its components must be important to the agency responsible for its implementation. Reaching consensus before the law is formally considered avoids adversarial situations, which take an enormous amount of time and negatively affect implementation.

Sediment and Runoff Law

The sediment and runoff law should provide a framework for the overall program. The law should have general design criteria or technical considerations to avoid the need for future amendments and political review by individuals unfamiliar with the issues. Delaware's law and regulations provide an example (Appendix A and B). Components to be considered in developing a statewide or regional program or law include the following:

- A statement of policy followed by text that provides a specific approach to implement the policy.
- Definition of important terms to avoid misunderstanding in their use.
- Delineation of the types of activities regulated under the law. Clearly identify activities not intended for coverage to avoid confusion over their status. For example, if agricultural land management activities are not included, specify this exception.
- Outline of funding resources. If the program is funded through permit fees, define the authority to collect fees. Discuss legal mechanisms, such as a runoff management utility, as a future option.
- Definition of agency responsibilities. If the program is implemented at a state level, define the role of the state agency in conjunction with those local agencies; if implemented at the local level, define responsibilities of other related local programs.
- Specification of the effective implementation date. Programs directed toward new development activities usually incorporate an existing building permit process to ensure plan design and approval. In addition, situations where plans have been approved but not yet implemented must be defined and a cutoff point specified for older plan redesigns or reconsiderations in light of new requirements.
- Definition of responsibility for review of state and federal activities.
- Definition of enforcement procedures to ensure consistency among projects and to educate regulated individuals about their serious responsibilities under the law.
- Other local requirements, such as phasing the program into the region or watershed or requiring educational assistance on program implementation. For example, both Delaware and Maryland mandate education by requiring contractors to certify that a responsible representative has taken a state course in erosion and sediment control.
- Definition of penalties and appeals procedures.

Sediment and Runoff Regulations

As the law provides a broad paintbrush for an overall program, regulations provide specific detail for day-to-day program implementation. Detailed regulations provide a means to implement the law's general requirements. Delaware's sediment and runoff management regulations provide an example of statewide regulations (see Appendix B).

Some components to consider in developing statewide or regional regulations include the following:

- The scope of the regulations, mentioning specific areas of additional emphasis.
- Term definitions. Give careful consideration to each, as they often determine policy issues and answer numerous questions about aspects initially given broad interpretation.
- Specific exemptions, waivers, and variances. Variances are particularly important where increased flexibility is needed to fit a strategy to a specific site.
- Details of the process of permit application and approval time frames and obligations.
- Specific design criteria. Criteria should address the level of control, preferences in practices, and information required on each project. Each application should include information, specified in the regulations, to enable the approval agency to make and defend its decision.
- Detailed construction inspection and enforcement requirements. Enforcement must be progressive, not random.
- Definition of any appeals procedures or hearing requirements.

Advice from Impacted Industries

A first step in developing and implementing a sediment control and runoff management program is to open and maintain a dialogue with the impacted industries. These include homebuilders, contractors' associations, developers, and consultants. Representatives must understand the program goals and their legal obligations. To ensure industry involvement, the various entities should be asked to assign a representative to attend meetings and review draft documents prior to public release.

Another way to receive input is through required educational programs. Delaware requires contractors and inspectors to receive training on sediment control and runoff management. The state has successfully received feedback from the impacted industries in a nonadversarial forum and has modified the program as a result.

Detailed Design Guidance

The permit review process places consultants who represent land developers in a difficult position. To provide a cost estimate of their services, consultants must understand the system design obligations. This understanding can only be ensured through a good relationship and good design guidance developed or accepted by the permitting agency. Thorough guidance results in fewer problems with individual plan review, fewer submissions, and a greater assurance that the design meets the best available standards for success.

The guidance should include all acceptable options for sediment control and runoff management and contain illustrated details and case studies to explain design standards and procedures. Legally, the regulations should refer to the design guidance; guidance modification should include public review and comment. A meaningful guidance document should be developed when the program is implemented, not just adapted from somewhere else—unless the document reflects a clear understanding of the original principles.

Problem Areas

In areas with existing runoff management programs, more than one entity or agency involved in policy may create a problem. Conflicts can be extremely frustrating and take time and resources away from program implementation. However, conflicts often come from a greater awareness of linkages between two or more previously unrelated programs. While linkage often improves program performance, conflicts can overshadow this positive aspect, and both programs can suffer. For example, conflicts can occur between emerging NPDES programs and traditional sediment and runoff or nonpoint source control programs. Conflicts can also exist when sediment, runoff, and wetlands programs are linked with traditional public works programs, planning agency responsibilities, and any number of other potentially conflicting areas. All entities need to recognize the compatibility of these programs and that overall goals can be enhanced through communication.

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A major problem can occur when sediment control and runoff management responsibilities are added to an existing building permit program. Far from improving both programs, experience has shown that overlapping responsibilities can reduce the emphasis on one program and weaken the overall effort. Sediment and runoff programs, along with other programs, need individual attention to succeed. Individual identities must be defined within the organization, not just function as an add-on. For example, a sediment and runoff program added to a sewer line review and approval program can reduce the effectiveness of both programs, especially in inspection and enforcement. Inspectors need a defined area of responsibility, not a requirement to inspect a project for multiple reasons.

Since the sediment and runoff program is a regulatory program, enforcement action will occasionally be required. However, if permit or inspection agencies are reluctant to engage in enforcement, the program's credibility can be reduced. While most contractors and developers willingly comply with laws and regulations, they periodically challenge the requirement to implement an environmental control. Erosion and sediment control are seen as temporary practices, and the industry sees avoiding these controls as a way to cut costs. Providing an enforcement presence and a willingness to take action improves the chance of properly installing controls.

Implementing an effective sediment control and runoff management program costs money. Few programs are adequately staffed or funded. This is especially true if the budget depends on permit fees or if the program is part of an agency's overall budget and must compete with other important areas. A dedicated source of revenue should be developed to maintain a sense of continuity.

Finally, a single individual cannot implement a statewide sediment and runoff program, even through a system of general permits. These programs are important components of a whole urban environment and must be treated on a level equal to other urban programs.

Recommendations

Programs should be consolidated, or at least closely coordinated, with existing related programs. In addition, communication must be established with other agencies (i.e., local land use, public works, and building permit) and other environmental programs (i.e., wetlands, groundwater, drainage, or others) that could affect the sediment and runoff program. While agencies must be educated about the direction and importance of the sediment and runoff program, program staff must be sensitive to issues and priorities of these agencies—especially on the issue of wetlands and the location of runoff management structures. Diverse programs need to work together, especially in times of limited fiscal resources.

Education, a constant theme in this guide, cannot be stressed enough. Educational efforts and activities, which significantly enhance the chances of legislative or regulatory approval, must be continuous to remind people of the importance of runoff control, both during and after construction projects.

Programs must be consistent in their implementation. Projects must be reviewed consistently, and any variation in review or approval procedures should be documented to avoid challenges to the final decision. Consistency must also be applied to site review and enforcement procedures. Written enforcement procedures should be developed and circulated to the impacted industry so that all concerned will understand enforcement steps to be taken if required controls are not implemented. Enforcement procedures should be progressive, with severity increasing as noncompliance continues. Steps could range from withholding occupancy permits until controls are implemented to halting work until environmental controls are correctly installed. Civil and/or criminal penalties can also force site compliance.

A successful program requires an open line of communication to the regulated community. One vehicle, a regulatory advisory committee, is important not only in program development but also in day-to-day implementation and evolution. Advisory committee meetings provide an interested and sympathetic forum to uncover design or implementation problems. Regular meetings reduce the "we-they" syndrome.

Other Available Sources

This guide refers to numerous localities and states that have implemented programs. In addition, case studies are presented in Chapter 16. Contact individual agencies mentioned throughout the guide for additional information.

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CHAPTER 14

Inspection and Maintenance of Runoff Control Practices

This chapter presents key elements and characteristics of both a comprehensive construction inspection and a postconstruction maintenance program, including preconstruction planning using postconstruction standards.

Effective runoff management using structural practices and facilities requires successful execution of all phases of development.

These phases include

- Comprehensive analysis of site conditions and potential adverse impacts and problems during the project planning phase;
- Accurate and intelligent design of practices and facilities for convenient maintenance that will prevent or minimize adverse impacts and protect aquatic resources during and after construction;
- Competent and comprehensive review of practices, facility designs, and plans during the permit application phase;
- Proper construction and implementation of the practices or facilities according to the approved plans and applicable permit conditions; and
- Proper operation and thorough maintenance of the practices or facilities after installation.

All of these phases can benefit significantly from increased understanding of the fundamentals of the runoff and soil erosion processes at the heart of any runoff management program, and from increased design, construction, and inspection skills and experience. Similarly, failure to competently complete any of the phases can lead to program failure and environmental damage.

Recent investigations and experience have highlighted the serious adverse impacts of inadequate planning, design, implementation, construction, inspection, and postconstruction maintenance. Correcting these weaknesses first requires comprehensive and aggressive inspection programs while constructing land development sites. These programs must do more than focus on the proper construction of permanent structural facilities intended to provide long-term management of site runoff. They must also concentrate on the proper installation and maintenance of the site's short-term erosion and sediment control measures. Finally, continuing inspection and maintenance programs are also needed to ensure effective and safe operation of the structural facilities after site construction is completed.

Despite the importance of construction inspection and postconstruction maintenance programs, several factors complicate or hinder their development. One is the legal authority to both perform inspections and enforce facility maintenance requirements (see Chapter 13). Although federal and state governments have begun developing inspection and maintenance standards, land development's diffuse nature and the country's long-standing tradition of local land use control require that local governments acquire legal authority. A second factor is the costs of these programs and local government's ability to meet them. A third is the inherent institutional and regulatory difficulty of adequately managing the diversity of permanent runoff management facilities and temporary soil erosion control practices currently available.

Although the subject is complex, the benefits of understanding how to develop a runoff management program are great. The chapter begins with an overview of key elements of the inspection and maintenance program. It explores the

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interrelationship between construction inspection and a facility's early planning, design, and permit phases, emphasizing the effect on long-term performance and maintenance. Much of this material is based on the *Stormwater Management Facilities Maintenance Manual* developed by the New Jersey Department of Environmental Protection and Energy (1989).

The remainder of the chapter contains two detailed presentations. One focuses on an inspection and maintenance program for construction site erosion and sediment control practices. The second focuses on permanent drainage and runoff management facilities at a land development site. It describes a program embracing both short-term inspection when the facilities are constructed and long-term inspection and maintenance to ensure effective operation. Both presentations emphasize inspector training and education, contain recommendations regarding program structure, and discuss key program elements. They also provide examples of field inspection checks. These presentations should give readers a head start in developing their own programs and, in particular, training the staff charged with program performance.

The presentations were derived from two courses at the University of Washington's Center for Urban Water Resources Management and Engineering Professional programs. Course manuals are available for erosion and sediment control inspector training (Reinelt, 1991) and permanent drainage system inspector training (Reinelt, 1992). Local governments and state agencies in the Puget Sound area of Washington State have worked actively to improve runoff management through effective inspection and maintenance and have contributed to these materials.

Inspection and Maintenance Overview

An effective inspection and maintenance program has a number of aspects. This overview discusses the importance of the key program elements—construction inspection and maintenance; the numerous aspects of preconstruction activities; enforcement options; funding techniques; and education and training.

Understanding Key Program Elements

The overall success of any runoff management program hinges on understanding each term. However, this cannot be done by simply quoting dictionary definitions because of the many aspects of land development involved in each. The following detailed descriptions should aid understanding:

■ ***Construction Inspection.*** This activity involves the careful field observation of construction activities and materials and their end products or measures. While construction activities—complexity, duration, manpower, and hazard—and construction materials—character, quantity, and cost—can vary widely, runoff management categorizes them in two ways. The first category includes activities and materials used to construct temporary erosion and sediment control (ESC) measures at land development sites. These measures control the amount of soil lost from erosion and minimize the adverse downstream impacts of subsequent sedimentation during site construction. The second category includes activities and materials used to construct permanent runoff management and drainage facilities that address both quantitative and qualitative effects on runoff produced by the developed site.

The key distinction between the categories is time. In the first, the effects of site development on soil erosion and sedimentation are temporary and limited to the construction period when soils are exposed to rainfall and runoff. As such, the measures and materials used are temporary and removed when the site is permanently stabilized. These measures range from temporary seeding and mulching of exposed soils to constructing sediment basins and barriers.

The second category deals with the more critical effects of the site's development on urban runoff quantity—volume, rate, and timing—and quality over the site's postdevelopment life. These measures, intended to minimize and mitigate development effects, must last as long as the site is used. Permanent measures include runoff detention and infiltration basins, storm sewer systems, and swale/channel networks.

Regardless of the timing or duration of the various measures, the construction program is responsible for ensuring that construction activity adheres to approved plans, designs, standards, and generally accepted construction techniques.

The importance of continuing inspections cannot be overstated. After temporary measures or permanent facilities are completed, continuing inspections ensure that measures perform as intended and remain in sound, safe condition. Inspections of ESC measures normally take place

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along with general construction inspection of the development site. Inspection of permanent facilities, however, must occur after site development and construction are completed; it therefore requires that an inspector take separate action. Effective inspections are usually combined with permanent facility maintenance.

▮ *Maintenance.* For both runoff facilities and ESC measures, this activity involves repairing, replacing, restoring, or replenishing the various components and materials of the measure or facility. Maintenance activities include preventive and corrective measures, with time the key distinction between the two. Preventive maintenance requires replacing components or materials before they cease to function adequately, often according to a schedule. Corrective maintenance is performed after failure or malfunction occurs, often quickly in an emergency. Obviously, preventive maintenance is preferred over corrective maintenance because of safety, time, cost, and overall effectiveness.

Maintenance keeps both the temporary ESC measure and the permanent facility functioning safely and at optimum efficiency levels. Maintenance can also correct design or construction deficiencies, improve performance, and enhance safety above constructed levels.

Preconstruction Inspection and Maintenance

Once the regulations have been satisfied on paper through planning, design, and permit stages, the project is ready for construction. The methods and materials used in construction must be competently inspected to ensure that the goals of the planning, design, and permit stages are met in the field.

ESC measures and runoff facility maintenance are vitally important. Structural facilities cannot perform their duties and achieve their goals without regular maintenance. Maintenance is particularly acute for structural facilities used to address runoff quality impacts. As particulate settling and removal efficiency has increased, the sediment and debris accumulation within runoff facilities has increased the maintenance need.

Runoff facilities also must be maintained structurally to ensure their continued safety and protect people and property. This is particularly true of facilities and measures that impound runoff, even for a short period. Structural failure causing release of stored runoff will usually result in greater downstream flooding and damage than would have occurred without the facility. This threat may greatly outweighs all benefits.

Inspection is also key to a maintenance program. Whether preventative or corrective, maintenance must be preceded by an inspection to evaluate the required procedures, materials, equipment, personnel, urgency, time, and cost. Effective and efficient inspection activities should be performed regularly and should emphasize prevention rather than correction. In addition, inspectors must be highly knowledgeable and experienced and take responsibility for the results of construction or maintenance. As such, inspector training is a vital component of any runoff management program. Training must be comprehensive, covering all aspects of the runoff management and soil erosion processes, from theory to practical applications.

Preconstruction stages and activities can cause significant construction and maintenance problems. Avoiding problems requires a close look at all preconstruction stages, from the regulations that define the structural measure or facility, through the technical planning and design stages, to the permit stage, where construction is authorized.

▮ *Regulatory Aspects.* Chapter 11 presented the various regulatory needs of a comprehensive runoff management program, including those for effective construction inspection and facility maintenance programs. This section addresses inspection and maintenance problems caused by the very regulations that initially created these programs.

While structural measures and facilities must be based on effective standards and accurate designs to achieve desired goals, the quality or level of standards, designs, and objectives means nothing unless the facility or measure is actually constructed. Unfortunately, in developing the various regulations, the importance of construction is sometimes lost or forgotten. While considerable effort is devoted to goals and how to achieve them, facility construction is sometimes treated as an afterthought or, even worse, a given or guaranteed end-product requiring little, if any, official attention.

The same is also true for facility maintenance. Despite the importance of maintenance to short and long-term performance, regulations requiring maintenance often lack purpose, effectiveness, or are simply nonexistent.

Therefore, consider the following in developing runoff regulations:

- Recognize the fundamental need for facility construction and maintenance to truly achieve program goals and objectives.

- Consider construction and maintenance of equal importance with planning, designing, and permitting. The regulations should promote the importance of inspection and maintenance at all stages and by all personnel.

- Regulations should officially designate a responsible party, frequently the development site owner, to have ultimate responsibility for the proper construction and continued maintenance. This official designation provides the opportunity for appropriate preparation and budgeting prior to actually assuming responsibilities. It also facilitates enforcement or other legal remedies necessary to address compliance or performance problems once the facility has construction approval.

- Regulations should clearly state the inspection and maintenance requirements during and following construction and address both temporary measures and permanent facilities. Construction requirements should be based on many standard construction practices and specifications, promulgated by various private organizations and government agencies, and fully comply with all applicable local, state, and federal laws. Inspection and maintenance requirements should also comply with all applicable statutes and be based on the needs and priorities of the individual measure or facility. A clear presentation will help owners and builders comply and inspectors enforce requirements.

- Regulations must contain comprehensive requirements for documenting and detailing construction and maintenance. For construction, this includes detailed, well-researched plans and specifications that fully describe the facility's construction. Plans and specifications should include pertinent information on locations, dimensions, elevations, materials, processes, and times. Drawings should be easy to use in the field under adverse weather conditions. Regulations should also require enough copies of plans and specifications to supply field and office personnel, builders, inspectors, and regulators. Provide a dissemination procedure guaranteeing that all involved have identical approved plans and specifications.

  Requirements are similar for maintenance. A facility operation and maintenance manual must be prepared containing accurate and comprehensive drawings or plans of the completed facility and detailed descriptions and schedules of inspection and maintenance. An emergency action plan should also be required for regional and other large runoff impoundment facilities. This plan should contain measures for various emergency conditions, such as structural failure, neglect, vandalism, or accident. The plan should also include the types and sources of repair materials and a list of individuals, agencies, and officials to be notified quickly if the facility appears to or actually malfunctions or fails. This list might include local and state government and public safety officials, downstream residents, and business owners. The plan should also contain the method of notification.

- The regulations should delineate the procedure for construction or maintenance noncompliance. This process should provide informal, discretionary measures to deal with periodic, inadvertent noncompliance and formal and severe measures to address chronic noncompliance or performance problems. In either case, the primary goal of enforcement is to construct a safe and effective facility—the enforcement action should not become an end in itself.

- Regulations must also address the possibility of total default by the owner or builder by providing a way to complete construction and continue maintenance. For example, the public might assume construction and/or maintenance responsibility. If so, the designated public agency must be alerted and possess the necessary staffing, equipment, expertise, and funding to assume this responsibility. Default can be addressed through bonds and other performance guarantees obtained before the project is approved and construction begins. These bonds can then be used to fund the necessary construction or maintenance activities.

- The regulations must recognize that adequate and secure funding is needed for all aspects of facility construction, inspection, and maintenance and provide for such funding. In fact, the program goals or accomplishments might be limited to available funding. Funding sources and techniques are summarized later in the chapter.

- To minimize overall inspection and maintenance effort and expense, the regulations should encourage and provide a way to regionalize runoff facilities. Situations where numerous independent on-site facilities are replaced by one or several regional facilities have been particularly effective for runoff quantity control and flood prevention. Regionalization also results in overall savings in planning, design, and construction efforts and costs and requires less total land disturbance. Finally, designing and implementing regional facilities requires planners, designers, regulators, developers, and residents to adopt a watershed approach to runoff. Such a comprehensive approach should be promoted at every opportunity.

Planning and Design Aspects. The efforts of planners, designers, and those who review and approve the final facility have a profound influence on inspection and maintenance activities. This influence is particularly true for permanent runoff management and drainage facilities, which are generally more complex and require greater effort from these groups. Temporary ESC measures may also be significantly affected, particularly regarding the measure selected and its location.

According to the New Jersey *Stormwater Management Facilities Maintenance Manual* (1989), approximately two-thirds of the maintenance problems encountered during a review of 51 constructed facilities were at least partly due to a combination of inadequate and misguided planning, design, and review. The result was increased maintenance effort and cost, reduced facility performance, and increased safety threats to both residents and maintenance personnel.

Fortunately, enlightened and focused planning, design, and review can improve inspection efficiency and effectiveness and reduce maintenance effort and expense. Therefore, inspection and maintenance should be a primary consideration throughout the entire planning, design, and review process, equal in importance to achieving required performance and safety.

The following inspection and maintenance issues should be addressed in planning, designing, and reviewing runoff management and ESC facilities and measures:

- **Durability.** The use of strong, durable materials, components, and fasteners will greatly reduce the maintenance required. These savings normally more than justify any additional expense incurred. Durability extends across the entire range of facility components—from basin and pond outlet structures where reinforced concrete remains the material of choice, to vegetative covers and landscaping where durability is defined by hardiness and suitability to local conditions.

- **Constructability.** "The road to maintenance headaches is paved with good planning and design intentions that somehow went awry" (New Jersey Dep. Environ. Prot. Ener. 1989). All concerned must remember that the structural measure or facility must be safely and properly constructed before it can provide any runoff management benefits. Therefore, runoff program goals and the ideas of those seeking to fulfill them must, within reasonable effort and expense, be constructable in the field.

  Required materials must be available and construction techniques feasible. Construction plans and specifications—the builder and inspector's instruction manual—must be clear, informative, and contain all necessary information presented in a format that assists, not impedes, field use. Anyone who has struggled in the field with construction plans on a cold, windy day knows that construction details and notes are easier handled on the same sheet than scattered randomly throughout the entire set of plans.

- **Maintainability.** Throughout the planning, design, and review or permit process, every attempt should be made to eliminate or facilitate maintenance, whether selecting facility goals or materials. This applies to the facility's location, materials, configuration, and the techniques and equipment necessary to construct and maintain it.

  Questions of maintainability should be raised about the vegetation used and the habitats or ecosystems created by and within a runoff facility. How complex are these systems? How difficult will they be to manage? Will those responsible for overall facility maintenance be able to do it themselves, know where to find help, and be able to af-

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ford it? If the answer to any of these questions is no, the runoff facility may wind up harming rather than protecting the environment.

■ Accessibility. Small oversights in planning, designing, and reviewing a runoff facility or measure can result in big inspection and maintenance problems. To perform inspection and maintenance tasks, personnel must have access to the facility and be able to bring the materials and equipment with them. Access can be as simple as hatches in gratings and gates on fences or as complex as access easements across private property. The best intentions of the most dedicated inspector or maintenance worker will go unfulfilled if they or their equipment cannot get to the facility to inspect, clean, repair, or replace.

Efforts to facilitate access and enhance safety can often yield significant savings in inspection and maintenance. For example, mosquito control personnel are considerably more efficient if they can drive by a runoff facility and check for unintended standing water rather than parking, locking the vehicle, and walking several hundred feet or yards. This is particularly true when their inspection route includes tens or even hundreds of facilities—not uncommon in densely developed areas. Therefore, addressing accessibility simply by locating the facility to be viewed from the roadway can greatly reduce inspection efforts and expense.

To further fulfill inspection and maintenance needs, planners, designers, and reviewers periodically ask themselves the following series of questions:

■ *Who* will perform inspection and maintenance? Arrangements should be made during the preconstruction, not postconstruction, stage to identify, train, equip, and fund the required personnel. If not, one of the postconstruction stages may be "facility failure."

■ *What* must be done? What construction activities need to be monitored? What intermediate or final conditions need to be inspected? Will the inspector require a level or other surveying equipment? What facility components will require periodic inspection once construction is completed and the facility begins operation? What regular maintenance tasks must be performed? What emergency measures may have to be taken? What kind of material or equipment will be required?

■ *When* will inspection and maintenance be required? Certain maintenance tasks, such as grass mowing, may need to be performed regularly during spring and summer but not at all in winter. During the wet season, can muddy, saturated slopes be accessed? Will equipment be available for slopes? Are roads and paths wide enough to provide access? Dams and embankments may require annual or biannual inspections for structural integrity, while trash racks may need to be inspected after every rain. And, although all inspections cannot be scheduled in advance—a fact that upsets managers and financial staff—they are certainly advisable after a major storm or flood.

■ *Where* will the inspection or maintenance be performed? Do those responsible have both legal and physical access to the facility or measure? Where will the equipment and materials be staged or stored? Where will the grass clippings, sediment, trash, and debris be deposited? Locate these places prior to construction rather than during or, even worse, after construction is completed.

Structural ESC and runoff management measures and facilities require competent inspection and regular maintenance to perform as required and provide safety to workers and residents. The efforts of planners, designers, and reviewers directly affect the need for and complexity of such inspection and maintenance. Enlightened planning, design, and review that recognizes and seeks to improve this relationship can significantly reduce inspection and maintenance costs and increase their effectiveness.

Enforcement Options

A public agency will sometimes need to compel those responsible for facility construction or maintenance to fulfill their obligations. Therefore, the inspection program must have enforcement options for quick corrective action. Rather than a single enforcement measure, the program should have a variety of techniques, each with its own degree of formality and legal weight. The inspec-

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tion program should provide for nonconforming performance and even default and contain suitable means to address all stages.

To avoid the need for enforcement measures, a spirit of cooperation should begin during the project's design review and permit stages by developing facility designs suitable to all parties. Education and training efforts and predesign or preapplication meetings can develop and promote such cooperation and allow each party to familiarize itself with the needs and interests of others.

Prior to receiving construction approval, the developer or builder should provide performance guarantees. The public agency overseeing the construction can use these guarantees, usually a performance bond or other surety in an amount equal to the facility's construction cost, to fund construction in case the builder defaults. As described under the next section, the developer or builder should provide sufficient funds to finance the construction inspection before the project begins. The dedicated inspection funds and the performance bond insure that construction can be completed regardless of the builder's ability or willingness.

Once construction has begun, the responsible public agency can issue a stop work order to compel the builder or developer to comply with project specifications and other requirements. Other techniques include withholding certificates of occupancy for completed portions of the development and formal civil or criminal action. Ideally, the cooperative attitude developed during preconstruction will continue through the construction period. This attitude, promoted through comprehensive preconstruction meetings and regular and informal progress and problem-solving meetings, can help avoid the need for formal and severe enforcement actions.

Public Funding Techniques

Funding techniques are critical to an effective inspection and maintenance program. The following paragraphs discuss four general techniques, each applying to specific inspection and maintenance efforts. The information is based largely on Chapter 6 of the *Stormwater Management Facilities Maintenance Manual* (New Jersey Dep. Environ. Prot. Ener. 1989). (See Other Sources for additional information on funding.)

Tax Revenues

Tax revenues are an obvious source of funding, particularly for the long-term inspection and maintenance of existing runoff and drainage facilities. The benefits and protection to the public from continued safe and effective operation of the facility justifies using revenues from general or specialized taxes. However, using these funds to inspect the construction or installation and maintain ESC measures at land development sites is more difficult to justify.

To use tax revenues, particularly from a general fund, the inspection and maintenance program must annually compete with all other programs included in the government's annual operating budget. This inconsistent and unreliable funding makes securing a long-term financial commitment to inspection and maintenance difficult and subject to political pressures. Nevertheless, tax revenues remain a popular funding source because the collection and disbursement system is already in place and familiar. In fact, this established and well-known system is often the first funding choice.

Turning instead to revenues from specialized taxes helps overcome some difficulties inherent in using general tax revenues. Relating the specialized tax program to runoff management and/or erosion and sediment control provides the necessary link between the revenue source and use. This method also avoids competing with other programs for general tax revenues. However, specialized tax programs must receive public and political support and legal authorization.

Utility Charges

Using utility charges to fund inspection and maintenance is a somewhat recent application of an already established financing technique. As noted in the *Stormwater Management Facilities Maintenance Manual* (1989), New Jersey began creating utility authorities and using charges collected within its service area to finance publicly owned water and sanitary sewerage systems in the early 1900s. Today, utility charges remain a popular financing technique in many New Jersey municipalities and counties. In addition, several municipalities and counties throughout the country have runoff management, drainage, and flood control authorities or districts to provide residents with runoff-related services.

Using utility charge financing has several advantages. By addressing only runoff needs and benefits, utility funding avoids competing with other programs and needs. Utility funding also demonstrates a direct link between the funding and the services it provides. This approach does, however, require an entirely new operating sys-

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tem and organization that needs legal authorization to exist, operate, and assess charges. The effort required to create such an entity can deter many, although the continued success of established authorities and growth of new ones have done much to allay concerns over the effort required.

In a runoff utility, the user charges are often based on the need for services rather than the benefits derived from them. While charges are based on actual costs to inspect and maintain runoff facilities and measures within the service area, the assessed rate structure should relate to site characteristics. These include property area size, extent of impervious coverage, and other factors with a direct and demonstrable effect on runoff. To be fair, the rate structure should also remain simple and understandable to the rate payer.

Permit Fees

Collecting permit fees to finance runoff inspection and maintenance is a long-standing funding procedure. Most governmental entities—local, county, and state—can establish and collect fees and other charges to obtain operating funds for programs and services. Many inspection services, most notably the construction inspection of both ESC measures and permanent drainage and runoff management facilities, are financed at least in part through fees collected by permitting agencies. Unlike taxes or some utility charges, inspection costs are borne by those who need them.

The permit fee collection program should have a demonstrable link to the runoff management or drainage systems. The public agency should demonstrate a direct link between the permit fees collected and the permitted project—one method is using dedicated accounts for individual projects and facilities. Finally, the rate structure should reflect site characteristics—such as area size or imperviousness—that directly relate to the measure or facility by affecting runoff or erosion.

Dedicated Contributions

Like permit fees, dedicated contributions require those creating the need to bear the cost. Under this system, land developers must provide the necessary funding for inspection or maintenance before receiving construction approval. Funds are deposited in a dedicated account controlled by the responsible public agency. In some New Jersey jurisdictions, developers fund construction inspection of the ESC and permanent drainage and runoff management facilities as part of the land development. The contribution is based on a cost estimate made prior to construction. Throughout construction, inspector time sheets and expense reports monitor and record actual costs; additional funds are obtained as necessary. When construction is complete, any unspent balance is returned to the developer.

Other public agencies have used developer contributions to fund long-term facility maintenance. This approach is particularly appropriate in single family residential subdivisions, where numerous individual property owners served by a single runoff facility can result in confusion over who has maintenance responsibility.

The exact funding technique depends on many factors, including community attitude and knowledge, economic and political viability, and program needs and costs. Some techniques, including permit fees and dedicated contributions, may be more appropriate for short-term activities, such as construction inspection. Others—utility charges and specialized tax revenues—may apply to all phases of an inspection and maintenance program but require considerable effort and special legal authorization to operate.

Education and Training

An important key to a successful inspection and maintenance program is the level of understanding and knowledge held by those affected. This includes the builders and inspectors who create or install the measure or facility; the planners, designers, and reviewers who use sound preconstruction techniques; and the public and its elected leaders who provide the necessary funding.

As such, a comprehensive and effective education and training effort must be part of any inspection and maintenance program. Details of such training efforts are highlighted in the following sections, which detail key elements of programs for erosion and sediment control measures at construction sites and permanent runoff management and drainage facilities.

Erosion and Sediment Control Inspection Programs

A comprehensive construction site erosion and sediment control program consists of several elements—erosion and sediment control planning, plan review, contractor education, and inspection and enforcement.

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The following sections cover ESC planning and inspection and enforcement, and provide examples of inspection guidelines for common practices.

ESC Planning

ESC planning is an absolute prerequisite for an effective program (see Chapter 12 for more details). A careful site analysis should produce a standalone plan devoted exclusively to this aspect of the project and executed with the same thoroughness and care as any other plan in the overall project.

Acquiring the familiarity with the site and proposed construction necessary to execute the ESC plan is an exercise in data collection and analysis. Information should be cataloged before laying out the ESC plan. Table 14.1 lists the data to be collected and the information to be cataloged.

An ESC plan consists of a narrative and site plans. It is the key element for implementing a comprehensive control program. Site plans are maps and engineering plans illustrating and specifying the project location, existing and modified site conditions, and BMPs. BMPs are usually spec-

Table 14.1—Preliminary information needed for ESC planning.

DATA TO BE COLLECTED	INFORMATION TO BE CATALOGED
■ Soils	■ Grading (location, amount)
■ Vegetation	■ Topographic changes
■ Topography	■ Clearing and grading limits
■ Groundwater table	■ Drainage changes
■ Neighboring waterbodies	■ Materials to be used
■ Adjacent properties	■ Locations of use and storage
■ Drainage routes and patterns (define subbasins)	■ Access points
■ Downstream channels and capacities	
■ Potential areas of serious erosion problems	
■ Existing development, utilities, and dump sites	

Table 14.2—Components of an ESC plan.

ESC PLAN NARRATIVE	SITE PLAN ELEMENTS
■ Project description	■ Data collection worksheet—shows topography, soils, and vegetation
■ Existing and modified site conditions	■ Data analysis worksheet—indicates drainage subbasins and primary drainage courses
■ Descriptions of ESC BMPs	■ Site plan development worksheet—shows existing and finished contours, roadways, and permanent runoff facilities
■ Descriptions of BMPs for pollutants other than sediments	■ Erosion control plan—shows BMP locations
■ Plans for permanent stabilization	■ Diagrams of representative BMPs—shows appropriate BMPs
■ Calculations	■ BMP operating procedures and maintenance schedules
■ Provisions for inspection and maintenance	

ified using a system of symbols defined in a legend. Table 14.2 lists the various elements of the ESC plan narrative and site plan.

Inspection and Enforcement

The most important needs of this program are dedicated staff, specific staff training, and administrative support. A dedicated revenue source, such as a runoff utility assessment, can best provide these needs. Staff should not have unrelated and distracting duties, like inspecting other facets of construction. Training should offer a background in legal and regulatory requirements, water quality, hydrology, soils, vegetation, and other related issues. Training should also provide detailed coverage of BMP requirements (see following section). Administrators must provide strong backing to staff filling a relatively new function that is sometimes unpopular with economic interests.

During program development, some additional issues must be clarified and incorporated as formal program elements. Recommendations are drawn from experience in the Puget Sound region, especially in King County and the cities of Bellevue and Redmond in Washington State. One issue is how to respond when measures in an approved ESC plan prove to be inadequate. Strong permit review should normally limit these instances, but unforeseen circumstances can arise. The jurisdiction should retain the authority to require additional measures if needed and note this option on each ESC plan.

Another issue is handling field change orders. Plan change requests should receive careful but expeditious consideration, generally after consulting plan review personnel. Variances from code requirements should be granted only under strict and specific conditions:

- The result should at least be comparable to the expected outcome with the approved method.
- Sufficient background information and justification should be presented to adequately assess the alternative.
- The variance should retain the ability to meet safety, function, appearance, environmental protection, and maintenance objectives, based on sound engineering judgment.
- The variance should be in the public interest.

The enforcement authority and system must be obtained, defined, and clarified to the regulated parties. A three-step system is successfully used by the city of Bellevue:

- A verbal warning, with a correction deadline;
- A correction notice, with specifications of corrections, a deadline, and a warning of noncompliance consequences; and
- A stop work order, with warning of noncompliance consequences.

ESC Practices and Inspections

The numerous ESC practices can be categorized in various ways. The most basic division is between erosion control practices, which prevent or minimize erosion, and sediment control practices, which attempt to recapture soil that has been released through erosion. Several categories represent general strategies for achieving either erosion or sediment control. Construction sites can also generate many other pollutants—petroleum products, solvents, paints, sanding dusts, pesticides, and fertilizers. These materials can often be efficiently managed in concert with sediments and inspected simultaneously with ESC inspection. Therefore, these practices represent another basic division.

Table 14.3 provides a listing of the most widely recognized and used practices (Reinelt, 1991). All but the sediment trapping techniques are preventive and are thus the most cost-effective options. However, the straw bale and filter fabric fences and sedimentation ponds among the trapping techniques are most commonly seen.

The following are inspection checklists for example practices, generally the most common, in each category and subcategory. The checklists indicate checks for installation and checks for follow-up visits to determine maintenance or replacement needs.

While an inspector performs much work in the field, some background work must be done in the office before going out to inspect an installation. This work consists mainly of consulting the ESC plan to determine the specifications. The plan should be retained on the construction site so the inspector or construction personnel can reference it.

Table 14.3—Commonly used erosion and sediment control practices.

PRACTICES	CATEGORIES	METHODS
Erosion Control	Natural vegetative cover	Phasing construction
	Temporary cover	Temporary seeding Straw mulch Wood fiber mulch Excelsior Mats and blankets
	Permanent vegetation establishment	Permanent seeding Sodding
	Stabilized construction entrance and roads	Quarry spalls
	Runoff control	Pipe slope drain Surface roughening Interceptor dikes or swales
Sediment Trapping Techniques	Sediment barriers	Filter fabric fence Straw bale fence Brush fences Gravel barriers
	Settling ponds	Sediment basin Sediment trap Permanent pond
Management of Other Construction Site Pollutants		Cement and concrete handling Material storage and handling Spill containment Waste management

A. Erosion Control

Natural Vegetative Cover

Phasing Construction. Clearing operations are done in stages to take advantage of existing cover before construction.

Installation checks

1. Are areas not to be cleared set off with plainly visible fencing?
2. Is plainly visible flagging placed at the drip line of trees to be protected (Figure 14.1)?
3. Are fills and cuts near protected trees treated as shown in Figure 14.1?
4. Is final vegetation established as soon as portions of the site can be made ready?

Maintenance checks

1. Do fencing and flagging need repair or replacement so personnel can see them well?
2. Do exposed or injured roots of protected trees need covering or dressing?

Temporary Cover

Portions of most construction sites often remain unworked for months at a time. During that time large amounts of soil could erode unless the areas are stabilized by temporary seeding, various kinds of slope coverings, or both. Slope coverings include mulches and commercial mats and blankets. Applying temporary cover to different areas several times during construction is often necessary.

Mulches, mats, and blankets serve several purposes in erosion control. They cover the slope temporarily to prevent erosion by raindrop impact and runoff friction, hold water to aid grass growth, protect grass seedlings from heat, and enrich the soil. Straw, hay, wood fiber, wood chips, and other natural organic materials can serve as mulches. Mats and blankets are manufactured from both natural and synthetic materials.

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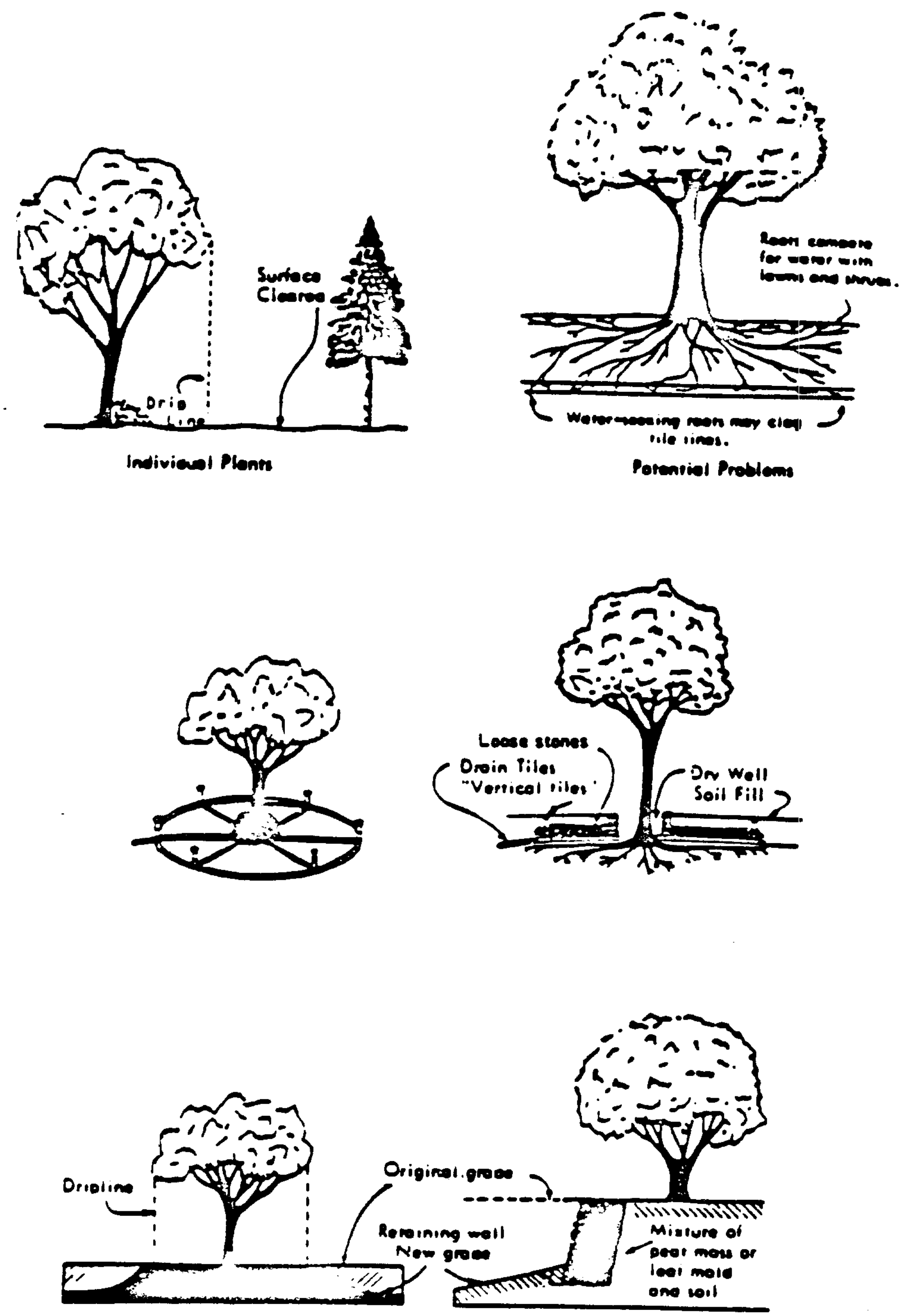
Figure 14.1—Guidelines for preserving natural vegetation.



Source: Washington Dep. Ecol. 1992.

Temporary Seeding

Installation checks

1. Is the soil stabilized within the period specified by regulation? This period varies from place to place depending on climate patterns. In the Puget Sound area of Washington State, which receives most of its rainfall in the winter, the specified periods are within two days from October to April and within seven days from May to September.
2. If used without slope covering practices, is temporary seeding limited to slopes less than 10 percent and 100 ft (30.48 m) in length? If the slope exceeds either limit, is a mulch or mat slope covering used?
3. Has the seedbed been prepared with 2 to 4 in (5.08 to 10.16 cm) of tilled topsoil?
4. Is fertilizer use limited as much as possible? If used, is it applied in amounts limited to grass needs for the prevailing soil conditions?
5. Is mulch applied to newly seeded areas that can be subject to high temperatures and runoff before the grass is well established?
6. Is irrigation provided for seeded areas that might have insufficient rainfall for good establishment?

Maintenance checks

1. Is irrigation and/or reseeding necessary?

Straw Mulch. Straw mulch can be used without seeding or, for better erosion control, with seeding.

Installation checks

1. Is the straw spread a minimum of 2 in (5.08 cm) deep (corresponding to 2 to 3 tons [4.47 to 6.72 Mg/ha] per acre), and deeper on very steep slopes, adjacent to sensitive areas, and where concentrated flow passes over the slope?
2. Is the mulch anchored as needed by crimping, disking, rolling, or punching into soil or by moistening, tackifying, or netting?

Maintenance checks

1. Should mulch be replaced because it blew away or decomposed over time?
2. Should mulch be moistened to eliminate a fire hazard?

Wood Fiber Mulch. Wood fiber mulch should only be used with seeding and generally with a soil bonding agent.

Installation checks

1. Is extensive runoff expected before good grass growth will occur? If so, is an extra coarse grade of wood fiber mulch applied?
2. Is the mulch used with seeding and a soil bonding agent? Were the application guidelines followed?
3. Has wood fiber been applied to cover the soil completely, allowing no bare soil to show through? This amount corresponds to about 1 ton per acre (2.24 Mg/ha) and is adequate for most circumstances. Do special circumstances, such as seeding during hot weather, require increasing the amount by about 50 percent?

Maintenance checks

1. Is replacement needed as a result of loss over time?

Excelsior. Excelsior is made of fine wood shavings in a helical form. Because this form does not allow excelsior to lie in close contact with the soil, runoff drains beneath it and causes erosion. Therefore, it should be used only with seeding when needed to hold moisture and provide protection from direct sun in hot periods. Suppliers generally market several grades for sheet and channelized flow and different velocities.

Installation checks

1. Is excelsior used only with seeding?
2. Was an appropriate material selected, placed, and stapled according to manufacturer's recommendations?
3. On slopes, was excelsior placed 3 ft (0.91 m) over the crest or in an anchor ditch?
4. In ditches, was excelsior placed in the direction of water flow, with any seams offset 6 in (15.24 cm) from the ditch centerline?

- **Maintenance checks**

1. Is replacement needed as a result of damage or loss over time?

Mats and Blankets. Examples of materials produced in mat or blanket form are jute, woven straw, and synthetics. Mats can be used without seeding or with seeding for better erosion control. As with excelsior, suppliers generally market several grades for sheet and channelized flow and different velocities.

- **Installation checks**

1. Was an appropriate material selected, placed, and stapled according to manufacturer's recommendations?
2. Was the material placed in the direction of water flow, in full contact with the soil but not tightly stretched?

- **Maintenance checks**

1. Is replacement needed as a result of damage or loss over time?

Permanent Vegetation Establishment

Permanent vegetation should be established in each segment of the site as soon as possible after construction is completed. Grass can be established by seeding or sodding. Seeding is generally preferred, because of lower cost and greater flexibility in selecting grass species. Sod is often available only in limited varieties that may not be suitable for erosion control and other purposes, unless grown to order. Overseeding with preferred species can be performed in the spring, while grass establishment must be done with sod in the winter. Species should be selected based on local climate and soil conditions, using regional guides and consulting with regional experts.

Permanent Seeding

- **Installation checks**

1. Has the seedbed been prepared by loosening with a plow if subsoils are highly compacted, spreading 2 to 6 in (5.08 to 15.24 cm) of topsoil, and lightly rolling?
2. Is fertilizer use limited? If used, is it applied in amounts no greater than needed for the prevailing soil conditions?
3. Is mulch applied for protection if areas are seeded when temperatures can be high or runoff is likely to occur before the grass is well established?
4. Is irrigation provided for seeded areas if rainfall is insufficient for good establishment?

- **Maintenance checks**

1. Is watering and/or reseeding necessary?

Sodding

- **Installation checks**

1. Is the sod placed beginning in the lowest area and perpendicular to water flow?
2. Are sod strips wedged tightly together and joints staggered at least 12 in (30.48 cm)?
3. On a steep slope, is the sod stapled?

- **Maintenance checks**

1. Is overseeding needed, either to repair damage or to install a preferred grass species?

Stabilized Construction Entrance and Roads

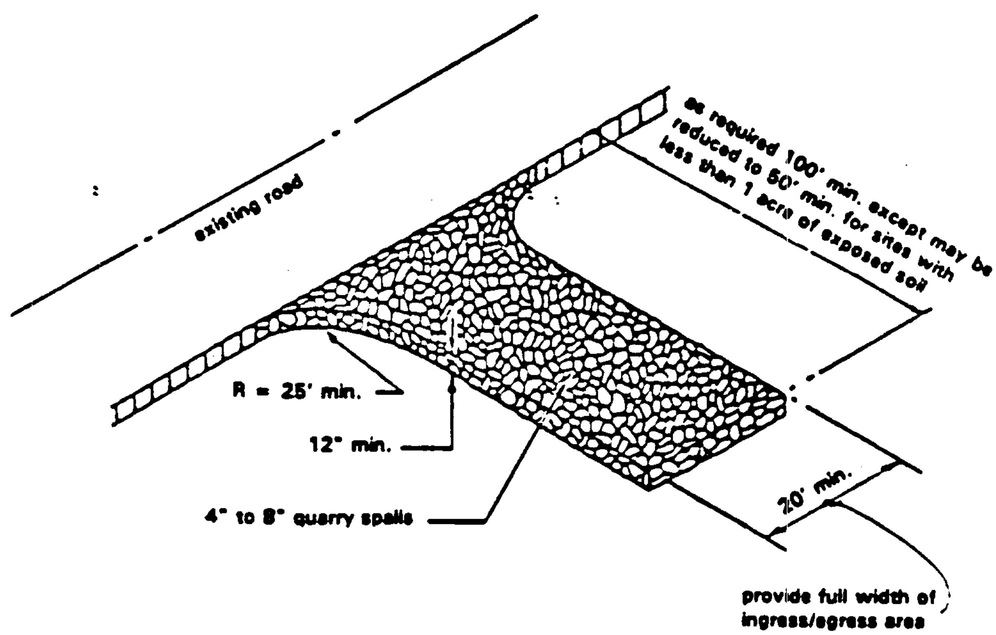
The entrance is the most important access route to stabilize, since it is the last point at which tracking sediment off-site can be stopped. If equipment travels extensively on unstabilized roads on the site, install a tire and vehicle undercarriage wash near the entrance on crushed rock. Treat wash water in a sediment pond or trap (Figure 14.2).

Stabilized Construction Entrance

- **Installation checks**

1. Is the entrance constructed with crushed rock 4 to 8 in (10.16 to 20.32 cm) in size and at least 12 in (30.48 cm) thick?
2. Is the stabilized entrance 50 ft (15.24 m) in length for sites up to 1 acre (0.4 ha) and 100 ft (30.48 m) for larger sites?
3. Is the stabilized entrance at least 20 ft (6.10 m) wide with enlargement to the street at a 25 ft (7.62 m) minimum radius curve?
4. If the entrance sits on a slope, is a filter fabric fence located down grade?

Figure 14.2—Stabilized construction entrance.



Source: Washington Dep. Ecol. 1992.

■ Maintenance checks

1. Is the entrance clogged with sediments, requiring top dressing the pad with 2 in (5 cm) of clean rock?
2. Must any sediments carried from the site onto the street be cleaned up?

Runoff Control

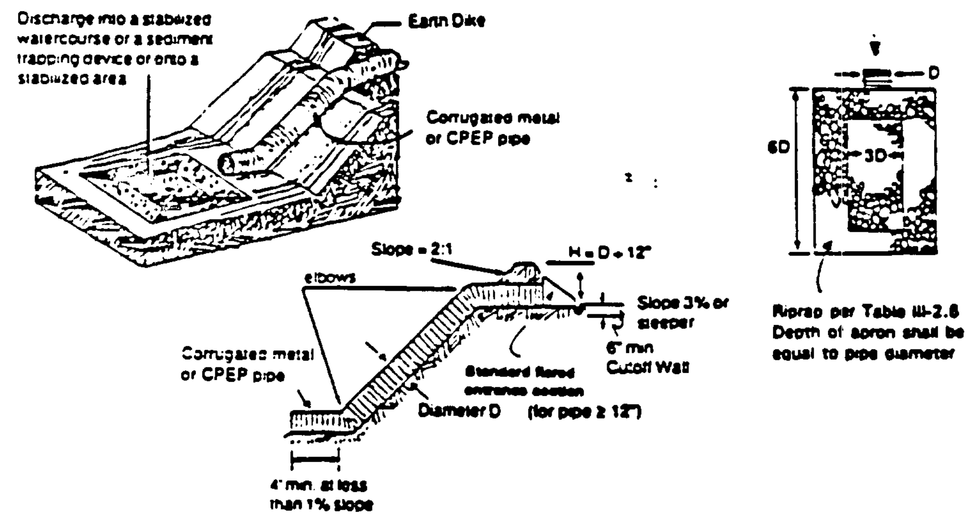
Runoff control represents various practices designed to keep water from contacting bare soil or, if so, controlling its velocity. Runoff control includes drains for surface and subsurface water, dikes and swales placed across slopes to interrupt and divert runoff, and roughness created on the surface to reduce velocity (Figures 14.3 and 14.4; see Chapter 11).

▮ *Pipe Slope Drain.* A temporary pipe slope drain is effective in preventing runoff erosion on a slope from a higher elevation. Upslope runoff needs to be collected and directed into the drain and then discharged in a controlled way to prevent erosion at the slope bottom.

■ Installation checks

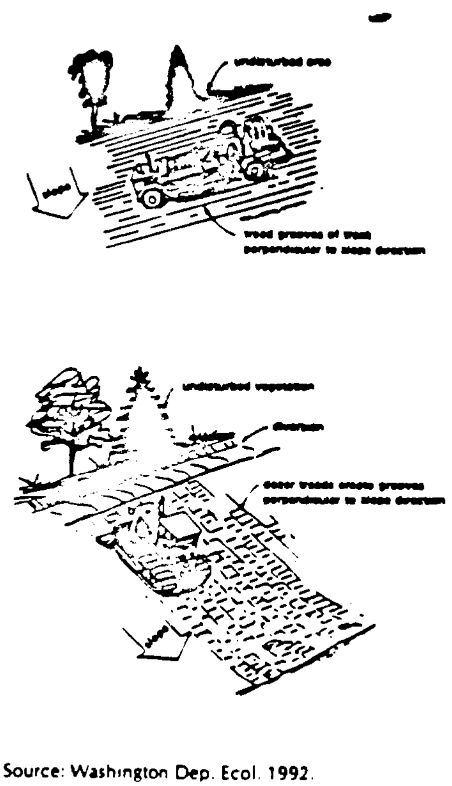
1. Are no more than 10 acres (4.05 ha) drained into a single pipe slope drain?
2. Was a minimum 6 in (15.24 cm) metal toe plate placed at the entrance to prevent undercutting?
3. Is runoff directed into the pipe with interceptor dikes at least 12 in (30.48 cm) higher at all points than the top of the pipe?
4. Is the slope toward the pipe on a grade of at least 3 percent at the inlet?
5. If the pipe is 12 in (30.48 cm) in diameter or larger, was a flared entrance section installed and connected securely to the drain with watertight connecting bands?
6. Was the soil thoroughly compacted at the entrance and under the pipe?
7. Were gasketed, watertight fittings placed between pipe sections? Were the sections securely fastened and the drain anchored to the soil?
8. Was the area below the outlet stabilized with a riprap apron?
9. If the drainage can carry sediment, is it treated in a sediment pond or trap?

Figure 14.3—Pipe slope drain details.



Source: Washington Dep. Ecol. 1992.

Figure 14.4—Maintenance standards for catch basins.



Source: Washington Dep. Ecol. 1992.

■ **Maintenance checks**

1. Is runoff undercutting or bypassing the inlet, requiring reinforcing of the headwall with compacted earth or sandbags?
2. Is erosion occurring at the outlet, necessitating rebuilding the apron?

I ***Surface Roughening.*** A roughened surface is an easy and cheap way to reduce runoff velocity, establish vegetation, increase infiltration, and trap sediment. The practice is not effective enough to be used alone—diversion is often necessary—but it can reduce the load on sediment trapping practices downstream. Roughening is best used on a slope with a horizontal-to-vertical ratio steeper than 3-to-1 that does not require mowing. The methods of roughening a surface all involve forming horizontal depressions with equipment. Methods include tracking perpendicular to the slope direction, driving treaded equipment along the slope direction to get grooves perpendicular to the slope, or tilling—preferred because it avoids compaction. On slopes with a ratio steeper than 2-to-1, a stair-step pattern should be formed.

■ **Installation checks**

1. Have all exposed slopes with a horizontal-to-vertical ratio steeper than 3-to-1 been roughened, with 40 to 50 in

(1.02 to 1.27 m) stair-steps on slopes steeper than 2-to-1?

2. Was the soil scarified if heavily compacted by the roughening?
3. Was the area seeded as quickly as possible?

■ **Maintenance checks**

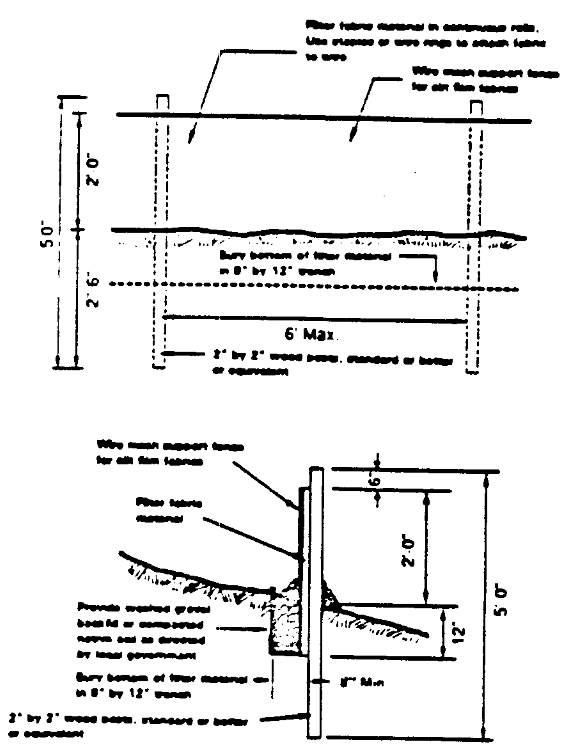
1. Have rills, gullies, or slumps appeared that should be regraded and reseeded?

B. Sediment Trapping Techniques

Trapping sediments once they are released requires slowing the transport velocity sufficiently so soil particles can settle. This means reducing the velocity below the settling velocity of the particles. Soil particles range in size from small clays to large sands. Settling velocity is related to the square of the particle diameter—halving the diameter approximately quadruples the time needed for settlement. Therefore, as particle sizes decrease, they become increasingly difficult to remove from a runoff stream. Thus, preventive techniques, more cost-effective than sediment trapping practices, are strongly preferred.

The two basic types of sediment trapping techniques are sediment barriers and settling ponds. Sediment barriers include the commonly used filter fabric and straw bale fences, brush fences, and barriers constructed of gravel. Both types trap sediments by ponding water. Although ponding is more obvious in ponds than in barriers, barriers have little ability to filter and can only slow the water long enough for some particles to settle. Thus, they can only trap relatively large particles, generally the larger silts and sands. The trapping ability of settling ponds depends on size. While ponds can theoretically be made large enough to trap any size particle, practical sizes generally limit efficient removal to medium and larger silts.

Figure 14.5—Filter fabric fence detail.



Source: Washington Dep. Ecol. 1992.

Sediment Barriers

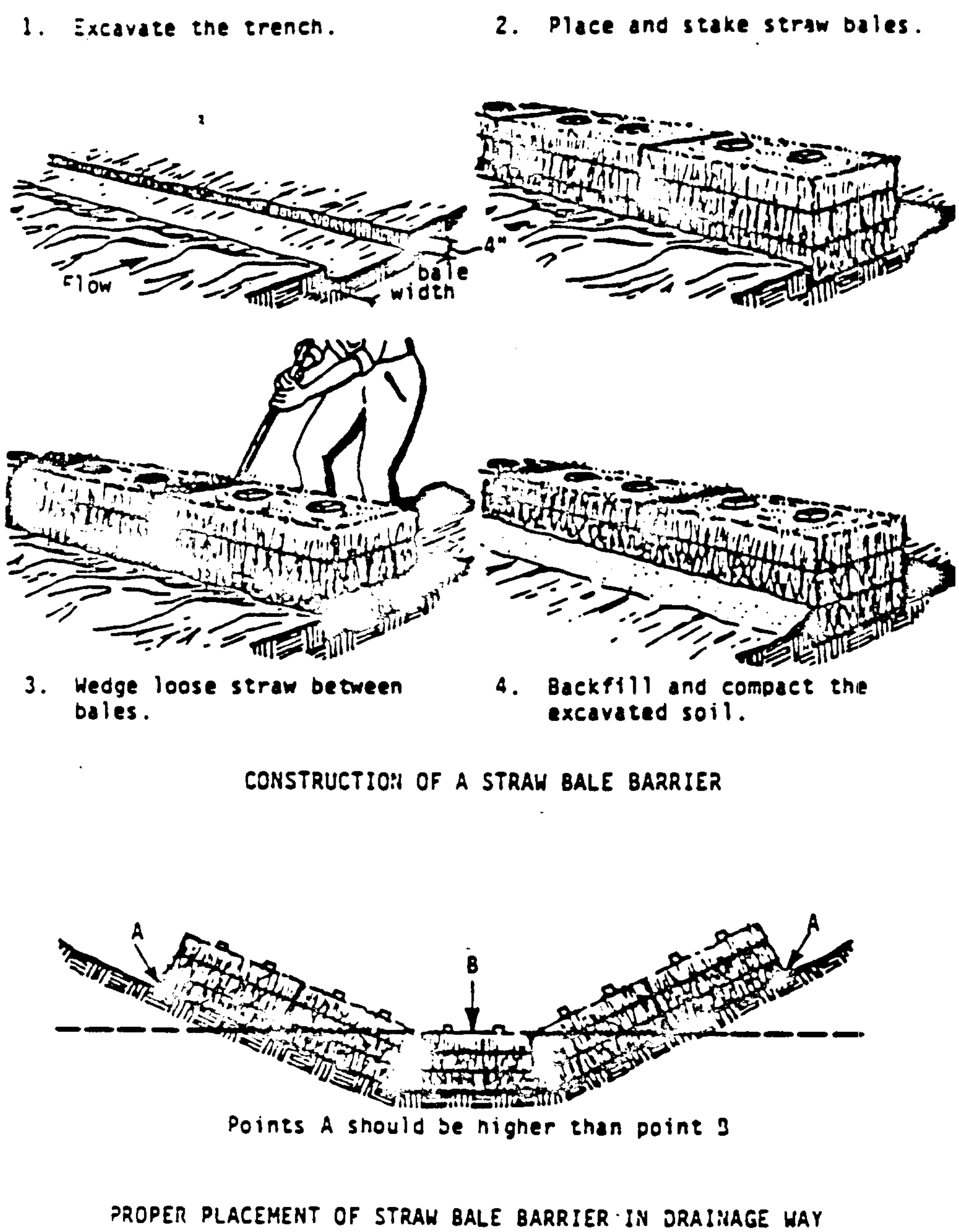
Several principles apply to the various types of sediment barriers. Maximizing a sediment barrier's ponding volume maximizes the sediment trapped. Therefore, barriers should be placed away from the immediate toe of slopes to increase the ponding area. Sediment barriers must be aligned on the contour, not up and down slopes. This alignment places them at a right angle to flow paths and increases ponding volume. Slopes draining to sediment barriers generally should not be more than 100 ft (30.48 m) long. Sediment barriers must be trenched in and staked to hold up under the pressure of the wall of water they will dam. Finally, sediment barriers do not provide effective sediment removal from concentrated flows. While straw bales are sometimes used in ditches, rock check dams are a better alternative for decreasing velocity in channels. Filter fabric and straw bale fences are illustrated in Figures 14.5 and 14.6.

Filter Fabric Fence

■ **Installation checks**

1. Are filter fabric fences used only in applications where
   - Maximum of 1 acre (0.405 ha) is served by a single fence?
   - Maximum gradient is 1-to-1 and slope length is ≤ 100 ft (30.48 m)?
   - Situation is sheet flow, never concentrated flow?

Figure 14.6—Proper installation of straw bale fences.



Source: Washington Dep. Ecol. 1992.

2. Is the fence aligned as closely as possible to slope contours?
3. Is the fence height above the soil no more than 3 ft (0.91 m)?
4. Are wooden posts 2 by 4 in (5.08 by 10.16 cm), and steel posts 1.33 lb/ft (1.98 kg/m), or the equivalent?
5. Are posts buried 2.5 ft (0.76 m) deep whenever possible and spaced no more than 6 ft (1.83 m) apart?
6. Is fabric attached on the upslope side with staples of at least 1 in (2.54 cm), tie wires, or hog rings?
7. Is the end of the fabric buried in a trench sized as shown in Figure 14.5 and backfilled on both the upslope and downslope sides?
8. Is splicing avoided? If unavoidable, is splicing done only at posts and overlapped at least 6 in (15.24 cm)?
9. Woven monofilament materials have the best properties for silt fencing. If a woven slit-film fabric is used, is 14-gauge reinforcing wire mesh with openings no larger than 6 in (15.24 cm) placed on the upslope side and fastened the same as the fabric?

■ Maintenance checks

1. Does the fence need restaking, reattaching, or replacing to maintain all previously cited conditions?
2. Is sediment removal needed before sediment reaches one-third fence height?

▌*Straw Bale Fence.* Straw bale fences, which tend to swell when wet, require frequent maintenance. Users should gain local experience on the expected service life of bales and replace them before they become ineffective. While not highly recommended, these fences could be somewhat effective if used according to the following guidelines:

■ Installation checks

1. Are straw bale fences used only in applications where
   - Maximum of 1/4 acre (0.1 ha) is served per 100 ft (30.48 m) of fence length?
   - Maximum slope gradient is 2-to-1 and slope length is 100 ft (30.48 m)?
2. Is the fence aligned as closely as possible to slope contours?
3. Are the bales bound with wire or alternatively with string placed around the sides, parallel to the ground?
4. Are bales installed in a 4 in (10.16 cm) trench as in Figure 14.6 and backfilled with 4 in (10.16 cm) of soil on the upslope side?
5. Are the bales forced tightly together and anchored with at least two stakes or rebars per bale, driven toward the previous bale, and flush to the top of the bale?
6. Are gaps wedged with straw spread on the upslope side?
7. Are straw bale fences used in channels with concentrated flow only when velocities are low, placed perpendicular to flow, and extended at least one bale length above the mid-channel bale (see Figure 14.6)?

■ Maintenance checks

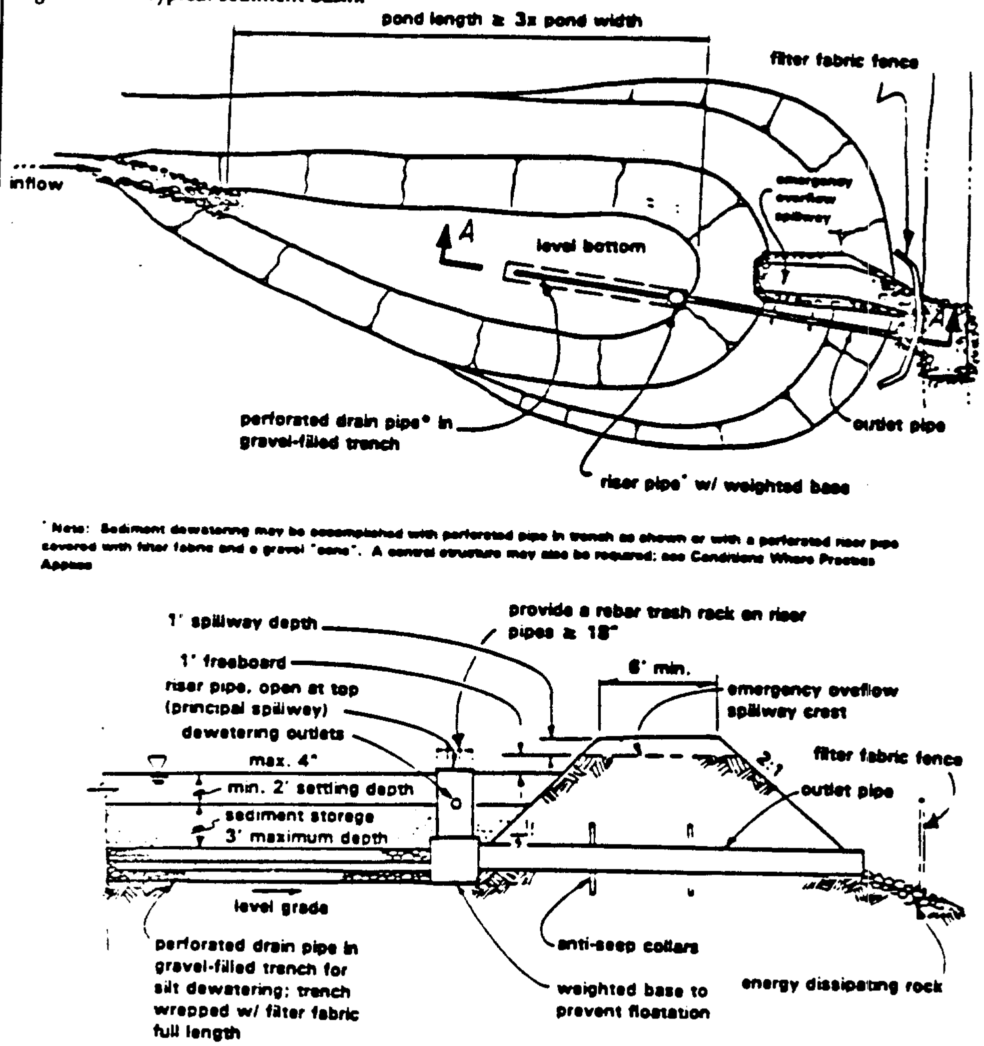
1. Must the fence be replaced to maintain all of the previously stated conditions?
2. Is removal needed before sediment reaches one-half the fence height?

Settling Ponds

Settling ponds have several advantages. They can function through all construction phases and have relatively low maintenance requirements if preventive erosion control is effective. Settling ponds can also be located to intercept runoff before and after the on-site drainage system is developed.

The three types of settling ponds differ in the their outlet structure. The term sediment basin is used for a settling pond with a pipe outlet that generally serves a drainage area of 3 to 10 acres (1.22 to 4.05 ha). A sediment trap is a settling pond with a stable spillway outlet and smaller service area. The third type is a permanent water quantity control pond used temporarily during construction. Used permanently, this pond could be designed to drain completely between storms. This operating mode is not effective for erosion and sediment control—residence time is too short for good particle trapping, and settled material

Figure 14.7—Typical sediment basin.



Source: Washington Dep. Ecol. 1992.

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becomes resuspended during draining. Therefore, a temporary riser outlet must to be installed for construction use.

In designing and constructing a settling pond, avoid allowing water to short circuit. Short circuiting can cut the actual residence time far below the theoretical value and harm performance. Therefore, divide the pond into two or more cells, locate the inlet and outlet far apart, and install baffling to increase the flow path. Figure 14.7 illustrates a typical sediment basin.

Sediment Basin

Installation checks

1. Is the bottom graded level?
2. Is the pond no deeper than 7 ft (2.13 m) plus 1 ft (0.31 m) of freeboard?
3. Are side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1?
4. Does the pond have an emergency spillway 1 ft (0.31 m) deep, a width two

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to three times the number of acres served by the pond, and is the pond lined with 2 to 4 in (5.1 to 10.16 cm) of rocks?

5. Does the pond discharge through a riser pipe having multiple orifices at the top of the sediment storage zone?
6. Are inlet and outlet areas protected from erosion with riprap?
7. Is baffling installed if the length-to-width ratio is less than 6 or if the entrance velocity is high?
8. A two-celled pond, preferably with cells divided by sandbags or a rock berm and connected by a riser pipe like the outlet, can prevent short circuiting of flow. A less desirable arrangement is to divide the pond with a filter fabric fence. Is the more effective feature installed if specified in the design?
9. Can the pond be easily accessed to remove sediment? Is there a plan to safely dispose of sediment or use it for fill?
10. Is the pond fenced if it presents any safety hazard to children?

Maintenance checks

1. Is sediment removal needed before 1.5 ft (0.46 m) accumulates?
2. Are any outlet orifices clogged and in need of cleaning?
3. Are any embankments damaged and in need of compaction or rebuilding?
4. Has riprap or spillway lining material been lost and need replacing?
5. Do signs of excessive drainage to the pond require rerouting or pond enlargement?
6. Do signs of excessive sediment loading to the pond require stabilizing the drainage area?
7. Is sediment being disposed of in a conscientious manner?

C. Management of Other Site Pollutants

Construction sites can create pollution problems over and above erosion and sediments through paving operations, handling and storage of various materials, spills, and waste handling. Inspectors should also be aware of the potential for runoff contamination from these sources and inspect the site according to the following guidelines:

Cement and Concrete Handling

Inspection checks

1. Do concrete trucks have a designated wash-out area with a sediment trap?
2. Is exposed-aggregate driveway wash water drained toward a collection point at the side or into a sediment trap where it cannot enter a street drainage system?

Material Storage and Handling

Inspection checks

1. Are weather-resistant enclosures used to store and handle materials like paints, coatings, wood preservatives, pesticides, fuels, lubricants, and solvents, and for potentially polluting wastes?
2. Are procedures for handling materials and wastes and washing containers designated and clearly communicated?
3. Is a chemical inventory maintained, including material safety data sheets?
4. Are containers and enclosures inspected periodically for leakage?
5. What is the fueling process? Are overflow prevention methods used?

Spill Containment

Inspection checks

1. Has a spill control plan been developed and have supplies been obtained to implement it? Does the plan include
   - Who to notify if a spill occurs?
   - Specific instructions for different products?
   - Who is in charge?
   - Spill containment procedures?
   - Easy to find and use spill clean-up kits?
   - How a spill will be prevented from getting into a drainage system—for example, valving, diversion, absorption?
   - A disposal plan?
   - A worker education program?

▮ *Waste Management*

- **Inspection checks**

1. Have waste reduction practices been instituted—for example, reusing solvents, substituting for toxic products, minimizing quantities of materials used?
2. Have recycling practices been instituted—for example, waste separation for recycling, purchasing recycled materials?
3. Are hazardous and nonhazardous wastes separated and each disposed of properly and promptly?
4. Is there an employee education program on waste management?

Comprehensive Inspection Program for Permanent Drainage

As previously discussed, a comprehensive inspection program for permanent drainage practices and facilities should contain the following elements:

- Runoff management planning
- Plan review
- Construction inspection and enforcement
- Follow-up inspection and long-term maintenance

Runoff management planning ensures that each site entering the permit process is comprehensively analyzed. Chapter 12 contains a discussion of the extensive considerations of plan review. Inspection of completed runoff management facilities determines that they have been installed consistently with the approved plans. The next section covers programmatic aspects of follow-up inspection and long-term maintenance, which ensures that sites continue to operate properly.

Follow-Up Inspection and Long-Term Maintenance

An effective program should have the following features:

- An ordinance designating public authority and public and private responsibilities
- A tracking system
- An inspection schedule
- A maintenance schedule
- A safety program
- A citizen response program
- Proper waste disposal practices
- Maintenance contractor education

The following information principally draws on experience in King County, Bellevue, Olympia, and elsewhere in the Puget Sound region of Washington State.

▮ *Public vs Private Responsibilities.* While inspection is usually a public function, who is responsible for upkeep of privately owned facilities? One model establishes a multiyear bonding period, during which the developer has all responsibility. After this period and a demonstration of effective operation, the government agency responsible for runoff takes over operation and maintenance.

A second model leaves maintenance as a private function—by a commercial property owner or homeowners' association—with inspection by the public agency. If the private party does not meet the responsibility, the government assumes the responsibility and charges the costs. This strategy requires access to private maintenance contractors who are competent in performing the needed work. The frequent lack of qualified contractors requires government agencies to consider training and certifying them.

▮ *Tracking System.* King County offers a good tracking system model to organize long-term inspections and maintenance using a computerized information system. Each inspector is assigned an inventory of facilities to inspect for specific maintenance and receives a laptop computer for field use. The information system contains an identification number for each facility, its type (e. g., wet pond, infiltration basin), location, any special needs, and data on previous experiences. After each visit, the inspector enters a maintenance needs assessment in the computer database. The computer then generates a maintenance work order.

▮ *Safety.* Safety is a major consideration because of potentially harmful atmospheres in below-ground spaces, corroded supports, traffic, falling objects, sharp edges, poisonous plants and in-

insects, and lifting. A tester should check all conditions and test all enclosed spaces before entering. The safety portion of an inspection and maintenance program should include the following:

- Testing instruments for harmful atmospheres—e.g., explosive, containing hydrogen sulfide, lacking in oxygen
- Ventilating equipment
- Checking structural soundness before entering a manhole
- Traffic warning devices
- Ladders, safety harnesses, and hard hats
- Removing poisonous plants and insect nests
- Adequate personnel
- Safety training

Waste Handling. Major maintenance on large facilities should be scheduled when the least runoff is expected. Inspectors should require ESC practices like filter-fabric fences, sandbags, grassed drainage areas, and revegetation to prevent sediment escape during maintenance.

The vactor truck—which vacuums out storm sewers, drains, and inlets—is the maintenance workhorse. A problem with vactor trucks is the mixing of relatively clean and very dirty waste. A solution, but an expensive one, is to have "clean" and "dirty" trucks. Another issue is the disposal of both solids and separated "decant" water picked up by vactor trucks.

The best solution is to discharge decant water to a special station with sediment and oil separation equipment before the water discharges to a sanitary sewer. However, oil separators should not be cleaned at the same time as sediment accumulation chambers. Few such stations exist now, and most vactor waste is discharged directly into the sanitary sewer. This practice can result in pollutants entering surface waters because of inadequate treatment at the municipal wastewater plant and in toxic materials that can upset biological processes at the treatment plant. Guidelines, while needed, generally do not exist for disposing of solids. The best programs now send solids to a lined municipal landfill, unless they fail a "looks bad and smells bad" test. In that case, they are treated as hazardous waste.

Table 14.4—Permanent drainage practices.

CATEGORIES	PRACTICES
Stormwater devices	Oil/water separators Pipes and culverts Catch basins
Detention facilities	Wet ponds Extended/detention dry ponds Vaults and tanks
Infiltration facilities	Infiltration basins Infiltration trenches Porous pavements
Biofilters	Vegetated swales Constructed wetlands Filter strips

Permanent Drainage Practices and Facilities Inspection

Table 14.4 provides a listing of practices (Reinelt, 1992). The practices include some variations on common devices, depending on their intended function as specified by the *Stormwater Management Manual for the Puget Sound Basin* (Washington Dep. Ecol. 1992). For example, detention facilities include wet ponds, which have a quantity control function, and water quality wet ponds, which are treatment devices.

The following are inspection checklists for the most common practices and facilities in each category. While brief descriptions are presented here, runoff management manuals or textbooks can provide detailed descriptions.

As previously suggested, inspectors must perform background work—consulting the design plans to determine the specifications before going out to inspect an installation. Infrequent inspection and maintenance is a main reason for poor performance by runoff facilities. The frequency of follow-up inspections varies with the type of device and the installation circumstances. Each installation should have an inspection and maintenance plan developed before it goes into service. As a general rule, surface facilities should receive a drive-by inspection at least monthly and after any rain totaling 0.5 in (1.27 cm) or more in 24 hours.

Stormwater Devices

These devices are used to collect and convey runoff and as special-purpose facilities. Within the category are catch basins, pipes and culverts, and

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oil/water separators. Inspection guidelines are provided for oil/water separators and tables of maintenance standards are included for the other types of facilities.

▌*Oil/Water Separators.* Figure 14.8 illustrates the three basic types of oil/water separators. The spill control unit (14.8A) catches small spills; it is not capable of separating dispersed oil. The American Petroleum Institute (API) separator (14.8B) is a baffled tank that can separate "free" (unemulsified) oil but requires a relatively large volume for effectiveness. The coalescing plate (CP) separator (14.8C) can separate free oil in a much smaller volume because of the large surface area provided by the corrugated plate pack. The following guidelines generally apply to all types, except as noted.

▬ Installation checks

1. Is the type appropriate for the service?
2. Is the unit sized and installed as specified in the plans?
3. Are adequate removable covers provided for observation and maintenance?
4. Is runoff excluded from roofs and other areas not likely to contain oil?
5. Is any pump being used placed downstream in order to prevent mechanical emulsification?
6. Is detergent use avoided upstream to prevent chemical emulsification?
7. For API and CP types, is a forebay provided and sized at 20 ft^2 (1.86 m^2) of surface area per 10,000 ft^2 (929 m^2) of drainage area?
8. For API and CP types, is an afterbay provided to place absorbents?
9. For the CP type, are the plates no more than 3/4 in (1.91 cm) apart and at 45 to 60 degrees from horizontal?

▬ Maintenance checks

1. Does the owner perform weekly inspections?
2. Are oil and any solids removed frequently enough—at least just before the main runoff period and after the first major runoff event?
3. Are absorbents replaced as needed—at least at the beginning and end of the main runoff season?
4. Is the effluent shutoff valve operational for closure during cleaning?
5. Are waste oil and solids disposed of as specified by regulations?
6. Is any standing water that is removed discharged to the sanitary sewer and then replaced with clean water?

▌*Pipes and Culverts.* Table 14.5 contains a summary of maintenance standards for conveyance facilities.

▌*Catch Basins.* Catch basins are routinely placed between drain inlets in streets and parking lots and the conveyances that transport water away to settle large solids. Table 14.6 contains a summary of maintenance standards.

▌*Wet Ponds.* A typical wet pond has a "dead storage" permanent or semipermanent pool and a "live storage" zone that fills during runoff events and then drains fairly quickly (see Figure 14.9). Designs differ depending on the purpose—quantity control, quality control, or both—but the checks made at installation and later during operation are generally the same, with the few exceptions noted.

▬ Installation checks

1. Does construction comply with local requirements for earthwork, concrete, other masonry, reinforcing steel, pipe, water gates, metal work, and woodwork?
2. Are all dimensions as specified in the approved plan?
3. Are interior side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1 and exterior side slopes no steeper than 2-to-1?
4. Is the bottom level?
5. Are the spillways—between cells, if any, and the emergency outlet spillway—sized and reinforced as specified in the approved plan?
6. Can the drain empty the dead storage zone within four hours?

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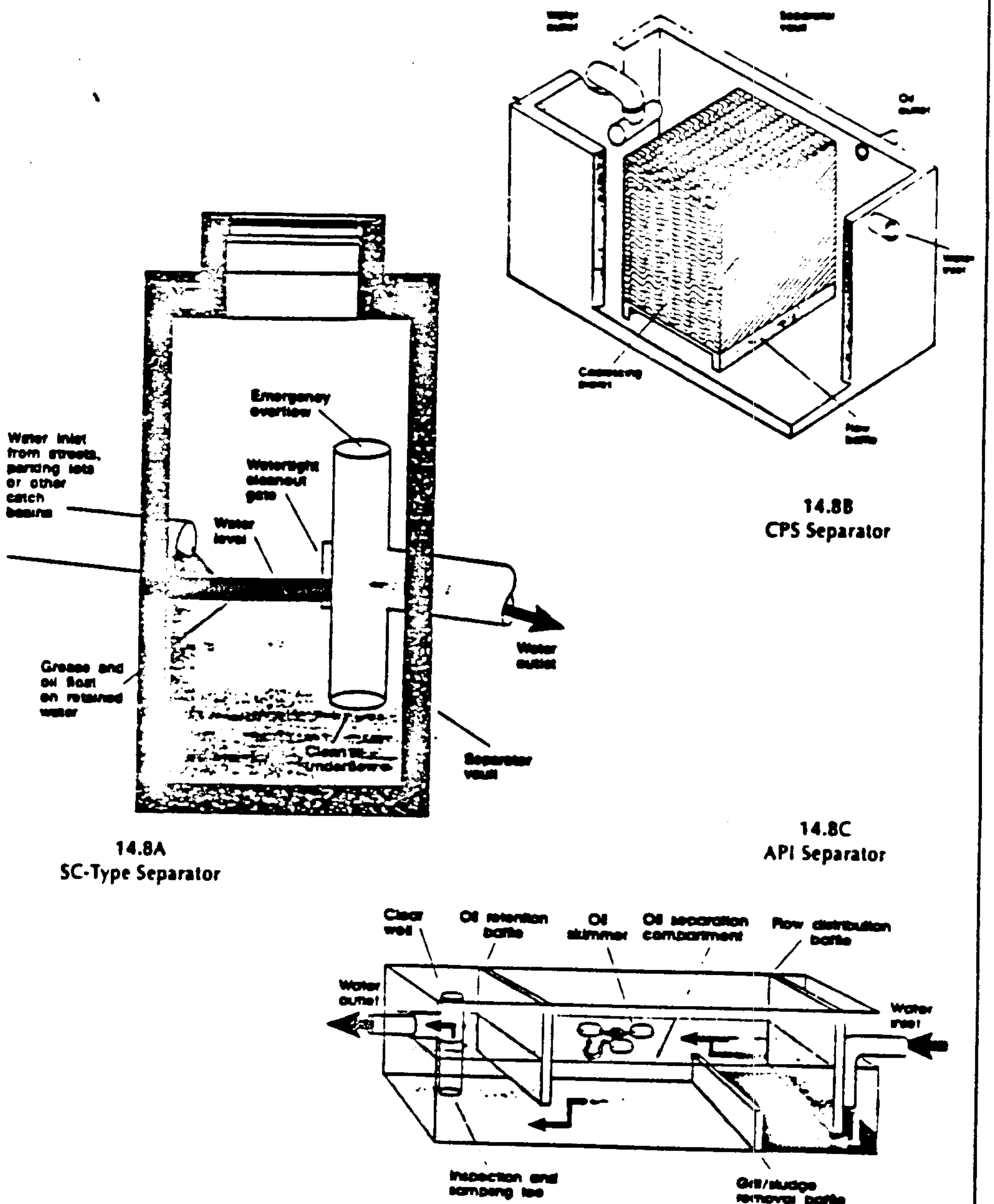
Figure 14.8—Types of oil/water separators.



Source: Washington Dep. Ecol. 1992.

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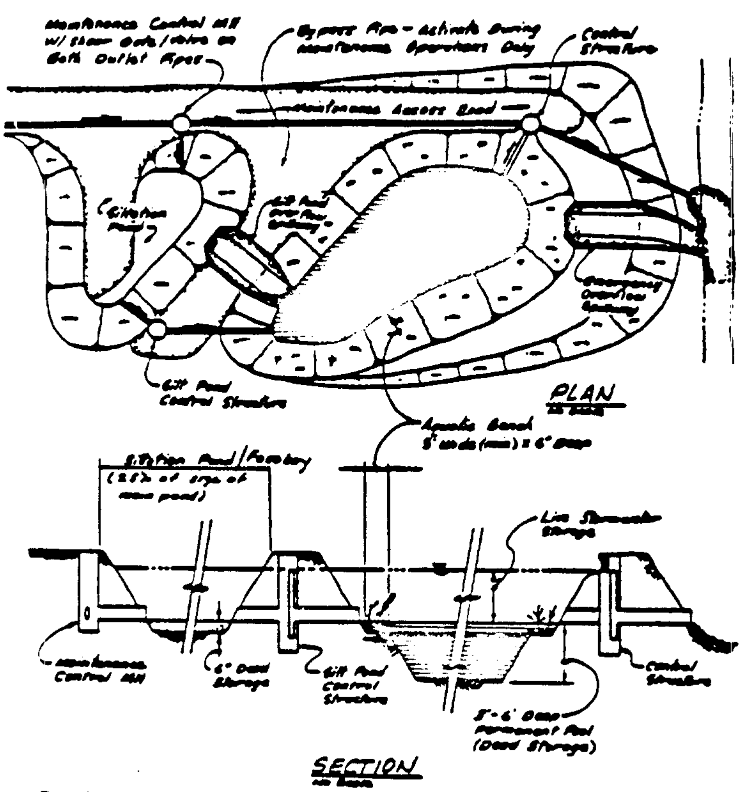
Table 14.5—Maintenance standards for pipes and culverts.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment and debris	Accumulated sediment that exceeds 20 percent of the pipe diameter	Pipe cleaned of all sediment and debris
Vegetation	Vegetation that reduces free movement of water through pipes	All vegetation removed so water flows freely through pipes
Damaged	Protective coating is damaged; rust is causing more than 50 percent of deterioration to any part of pipe Any dent that decreases the end area of pipe by more than 20 percent	Pipe repaired or replaced
Debris barriers	Trash or debris plugging more than 20 percent of the barrier openings	Barrier clear to receive capacity flow
Damaged/missing bars	Bars are bent out of shape more than 3 in (7.62 cm)	Bars in place with no bends > 3/4 in (1.91 cm)
	Bars are missing or entire barrier missing	Bars in place according to design
	Bars are loose and rust is causing 50 percent deterioration to any part of barrier	Repair or replace barrier to design standards

Source: Adapted from Reinelt, 1992.

Figure 14.9—Typical wet pond.



Source: Washington Dep. Ecol. 1992.

Table 14.6—Maintenance standards for catch basins.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris (including sediment)	Trash or debris of more than 1/2 ft^3 (14.16 dm^3) located in front of the catch basin opening or blocking capacity of basin by > 10 percent	No trash or debris located immediately in front of catch basin opening
	Trash or debris in the basin that exceeds 1/3 to 1/2 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin	No trash or debris in catch basin
	Trash or debris in any inlet or outlet pipe blocking more than 1/3 of the height	Inlet and outlet pipes free of trash or debris
	Dead animals or debris that could generate odors that would cause complaints or dangerous gases	No dead animals or vegetation present
	Deposits of garbage exceeding 1 ft^3 (28.32 dm^3) in volume	No trash or debris in catch basin
Structural damage to frame and/or top slab	Corner of frame extends more than 3/4 in (1.91 cm) past curb face into the street (if applicable)	Frame is even with curb
	Top slab has holes larger than 2 in^2 (12.9 cm^2) or cracks wider than 1/4 in (1.61 cm) (to ensure that all materials run into basin)	Top slab is free of holes and cracks
	Frame not sitting flush on top slab—i.e., separation of > 3/4 in (1.91 cm) of the frame from top of slab	Frame is sitting flush on top of slab
Cracks in basin walls or bottom	Cracks wider than 1/2 in (3.23 cm) and longer than 3 ft (0.91 m), any evidence of soil particles entering catch basin through cracks, or structure is unsound	Basin replaced or repaired to design standards
	Cracks wider than 1/2 in (3.23 cm) and longer than 1 ft (0.305 m) at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through crack	No cracks more than 1/4 in (1.61 cm) wide at joint of inlet/outlet pipe
Settlement/misalignment	Basin has settled more than 1 in (2.54 cm) or has rotated more than 2 in (5.08 cm) out of alignment	Basin replaced or repaired to design standard
Fire hazard	Presence of chemicals such as natural gas, oil, and gasoline	No flammable chemicals present
Vegetation	Vegetation growing across and blocking more than 10 percent of basin	No vegetation blocking opening to basin
	Vegetation (or roots) growing in inlet/outlet pipe joints > 6 in (15.24 cm) tall and < 6 in (15.24 cm) apart	No vegetation or root growth present
Pollution	Nonflammable chemicals of > 1/2 ft^3 (14.16 dm^3) per 3 ft (0.91 m) of basin length	No pollution present other than surface film

Source: Adapted from Reinelt, 1992.

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7. Are inlet and outlet areas stabilized to avoid erosion?

8. Are safety features provided such as a shallow bench surrounding the pond edge, barrier plantings to discourage approach by children, and/or fencing (unnecessary if sloped as recommended and other safety features provided)?

9. For a water quality pond, is the effective length-to-width ratio at least 3-to-1 and preferably 5-to-1? Are the inlet and outlet separated as widely as possible?

- **Maintenance checks**

1. Has a maintenance plan and schedule been developed?

2. Table 14.7 contains specific checks and maintenance standards, which also apply to other types of ponds.

Vaults and Tanks. Refer to Table 14.8 for a summary of maintenance standards for closed detention systems.

Infiltration Facilities

Infiltration facilities discharge most of the entering water into the ground. They include surface basins and trenches, below-ground perforated pipes, roof drain systems, and porous pavements. Inspection guidelines are given for infiltration basins in Figure 14.10 and a table of maintenance standards is included for infiltration trenches as well (Figure 14.9).

Infiltration Basins

- **Installation checks**

1. Does construction comply with local requirements for earthwork, concrete, other masonry, reinforcing steel, pipe, water gates, metal work, and woodwork?

2. Are all dimensions as specified in the approved plan?

3. Does the timing of basin construction avoid any runoff containing sediment from elsewhere on the site?

4. Is the basin preceded by a pretreatment device— presettling basin or biofilter—to prevent failure caused by siltation?

5. Is the basin at least 50 ft (15.24 m) from any slope greater than 15 percent and at least 100 ft (30.48 m) upslope and 20 ft (6.1 m) downslope of any building?

6. Is the outlet orifice design consistent with the facility's infiltration capacity—e. g., to avoid the collection of more water than can infiltrate in 48 hours?

7. Are the spillways—between cells, if any, and the emergency outlet spillway—sized and reinforced as specified in the approved plan?

8. Are all disturbed areas stabilized to prevent erosion?

9. After final grading, has the bed been deeply tilled to provide a well-aerated, highly porous surface texture?

- **Maintenance checks**

1. Has a maintenance plan and schedule been developed?

2. Table 14.9 contains specific checks and maintenance standards.

3. Is tilling necessary to restore infiltration capacity (regular annual tilling is recommended)?

Infiltration Trenches. Table 14.10 contains a summary of maintenance standards for infiltration trenches.

Biofilters

Biofilters, or vegetated land treatment systems, can be vegetated swales where water flows at some measurable depth. Biofilters can also be broad surface areas where water flows in a thin sheet, sometimes called filter strips. Constructed wetlands are also sometimes put in this category. The following guidelines generally pertain to swales and filter strips, although some exceptions are noted. To inspect constructed wetlands, refer to both these guidelines and those given previously for wet ponds.

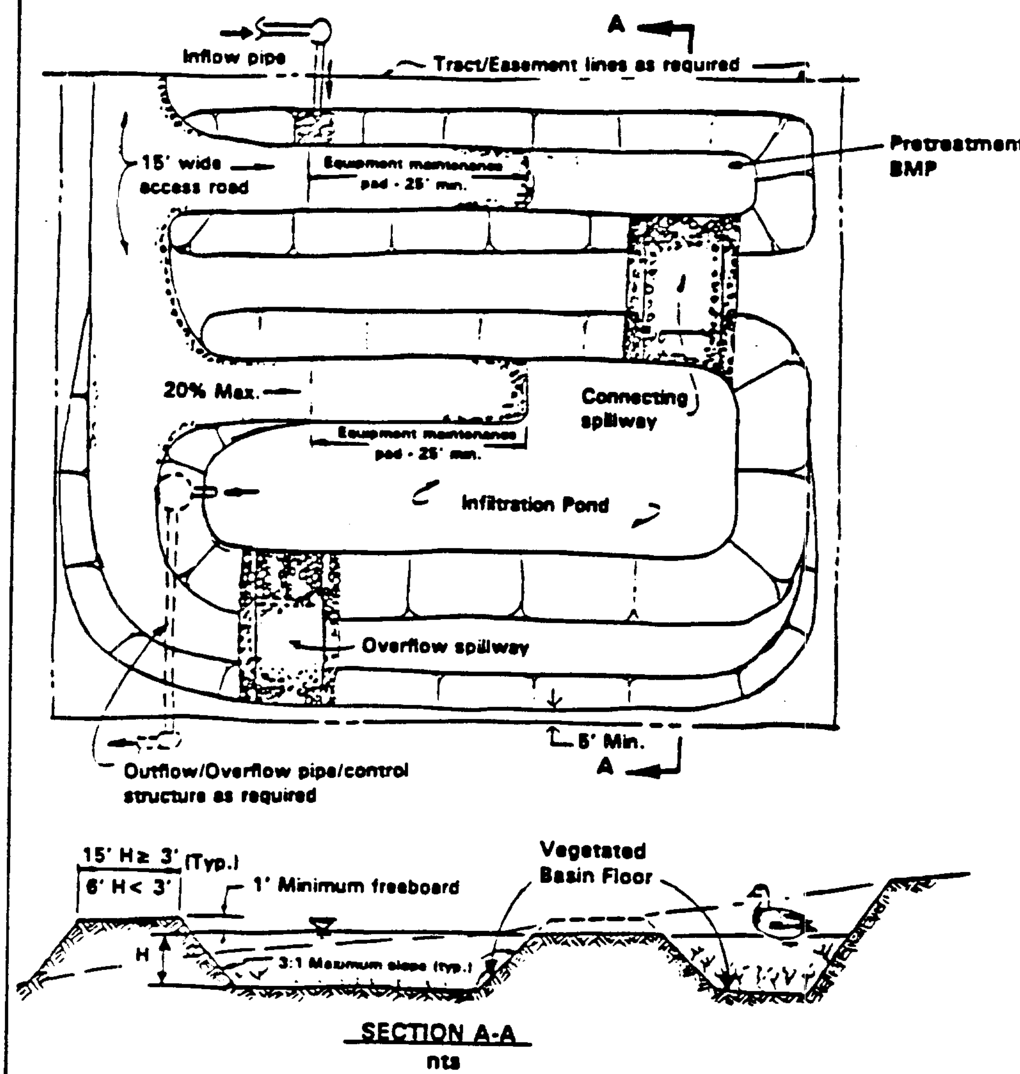
Biofiltration Swales and Filter Strips

- **Installation checks**

1. Are the dimensions and plantings as specified in the approved plan?

2. Is the vegetation cover dense and uniform?

Figure 14.10—Typical infiltration basin.



Source: Washington Dep. Ecol. 1992.

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Table 14.7—Maintenance standards for detention facilities.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris	Any trash or debris that exceeds 1 ft^3/1,000 ft^2 (28.32 dm^3/92.9 m^2); no evidence of dumping should exist	Trash and debris cleared from site
Poisonous	Presence of any poisonous vegetation that constitutes a hazard to maintenance personnel or the public (e.g., tansy, poison oak, stinging nettles, devils club)	No evidence of poisonous vegetation; coordinate with local health department
Pollution	One gallon or more of oil, gas, or contaminants, or any amount that could (1) cause damage to plant, animal, or aquatic life; (2) constitute a fire hazard; (3) be flushed downstream during storms; or (4) contaminate groundwater	No contaminants present other than a surface film; coordinate with local health department
Unmowed grass/ ground cover	In residential areas, mowing is needed when the cover exceeds 18 in (.46 m) in height; otherwise, match facility cover with adjacent ground cover and terrain as long as facility function does not decrease	Grass/ground cover should be mowed to 2 in (5.08 cm); maintain dense cover on slopes and in bottom of dry ponds
Rodent holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes	Rodents destroyed and dam or berm repaired; coordinate with local county health department
Insects	When insects such as wasps or hornets interfere with maintenance activities	Insects destroyed or removed from site; coordinate with people who remove wasps for antivenom protection
Tree growth	Does not allow maintenance access or interferes with maintenance activity; if trees are not interfering with access, leave alone	Trees do not hinder maintenance activities
Erosion of pond side slopes	Eroded damage > 2 in (5.08 cm) deep where cause of damage is still present or potential for continued erosion exists	Slopes stabilized with appropriate erosion control BMPs (e.g., seeding, mats, riprap)
Sediment accumulation in forebay/pond	Accumulated sediment that exceeds 10 percent of the design forebay/pond depth, or every 3 years	Sediment cleaned out to design depth; reseed if necessary for erosion control
Dike settling	Any part of dike that has settled more than 4 in (10.16 cm)	Dike is rebuilt to design elevation
Rocks missing from overflow spillway	Only one layer of rock above native soil in an area of 5 ft^2 (0.47 m^2) or greater, or any exposed soil	Rock replaced to design standard
Inadequate spillway size	Emergency overflow or spillway not large enough to handle flows from large storm events	Increase capacity of spillway to current design standards

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Table 14.7—continued

Missing, broken, or damaged fencing	Any defect in fencing that permits easy entrance to the pond	Fencing repaired to prevent entrance
	Damaged fencing including posts out of plumb by > 6 in (15.24 cm), top rails bent > 6 in (15.24 cm), missing or loose tension wire, missing or sagging barbed wire, missing or bent extension arms	Fencing parts that have a rusting or scaling condition affecting structural adequacy
	Opening in fencing that allows passage of an 8 in diameter ball	No opening in fence
Erosion under fencing	Erosion 4 in (10.16 cm) deep and 12 to 18 in (.31 to .46 cm) wide permitting an opening under fence	No opening under fence > 4 in (10.16 cm)
Missing or damaged gates	Missing or damage gate, locking device, or hinges	Gates, locking devices, and hinges repaired
	Gate is out of plumb by > 6 in (15.24 cm) and > 1 ft (.31 m) out of design alignment	Gate is aligned and vertical
	Missing stretcher bar, bands, or ties	Stretcher bar, bands, and ties in place
Blocked or damaged access roads	Debris that could damage vehicle tires	Roadway free of debris
	Obstructions that reduce clearance above road surface to < 14 ft (4.27 m) (e.g., tree branches, wires)	Roadway clear overhead to 14 ft (4.27 m)
	Any obstructions restricting access to a 10 to 12 ft (3.05 to 3.66 m) width for a distance of > 12 ft (3.66 m), or any point restricting access to a width of < 10 ft (3.05 m)	Obstructions moved to allow at least a 12 ft (3.66 m) access route
	Any road settlement, potholes, mushy spots, or ruts that prevent or hinder maintenance access	Road surface repaired and smooth
	Weeds or brush on or near road surface that hinder access, or are > 6 in (15.24 cm) tall and < 6 in (15.24 cm) apart within a 400 ft^2 (37.16 m^2) area	Weeds and brush on or near road surface cut to 2 in (5.08 cm)
	Erosion within 1 ft (.31 m) of the roadway > 8 in (20.32 cm) wide and 6 in (15.24 cm) deep	Shoulder and road free of erosion

Source: Adapted from Reinelt, 1992.

Table 14.8—Maintenance standards for closed detention systems.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Plugged air vents	Half of the end area of a vent is blocked at any point with debris and sediment	Vents free of debris and sediment
Debris and sediment in storage area	Accumulated sediment depth is > 10 percent of the diameter of the storage area for 1/2 the length of storage vault or any point exceeds 15 percent of the diameter; for example, 72-in (1.83-m) storage tank would require cleaning when sediment reaches a depth of 7 in (17.78 cm) for more than 1/2 the tank length	All sediment and debris removed from storage area
Cracks in joints between tank/pipe sections	Any crack allowing material to be transported into the facility	All joints between tanks/pipe sections are sealed
Problems with manhole cover	Cover is missing or only partially in place; any open manhole requires maintenance	Manhole is closed and secured
	Locking mechanisms cannot be opened by one maintenance person with proper tools; bolts into frame have < 1/2 in (3.23 cm) of thread (may not apply to selflocking lids)	Mechanism is repaired or replaced so it functions properly
	Cover difficult to remove by one maintenance person applying 80 lbs (36.29 kg) of lift	Cover can be removed and reinstalled by one maintenance person
Ladder rungs of manhole unsafe	Local government safety officer or maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks	Ladder meets design standards and allows for maintenance access
Catch basins	See Table 14.6	See Table 14.6

Source: Adapted from Reinelt, 1992.

Table 14.9—Maintenance standards for infiltration basins.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment buildup in system	Soil texture test indicates facility is not functioning as designed	Sediment is removed and/or facility is cleaned so that system works according to design; a forepay or presetting basin is installed to reduce sediment transport to facility
Poor facility drainage (more than 48 hours)	Soil texture test indicates facility is not functioning as designed	Additional volume added through excavation to provide needed storage; soil aerated and rototilled to improve drainage
Sediment trapping area	Sediment and debris fill more than 10 percent of sediment trapping facility or sump	Sediment trapping facility or sump cleaned of accumulated sediment
No sediment trapping facility	Runoff enters infiltration area without pretreatment	Add a trapping facility (presettling basin, detention pond, biofilter) before infiltration facility

Source: Adapted from Reinelt, 1992.

Table 14.10—Maintenance standards for infiltration trenches.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment and debris buildup in trench	By visual inspection, little or no water flows through the trench during large storms	Debris blocking infiltration trench removed; gravel in infiltration trench replaced or cleaned
Observation well	Observation well buried, covered, or inaccessible	The observation well/cap is accessible to the inspector for opening and inspection
Water percolates up from trench	Trench water or water with dye percolating to surface	Gravel and filter fabric in infiltration trench replaced or cleaned; trench functions according to design standards
Filter fabric exposed	Filter fabric is exposed or damaged	Filter fabric is replaced or repaired and covered with proper backfill material

Source: Adapted from Reinelt, 1992.

3. If the biofilter is a swale, is it parabolic or trapezoidal in shape, with side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1?
4. Is the biofilter placed near buildings and trees so that no portion will be shaded throughout the day and possibly experience poor plant growth?
5. If the longitudinal slope is less than 2 percent or if the water table can reach the root zone of vegetation, is water-resistant vegetation planted to survive a standing water condition? Is an underdrain system installed to assist drainage (underdrains may not be practical with a large filter strip)?
6. If the longitudinal slope is in the 4 to 6 percent range, are check dams provided approximately every 50 to 100 ft (15.24 to 30.48 m) to reduce velocity (check dams may not be practical on a larger filter strip)?
7. If a swale is installed on a slope that exceeds 6 percent, does it traverse the slope so that no reach slopes more than 4 percent, or 6 percent with check dams?
8. Is the lateral slope entirely uniform to avoid any tendency for the flow to channelize?
9. Is flow introduced so that entrance velocity is dissipated quickly, flow is distributed uniformly, and erosion is avoided (e. g., by using a riprap pad or some means of level spreading)?
10. Was construction-phase runoff excluded or was the biofilter reestablished after construction? Are upslope areas stabilized to avoid erosion into the biofilter?
11. Is a bypass in place for flows larger than the flow rate the biofilter was designed to treat? Is the facility sufficiently large to at least pass the 100-year, 24-hour storm without eroding (a bypass is preferred to maintain treatment and prevent resuspension of settled material)?

■ **Maintenance checks**

1. Has a maintenance plan and schedule been developed?
2. Table 14.11 contains specific checks and maintenance standards.

Recommended Reading

References Cited

New Jersey Department of Environmental Protection and Energy. 1989. Stormwater Management Facilities Maintenance Manual. Trenton, NJ.

Table 14.11—Maintenance standards for biofilters.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris	Dumping of yard wastes; accumulation of nondegradable materials	Remove degradable wastes and compost; recycle other waste when possible
Sediment buildup	Accumulation exceeds 20 percent of design depth	Cleaned or flushed to match design; vegetation restored as necessary
Poor vegetation cover	Vegetation sparse and/or weedy; overgrown with woody vegetation	Aerate soil and plant; remove woody growth and replace
Erosion damage to slopes	Erosion > 2 in (5.08 cm) deep where cause still present, or potential for continued erosion	Find cause and eliminate; stabilize with appropriate erosion controls (e.g., seeding, mat, mulch)
Conversion to use incompatible with water quality control	Filled or planted inappropriately, or blocked	Discuss with nearby property owners and specify corrections to be made
Poor drainage	Water stands in swale	Determine cause; if high water table, consider rebuilding with liner or underdrain; if slope < 1 percent, use underdrain

Source: Adapted from Reinelt, 1992.

Reinelt, L.E. 1991. Construction Site Erosion and Sediment Control Inspector Training Manual. Eng. Continuing Edu., Univ. Washington, Seattle, WA.

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CHAPTER 15

Watershed Management

Runoff management and nonpoint source pollution present many complex challenges to the water resources manager. This chapter discusses how to meet these challenges by using a watershed management approach to integrate land planning and other resources within the watershed.

The challenges, quite different from those encountered when managing traditional point sources of pollution, include

- Integrating land use management, since the change in land use creates the runoff problem;
- Educating the public about how everyday activities contribute to the runoff problem and how they must be part of the solution;
- Developing a management framework given that we all live downstream and that runoff flows are not constrained by political boundary lines;
- Obtaining the cooperation and coordination of neighboring political entities within a watershed;
- Managing runoff from new development and retrofitting the existing drainage system built solely to convey runoff away from developed lands to the nearest waterbody as quickly as possible.
- Coordinating point and nonpoint source runoff strategies and activities.

Additionally, constraints imposed by current runoff treatment technology—such as treatment efficiency, land needs, and maintenance needs—and by the costs of assessing and solving existing runoff/nonpoint source pollution problems call for a cooperative regional framework. Finally, a watershed management approach includes planning efforts to prevent problems and traditional regulatory efforts to mitigate adverse effects caused by land alterations and changes in land use. This approach permits extensive use of inexpensive nonstructural management practices.

Definition and Rationale

What Is a Watershed?

The term watershed refers to a geographical area in which water, sediments, and other materials drain to a common outlet such as a stream, lake, or estuary. This area is also called the drainage basin of a receiving waterbody. When a raindrop falls in this area, it flows until it reaches the downstream receiving waterbody.

Watershed dimensions depend on the waterbody. A large river's watershed may cover thousands of square miles, while each of its tributaries has a smaller watershed. The U.S. Geological Survey has segmented the nation into hydrological units, a standard way to define the many subbasins or small watersheds that combine to make up large watersheds.

What Is Watershed Management?

Watershed management is a flexible framework for integrating the management of all resources—land, biological, water, infrastructure, human, economic—within a watershed. Human activities are managed so they cause the least disruption to our natural systems and native flora and fauna. The crucial factor in managing runoff and nonpoint sources is integrating land use, water/runoff,

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and infrastructure management. Watershed management includes numerous facets—planning, education, regulation, monitoring, and enforcement. These facets should be accomplished on a watershed basis and involve a diverse set of stakeholders in the process.

Selection of watershed size depends on many factors—watershed ecological systems, groundwater hydrologic influences, type and scope of resource management problems and goals, and level of available resources. The institutional framework also varies greatly, depending on the legal framework established by state laws and local ordinances.

Why Watershed Management?

Solving our nation's runoff problems, especially retrofitting existing drainage systems to reduce pollutant loads discharged to receiving waters, presents many complex challenges. Correcting these problems is expensive, technically difficult, and requires a long time period. Accordingly, we need to reevaluate our current approach to runoff management and shift the emphasis toward more comprehensive, prevention-oriented strategies such as watershed management.

The following comparison illustrates the differences between the traditional, piecemeal approach to runoff management and a comprehensive watershed approach (Camp, Dresser, McKee, 1985).

The Traditional Versus the Watershed Approach

The Piecemeal Approach

The traditional approach for existing urban development is to address local runoff problems without evaluating the potential for the control measure to adversely affect downstream areas (see Chapter 10). In new urban development, runoff management responsibilities are delegated to local land developers, with each responsible for constructing runoff management facilities on the development site. Their goal is to control runoff from the development site with little regard to how the discharges affect the system as a whole or the effects on the local government infrastructure. This is a piecemeal or individual site approach to runoff management.

While the usual approach to urban runoff management is relatively easy to administer it has several disadvantages. The risk of negative effects, particularly in watersheds that cover several jurisdictions, is greater. The failure to consider downstream impacts in selecting runoff management facilities causes ineffective runoff control throughout the watershed. This approach incurs relatively high local costs for facility maintenance. In addition, unnecessary costs are used for small-scale structural solutions rather than using large-scale nonstructural solutions, which are typically much cheaper.

Other negative effects of piecemeal runoff management are the following:

- It only partially solves major flooding problem(s).
- It solves flooding problems in the upstream jurisdiction, but may create flooding problems downstream.
- Randomly locating detention basins may actually increase downstream peak flows.
- Maintenance needs and costs associated with numerous on-site runoff controls are very high.
- Significant capital and operation/maintenance expenditures may be wasted.
- Remedial structural solutions cost more than implementing proper management programs in the first place.
- Other watershed management changes in the hydrolic regime or in stream temperature may not be considered.

The Watershed Approach

The watershed approach develops a comprehensive watershed plan—a runoff master plan—to identify the most appropriate control measures and the optimum locations to control watershed-wide activities. The watershed approach typically results in the following combinations:

- Reviewing watershed and its characteristics overall to assess problems and potential solutions.
- Using regional systems where appropriate.
- Providing runoff conveyance improvements where necessary.

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- Developing nonstructural measures throughout the watershed, such as acquiring floodplains, wetlands, and natural runoff depressional storage areas, limiting the amount of imperviousness, requiring grassed swales rather than storm sewers, and directing roof runoff to pervious areas.

- Coordinating point and nonpoint source program implementation.

Watershed master planning offers significant advantages over the piecemeal approach. It reduces capital and operation/maintenance costs and the risk of downstream flooding and erosion, particularly in multijurisdictional watersheds. It offers better opportunities to manage existing runoff problems and to consider and use nonstructural controls. Other benefits include increased opportunities for recreational uses of runoff controls, potential contributions to local land use planning, enhanced opportunities for runoff reuse, and popularity among land developers.

The major disadvantages of the watershed-level runoff master plan include

- Local governments must conduct advanced studies to locate and develop preliminary designs for integrated management facilities without fully knowing local plans.

- Local governments must develop and adhere to a future land use plan and properly design an effective mix of local and regional controls to capture runoff from present and future development and impervious surfaces.

- Local governments must often finance, design, and construct the regional runoff management facilities before most development occurs and provide for reimbursement by developers over a build-out period that can be many years long.

- In some cases, local governments may need to conduct expensive maintenance activities for regional facilities that the public views as primarily recreational.

However, another advantage of watershed management is that resource management goals can be resource oriented. This approach stresses prevention practices and programs to protect natural systems and beneficial uses of our waterbodies. These practices and programs are typically more cost-effective than trying to restore natural systems after they have been adversely affected by human activities.

Watershed management allows coordination of infrastructure improvements with point and nonpoint source management programs and, most importantly, provides a vital link between land use and water resources management.

Watershed Management Framework

Until recently, watershed management has faced many deterrents. Initially, the goal of a runoff management program was drainage—preventing flooding by quickly conveying runoff away from buildings and other developed areas, typically to the nearest waterbody. Restricting the use of private property through growth management/land use planning programs and regulations—the most cost-effective management option—has not been effective until recently. Little thought was given to the potential impacts of a land use change on the local drainage system or on the community at large. The generally accepted tenet was that development was good for the community, helped increase the tax base, and stimulated the economy—i.e., "growth pays for itself."

Other major deterrents to establishing comprehensive, integrated watershed management programs have been prevailing attitudes that foster turf wars and a lack of cooperation between state and local governments and, more important, between cities and counties. Each political entity believes it is an island unto itself. Far too little attention has been paid to intergovernmental coordination and cooperation.

Implementing watershed management programs requires a long-term commitment of time, energy, and money. Elected officials, responding to the citizens' cries to be frugal with their tax dollars, are reluctant to spend money on the planning studies required to implement watershed management programs. In only a few locations have elected officials recognized the long-term benefits and cost savings that can accrue by implementing comprehensive land use plans and runoff master plans.

Establishing a Framework

No single approach or institutional framework is available to establish a watershed management

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program. Establishing an institutional and legal framework would be easy if we could start with a clean slate. However, each state, county, and city has an existing legal framework and most differ greatly. Some states have comprehensive laws, rules, and programs. Other states do not have an adequate statutory or regulatory framework to form a foundation for watershed management programs. Therefore, a key to opening the watershed management door is flexibility. In some cases, the focus will be on enacting new laws; in other cases, the focus is on revising existing laws or ordinances to better integrate and coordinate programs and objectives.

Another key to a watershed management framework is patience. Enacting or modifying state laws or local ordinances is not an easy process. A long-term game plan must be developed and pursued with diligence. Each component of a watershed management program has its own controversies, assuring that public debate on many issues will be vociferous. Therefore, priorities must be established. Typically, priority setting depends on state resource problems and needs, public sentiment, and whether an issue becomes "sexy," thereby receiving coverage by the news media. In many cases, a particular piece of legislation will take several years to pass or revise.

To succeed, educating elected officials, state agency managers, and the public is a priority. Public participation and support are essential to build consensus. Many issues addressed by watershed management programs are complex and not easily demonstrated. Managers of runoff and other nonpoint sources of pollution, unlike the managers of traditional point sources, cannot point to pipes that continuously discharge effluents. Therefore, promoting watershed management programs requires multimedia presentations, not only to educate but also to entertain. You must *sell* the need for watershed management.

Taking advantage of opportunities that arise is another key to success. Unfortunately, opportunities often occur after a natural disaster that results in lost property or lives. After hurricanes Frederick and Andrew struck South Carolina and South Florida respectively, considerable public debate arose. Issues included building codes, land uses, and development within sensitive and susceptible coastal areas; whether to allow rebuilding in these areas; and whether public programs such as the National Flood Insurance Program should subsidize development. These debates, especially on costs and benefits, can help build support for growth management and land acquisition programs. Furthermore, flooding—and in a few locales, water quality problems—can be used to break the "hydro-illogical cycle" and gain support for runoff management programs and local runoff utilities.

In building a watershed management framework, establishing clear goals for the overall program should include

- Providing opportunities for preventive nonstructural controls, in addition to structural controls, to mitigate the impacts of human activities.
- Establishing clearly defined, holistic natural resource management goals.
- Setting priorities for a long-term legislative agenda.
- Encouraging public participation so that all parties buy in and feel a part of the solution.
- Integrating all available tools and resources into a coordinated, cost-effective, cooperative approach (i.e., integrate point and nonpoint source programs).
- Finding dedicated funding sources outside the main funding stream (general revenues) so that the watershed management programs do not compete against law enforcement, education, and other high priority societal needs.

In developing, selling, establishing, and implementing a watershed management framework and associated programs, keep in mind the following "big Cs" of watershed management:

- *Comprehensive* management of people, land use, natural resources, water resources, and infrastructure throughout a watershed.
- *Continuity* of runoff/watershed management programs over a long time period to correct existing problems and prevent future ones.
- *Cooperation* between federal, state, and local governments; cities and counties; the public and private sectors; and among all citizens.
- *Communication* to educate ourselves and elected officials about how everyone is part of the problem and must be part of the solution.
- *Coordination* of runoff retrofitting to reduce pollutant loading and other natural sys-

tems restoration activities; includes complementary infrastructure improvements (e.g., road projects) or development/redevelopment projects to maximize benefits and cost-effectiveness.

- *Creativity* in best management practices, technology, funding sources, and approaches to solve these complex, costly problems.
- *Consistency* in implementing laws, rules, and programs nationally and statewide to assure equity and fairness.
- *Cash* in large amounts and over a long time period to correct existing problems and prevent future ones.
- *Commitment* to solve our current problems and prevent future ones to ensure that our children have a bright future—a willingness to put our money where our mouths are.

Program Components and Legislative Needs

Watershed management integrates management programs that address the many differing human activities within a watershed. The following brief discussion of components and programs that are part of watershed management is not all inclusive—other programs address specific state or regional needs. In developing or implementing programs, take advantage of information and technology transfer clearinghouses and communicate with people in other jurisdictions that have implemented similar programs.

Watershed management programs include common aspects, such as planning, holistic goals, scientific/technical support, and implementation—regulatory and nonregulatory approaches. Extensive public participation is also needed in all aspects of the program—planning, developing and adopting rules, permitting, and inspecting and enforcing. Programs must also address obtaining adequate funding and staffing; training staff and the public, especially the regulated community; assuring inspection and compliance; and assuring long-term operation and maintenance of structural controls. Finally, programs must be evaluated regularly to optimize their environmental effectiveness, cost-effectiveness, and service efficiency. This evaluation requires a commitment to monitoring programs that can actually ascertain if the program's goals are being met.

Typically, these programs are implemented after a state law is enacted and a state agency is set up to address a specific concern. A legislative mandate usually ensures that a program has adequate legal authority, staffing, and funding support. Programs have been established by a state agency using its general legislative powers to pass a rule—for example, programs for pubic education, pollution prevention, and monitoring and prioritizing target watersheds. Given the current scientific data on runoff pollutants, erosion and sediment control and even runoff treatment programs can be established using general water pollution control authorities. However, these programs are staff and resource intensive and, at a minimum, require legislative approval of budget requests.

Common watershed management programs include both planning and regulation. While the difference between comprehensive planning and permitting are important, both are needed to manage growth effectively and protect the quality of our environment and the lives of our citizens.

Comprehensive Planning. Planning allows a community to make decisions about how and where growth will occur in the future. Comprehensive planning asks several questions: Is this the right location? Is this the right time? Is this the right intensity for the proposed land use? Comprehensive planning seeks to prevent problems—social, economic, environmental—before development occurs.

Permitting. Permitting is site-specific and seeks only to mitigate the impacts of the land use decision. It asks: How can we do the best job with this development on this particular site? Any regulatory program has inherent limitations that comprehensive planning can help overcome. Principal among these limitations is that permitting is piecemeal and does not consider cumulative effects. Therefore, regulation and permitting cannot substitute for planning.

Watershed planning and management programs must include two equal components: the land planning framework and the water planning framework (Figure 15.1).

The Planning Framework

A watershed management framework can be divided into three categories:

- Land planning and management.

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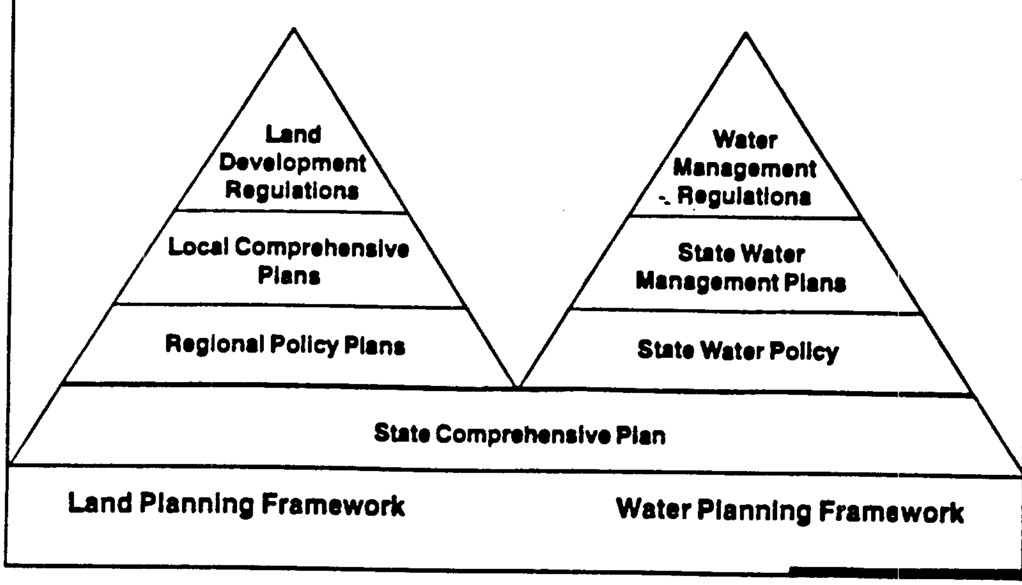
Figure 15.1.—The land planning and water planning frameworks.



- Water planning and management
- General resources planning and management

Land Planning and Management Programs

Land planning and management programs are often called growth management programs. However, growth management, comprehensive planning, and land and environmental regulations are clearly distinct.

Growth management looks at broad issues and the interrelationship of systems—natural systems, infrastructure, land use, and people. It assesses our past success in providing for citizens' needs and determines the needs of new arrivals and how to meet them. Growth management encompasses comprehensive planning, natural resource management, public facilities planning, housing, recreation, economic development, and intergovernmental coordination.

Comprehensive planning is a governmental process to inventory resources, establish priorities and a vision of where the community wants to go, and determine how to get there. It is a systematic way of looking at the different components of a community, county, region, and state.

Regulations are the specific controls applied to different types of development activities to regulate and minimize their negative impacts. Typically, regulations are administered by all levels of government—federal, state, and local. Locally, land development regulations are the ordinances that implement the local comprehensive plan.

State Comprehensive Plan

A state comprehensive plan serves as the base of the land and water planning pyramids (Figure 15.1). A state comprehensive planning act establishes goals and policies for each of the plan's elements and requires the state land planning agency to prepare a general state comprehensive plan. Elements of a plan usually include water resources, natural systems, air quality, coastal and marine resources, land and wildlife resources, waste management, public facilities (infrastructure), transportation, mining, agriculture, education, and economic development. If the state's land planning framework includes regional planning councils or council of governments, those agencies would develop a regional plan.

Both the state and regional plans should be consistent with the goals and policies stated in the state comprehensive planning act. These goals and policies, set by the legislature, provide guidance to state, regional, and local governments in developing and implementing programs, rules, or-

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ordinances. The planning pyramid should be consistent from its base to its apex. To ensure consistency and integrate agency implementation programs with the law's goals and policies, the law can require state agency functional plans. These plans form the basis for agency budget requests, which are related to the goals and policies of the comprehensive plan.

Growth Management and Land Development Regulation

The Local Government Comprehensive Planning Act (LGCPA), often referred to as the growth management act, establishes the key piece of the natural resources jigsaw puzzle. It provides the direct connection between land use management and water/natural systems management. Eight states—Oregon, Florida, New Jersey, Maine, Vermont, Rhode Island, Georgia, and Washington—have implemented state growth management programs (Gale, 1992). While these programs have elements in common, each state has different implementation requirements. Some states "require" while other states "recommend" local plans, consistency, or compliance. A LGCPA should address, at a minimum, the following questions common to the existing state growth management programs:

- What is the legislative authority and intent?
- Are local comprehensive plans required or voluntary? Do they require a schedule or planning period? Do they require specific or minimum elements?
- Are plan implementation, site planning, or land development regulations required?
- Must plan be consistent with state goals and policies? Are monitoring and enforcement required?
- Are state review and approval required? From which agencies or administrative process?
- Is compliance or monitoring required? Does the plan provide incentives, disincentives, or citizen enforcement?
- Does the plan limit the number and type of amendments, the frequency, or the amendment process?
- Does the plan provide for regular updates and implementation appraisals and their frequency?

Wetlands and Floodplain Protection

Wetlands and floodplains provide storage and treatment for watersheds. They provide a wide range of irreplaceable services at no cost, including maintenance and improvement of water quality; floodwater conveyance and storage; shoreline stabilization; water recharge and supply; sediment control; aquatic productivity; spawning and nursery grounds; habitat for shellfish, fish, waterfowl, endangered species, and other wildlife; and open space and recreation.

Unfortunately, the benefits provided by wetlands and floodplains are not fully appreciated. Instead, these areas are seen as unproductive, snake invested, mosquito havens with no socially accepted redeeming value. Consequently, only about 40 percent of our nation's original 215 million acres (87 million ha) of wetlands in the 48 contiguous states remain, largely the result of the conversion of wetlands and floodplains to agricultural lands.

Section 404 of the Federal Clean Water Act established a wetlands program to maintain, protect, and restore our nation's wetlands. However, nationwide general permits to conduct activities in wetlands are easy to obtain. In addition, agricultural and silvicultural activities are largely exempt. Another problem hindering the environmental effectiveness of this federal program is a lack of national consistency. Furthermore, other federal programs (e.g., section 205 of the 1948 Flood Control Act, National Flood Insurance Program) directly conflict with wetland and water quality protection efforts by promoting alteration and development of these sensitive lands.

A state wetlands protection act can be an important addition to a state's watershed management arsenal to fill the gaps in the federal program or expand the protection of wetlands and floodplains. A state wetlands protection program should *integrate with, not duplicate,* existing federal programs. Since the current federal wetlands permitting program is administered by the Army Corps of Engineers and U.S. EPA, the state water quality/environmental management agency typically implements the program at the state level. Frequently, the wetlands protection act is simply a new section within a state's existing environmental laws.

Components that should be addressed by a state wetlands/floodplain protection act include

- Establishing wetland protection/management goals and policies as the basis for wetland regulations and permitting criteria.

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- Initiating goals and policies that foster cost-effective pollution prevention by stressing wetland avoidance rather than mitigation.

- Precisely defining a wetland. A wetland should be defined by three characteristics—the elevation and duration of flooding, the presence of certain wetland-specific plants, and hydric soil conditions. The law should clearly state that wetlands are "waters" similar to a river, lake, or estuary.

- Establishing a standard method to delineate wetlands. Wetlands represent the transitional edge between waters and uplands. Determining where a wetland and an upland begins is not easy—and is frequently controversial. Wetland scientists should be allowed to establish—through combinations of hydrologic, vegetation, and soil indicators—a process to "draw the wetland line."

- Requiring consistent statewide application of the definition and wetland jurisdictional delineation method by all government levels.

- Requiring or encouraging regional mitigation banks rather than on-site mitigation.

- Establishing a fair permitting process that assures public participation, equity, an appeals process, and decisions based on scientific and technical merit.

- Allowing, with strict pretreatment requirements, incorporation of certain wetlands into domestic wastewater and runoff management and reuse systems, provided the ecological characteristics of the wetland are protected, restored, or enhanced.

- Requiring the annual tracking of wetland losses and mitigation efforts, successes, and failures.

- Providing for state assumption of the federal section 404 wetlands program.

State and Local Land Preservation and Acquisition

Regulating and restricting the use of private property is controversial. However, the U.S. Supreme Court has ruled several times that state and local governments have that legal authority. In fact, the government is responsible for ensuring the health, safety, and welfare of the public. Restricting what can and cannot be done on a piece of property helps maintain property values and prevent contamination of air, land, water, and human resources. However, care must be exercised to avoid the taking of property. Land acquisition programs help ensure that this goal is met and that extremely crucial or sensitive lands within a watershed are preserved.

The federal government has set up several types of land acquisition programs to preserve sensitive lands, protect vital wildlife habitats, and establish recreational lands, such as national parks and wildlife refuges. However, federal budget problems and intense competition makes obtaining limited federal land acquisition funds difficult, especially for properties without national—or at least regional—significance. Additionally, federal programs generally require matching funds from state and/or local governments. Therefore, establishing state and local land acquisition programs can greatly increase the ability to purchase and protect sensitive lands and, equally importantly, capture limited federal funds.

State or local land acquisition programs require extensive citizen participation and support. They require asking individuals to tax themselves to raise money to purchase lands, preserve them, and provide recreational opportunities. Catchy phrases and acronyms are helpful to "sell" the program. Citizens must be convinced that they and their children will benefit and that funds will be spent wisely and cost-effectively. Land acquisition programs must avoid conflicts of interest and be administered with integrity and openness.

A state and local land preservation and acquisition act should contain the following components and considerations:

- Clearly defined program goals and policies. Such policies form a foundation to determine the types of properties to be purchased and how to establish purchasing priorities. The program's goals and policies should advocate preserving and restoring lands that contribute nonstructural environmental benefits. Additional resource management factors to consider in purchasing lands includes open space, recreational, and wildlife benefits.

- Integrated and coordinated federal, state, local, and private land preservation and acquisition programs. This component maximizes the ability to leverage funds from various sources. Establishing interconnected wildlife corridors and greenways should be a priority goal.

- Extensive participation by citizens, private conservation groups, and state and local governments to establish program regulations, administrative procedures, and—most important—land buying priorities.

- Long-term ownership and active land management once the property is purchased. The act should specify which agency will be in charge—an environmental agency, a parks and recreation agency, a fisheries or wildlife agency, or a private organization (e.g., Trust for Public Land). The act should determine if a land management plan must be developed and how land management will be funded.

- Dedicated funding sources. Purchasing and managing sizable amounts of land, especially with public access and use, requires large sums of money over a long time period. To obtain sufficient funds, a state or local government might choose to sell bonds, which allow it to raise large amounts at one time and pay bonds off like a mortgage. However, this decision requires a stable and predictable funding source over the life of the bond. Fees on real estate transactions, such as documentary stamps, and local option sales taxes have been used extensively.

Water Resources Planning and Management Programs

The United States is generally blessed with an abundance of clean water resources. Water is available whenever we want it, in whatever quantity we desire, and at a very low cost. Consequently, we have placed less attention and emphasis on water resources planning and management, especially from a holistic approach. In the past, water planning and management programs were implemented to address a crisis. However, our population's continuing growth exerts ever expanding demands on our vulnerable and limited water resources. Additionally, to manage unconventional pollution sources, such as runoff and other nonpoint sources, we need to reevaluate the way we manage water. Accordingly, water resource planning and management programs are receiving increased attention and evaluation.

Watershed management programs include water quantity and quality programs to protect and manage surface and groundwaters and general environmental protection programs. These programs usually contain pollution prevention and treatment aspects.

Environmental Protection

Most states have enacted some type of state environmental protection act to control traditional point source pollution. These laws, generally patterned after the federal Clean Water Act, are frequently revised as a new state environmental crisis or concern arises or as Congress amends the Clean Water Act. The Clean Water Act shows how, over a long period, laws can be revised to establish or refine existing or new environmental requirements or programs.

While state environmental protection laws include many similar requirements and mandates, they vary considerably because states approach the same problem differently. For example, some states enact separate erosion and sediment control and runoff management acts; other states combine these important watershed management components. In some states, the law governing the siting and use of on-site wastewater disposal systems is found within a state's general health code law; in other states, the law is within the environmental law. These watershed management components are discussed separately, even though their legislative authority is often integrated into a state's environmental laws.

State environmental protection laws generally contain components and considerations that establish

- The state environmental agency, its legal authority, and its powers and responsibilities.

- An environmental regulation commission generally composed of citizens appointed by a political body (e.g., the governor) that holds public workshops and adopts environmental regulations and standards.

- Permit evaluation criteria, permit fees, and administrative procedures, which include a legal administrative hearing process to appeal permitting decisions.

- Programs—with adequate legal authority, direction, and resources (i.e., staffing and funding)—to address general environmental protection and management of air, land, and water resources such as surface and groundwater.

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- Programs—with adequate legal authority, direction, and resources—to minimize the impacts of specific pollution sources such as wastewater and industrial discharges, solid wastes, hazardous wastes, and toxic wastes.

- Pollution prevention programs such as "amnesty days" that allow citizens to safely dispose of hazardous or toxic household wastes, used-oil recycling centers, waste reduction and assistance programs for industry, adopt-a-road (stream, lake, bay, shoreline), recycling, and farmstead assistance (Farm*A*Syst).

- Programs to restore environmentally damaged lands and waters, especially critical areas such as wetlands, floodplains, steep slopes, and eroding lands.

- Programs to monitor the environmental health and assess the effectiveness of watershed management programs. Monitoring programs should include sampling the water column, sediment, and biological community. Programs must provide information concerning long-term trends in environmental health and the health of selected waterbodies or natural systems.

Water Resources Planning and Management

Many states have enacted a water resources act distinct and separate from the state environmental protection act. States are recognizing that planning and managing water resources are essential to the continued survival of life on the planet and that water is a major determinant of economic development and quality of life. Water resources planning and management must consider both water quantity (i.e., supply, allocation, flooding) and quality. An effective state water resources act must be fully integrated with the state environmental protection act. State environmental protection and state/regional water resources programs must be coordinated, consistent, and complementary.

A state water resources act creates the framework for water resources planning and management programs by state, regional, and local governments (see Figure 15.1). Using goals and policies of the state comprehensive planning act, the environmental regulation commission adopts a regulation, or state water policy. This regulation contains general policy statements addressing a myriad of water resource topics, such as water supply and conservation, surface water preservation and management, and natural systems preservation and management. It guides the implementation of all water resource programs and regulations, whether by a state, regional, or local entity. The act could establish regional watershed management districts, set up by watershed boundaries. The districts conduct regional watershed planning, coordinate water management efforts undertaken by local agencies to ensure that watershed goals are cooperatively met, and operate regulatory and research programs.

A state water resources act should include

- Establishing watershed management districts to administer special regional (watershed) water planning and management programs and providing statutory authorities and responsibilities to give them broad powers to protect, manage, and restore surface and groundwater resources.

- Setting the institutional relationships between the state environmental agency, regional water management districts, and local governments. Strong oversight of programs, especially regulatory ones, implemented downwards is essential for program consistency.

- Developing a state water policy (SWP) to guide all state water programs and regulations and adopt them as part of the state's environmental regulation code.

- Basing the SWP on the goals and policies of the state planning act and ensuring that state, regional, and local water regulations and programs are consistent. Goals and policies of the local comprehensive plan should also be consistent with SWP.

- Providing the districts with dedicated sources of revenue to ensure long-term, adequate funding of all necessary water resource management programs. Sources used include ad valorem assessments (property taxes), fees on water use, permitting fees, and special assessments.

Supplemental Surface Water and Environmental Protection Programs

Several watershed management components can be included in the state environmental protection or water resources act or established in a separate statute.

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Erosion and Sediment Control Act/Program. Land disturbing activities are among the largest source of sediments and particle-borne pollutants. Preventing erosion and minimizing and capturing sediments, especially from construction sites, is an essential part of any watershed management framework (see Chapter 7). Since 1972, over 20 states have enacted erosion and sediment control laws and programs.

An erosion prevention and sediment control law or program should include the following components and considerations:

- A clearly defined legal authority, goals/performance standards, and responsibilities of the state, regional, or local agencies.
- Measures to ensure that publicly funded projects, especially highways, comply with all program requirements and use of these projects as models.
- A clear statement on whether utility construction, agricultural, and forestry projects are included in the program.
- Agency responsibilities and relationships. Typically, implementing an erosion and sediment control program involves a state agency and a regional/local agency, such as a soil and water conservation district or a local government. The state must oversee programs delegated to a local agency to ensure consistency.
- Adequate staffing and other resources to conduct research on effective control measures, developing scientifically sound rules, and conducting training and education programs for plan reviewers, inspectors, developers, engineers, and site contractors.
- A state training and certification program for plan reviewers, inspectors, and contractors is highly recommended since public agencies will not likely obtain sufficient staffing to conduct regular inspections of construction sites.
- Mutual integration of the state erosion and sediment program and runoff management program and the new federal NPDES stormwater permitting program.

Runoff Management Act/Program. Most states have implemented some type of runoff drainage program to protect citizens and properties from flooding. Some states have established special drainage districts or drain commissions regionally or locally. However, today we know that runoff is a major source of pollutant loadings to our nation's wetlands, rivers, lakes, and estuaries. Runoff management is evolving slowly from its drainage focus to a much more comprehensive, multiple objective program that addresses runoff quality and quantity. Runoff programs must prevent or minimize problems associated with new land use activities and also develop programs to reduce the pollutant loading discharged from older drainage systems. This latter objective is extremely difficult and expensive to address—therefore, watershed management is essential. Typically, a state runoff management program first addresses the problems associated with new land uses. It then evolves into a more comprehensive, watershed-based program and addresses retrofitting older runoff systems.

Components and considerations that should be addressed by a state runoff management act/program include

- A clearly defined legal authority, goals/performance standards, and responsibilities of the state, regional, and local agencies.
- Measures to ensure that publicly funded projects, especially highways, comply with all program requirements and use of these projects as models.
- Agency responsibilities and relationships. Typically, implementing a runoff management program involves a state agency and a regional/local agency such as a watershed management district, a soil and water conservation district or a local government. The state must oversee programs delegated to a local agency to ensure close consistency.
- State water policy should be used to set the program's general goals, minimum treatment performance standards upon which BMP design criteria will be based, and a biological or resource-based performance standard for reducing the pollutant loading from existing drainage systems.
- Adequate staffing for planning, coordinating, and permitting; enforcement and resources for research on effective control measures to develop scientifically sound rules; and adequate staffing to conduct training and education programs for plan reviewers, inspectors, developers, engineers, and site contractors.

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- A state training and certification program for plan reviewers, inspectors, and contractors is highly recommended since public agencies will not likely obtain sufficient staffing to conduct regular inspections of runoff systems during or after construction. These programs can be integrated with the similar erosion and sediment control programs.

- Integrating the state runoff management program with the erosion and sediment control program and the new federal NPDES permitting program.

- Establishing a mechanism, such as runoff operating permits, to ensure at least annual runoff management system inspections. Inspections determine maintenance needs and ensure that systems are maintained and operated properly. This system could be operated by a local runoff utility and provide the owner of a properly maintained and operated system a utility fee credit as an economic incentive.

- Providing statutory authority to establish dedicated state and local funding sources for runoff management programs. State sources could include small fees on concrete, asphalt, fertilizer, or pesticides. Communities nationwide use runoff utilities with great success.

Watershed Prioritization and Targeting Act/Program. The growing number of water resource problems and the financial constraints faced by all levels of government strongly suggest a need to establish watershed prioritization and targeting programs. Many states have set up such programs, often as part of their runoff/nonpoint source management programs.

Considerations and components of a state watershed prioritization and targeting act/program include

- Clearly identifying which state, regional, and local agencies are involved in establishing priority watersheds. Public participation is essential to ensure citizen cooperation and buy in around the state and within the targeted watershed. Cooperation and joint ventures with private land conservation groups should be encouraged.

- Providing guidance on factors to consider in the prioritization process. These factors may include requiring that waterbodies be state or regionally significant or at a certain degradation level; a specific level of local government and citizen support, especially from land owners who need to install management practices; and the availability of local matching funds. Pristine waterbodies may also be given priority.

- Providing a legal mechanism for the appropriate state, regional, or local agency to adopt the priority list; ensuring that the list is reviewed regularly and updated or refined as needed.

- Providing a dedicated source of state, regional, or local funds to develop and implement a watershed management plan within a realistic time schedule.

On-Site Wastewater Management Act/Program. The nation's rapid population growth and accompanying migration to the suburbs and beyond has led to a tremendous proliferation in on-site wastewater disposal systems (OSDS). Often considered an inexpensive alternative to centralized wastewater collection and treatment systems, OSDS can cause or contribute to health and environmental resource problems that are difficult and expensive to solve. Like many areas of nonpoint source management, OSDS programs should stress prevention and correct problems caused by past use and misuse. Traditionally, state, county, and local health departments, rather than environmental or water resources agencies, have administered OSDS programs. However, OSDS are increasingly considered major contributors to impairment of aquatic systems.

A state on-site wastewater management act/program should include the following components and considerations:

- Clearly defined legal authority, goals and performance standards, and responsibilities of the state, regional, or local entities charged with implementing the program.

- Goals and performance standards that address traditional health concerns and consider the potential environmental effects of OSDS.

- Provisions to adopt regulations that govern the types of OSDS systems (i.e., drainfields, mound systems, aerobic units); the siting of systems (i.e., water table elevation, soil types, setbacks from wetlands/waters);

the design and performance of OSDS (i.e., secondary treatment or nitrates less than 10 mg/L); whether surface discharges will be allowed and under what conditions; inspections during construction and throughout the use of the system; and maintenance.

- Regular inspection (every two to three years) and maintenance (e.g., pump out, drainfield) to help ensure that OSDS continue to function properly. One mechanism is to establish OSDS management districts with defined service areas, funding sources, and legal authorities.

- Another method to assure that OSDS continue to function properly is to require inspections, upgrading, and maintenance of systems when a property is sold.

General Resources Planning and Management

One complication in implementing watershed management frameworks and programs is their complex, interwoven nature. Many aspects of watershed management transcend the simple classification scheme outlined in Figure 15.1. These include the need for broad-based natural resource management programs and environmental education programs. Many states have established separate agencies responsible for management of land, fish and wildlife, agriculture, mining, and for providing parks and recreation. Often a state forestry department is responsible for acquiring and managing state forest lands. These activities and programs typically are essential to watershed management. Close coordination and cooperation between these agencies and the other primary natural resources management agencies ensure that programs do not conflict and maximize the benefits and cost-effectiveness of all programs.

Additionally, while nearly every natural resource management agency has some type of environmental education program, these programs are often narrowly focused. The growing importance of nontraditional pollution sources such as runoff and nonpoint sources requires developing and implementing a broad-based environmental curriculum that begins teaching children in kindergarten and continues all the way through senior high school. Each individual must understand the basic interrelationships of air, land, and water and how everyday activities degrade our natural systems. The best way to establish the ethic of stewardship is by educating our youth.

State Watershed Management Initiatives

Several states have developed and implemented some or many of the watershed management components previously discussed. In recent years, states have begun integrating ongoing programs into a comprehensive watershed management framework. Chapter 16 provides case histories from the states of Florida, Delaware, and New Jersey. The Puget Sound Management Program in Washington State and the Priority Watershed Program in Wisconsin are also good examples of watershed management initiatives.

North Carolina's ongoing efforts demonstrate one way that existing programs, especially planning and regulatory, can evolve into an integrated watershed approach. The North Carolina Division of Environmental Management (NCDEM) has developed a plan in which basins—not stream reaches—are the basic unit of water quality management. According to the U.S. Environmental Protection Agency (1991), the objectives of North Carolina's Basinwide Water Quality Management Initiative include

- Identifying priority problem areas and pollution sources that merit particular pollutant control, using modifications of rules (e.g., basin criteria) and increased enforcement.

- Determining the optimum water quality management strategy and distribution of assimilative capacity for each of the 17 major river basins within the state.

- Preparing, in cooperation with local governments and citizens, comprehensive basinwide management plans that set forth the rationale, approaches, and long-term management goals and strategies for each basin.

- Implementing innovative management approaches that protect the state's surface water quality, encourage the equitable distribution of assimilative capacity, and allow for sound economic planning and growth.

The whole-basin initiative is a fully integrated approach to water quality assessment and management. It integrates planning, monitoring, modeling, point source permitting and control, nonpoint source control, and enforcement within

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a basin. NCDEM has rescheduled its NPDES permit activities to occur simultaneously with permit renewals, which are repeated at five-year intervals within a given basin.

Difficulties in implementing a basinwide approach include setting priorities, establishing a rotating schedule among the basins, and correlating management needs (e.g., monitoring, planning, permitting, and enforcement) with staff and resource allocations. North Carolina prioritized and scheduled its 17 basins by considering the nature and extent of known problems, the basin's important human use, data availability, and balancing staff workload.

North Carolina will perform a 15-step process for each basin as follows:

1. Compile all existing relevant information on basin characteristics and water quality.
2. Define the water quality goals and objectives for waterbodies within the basin; revise as more data are obtained.
3. Identify the critical issues (e.g., water supply protection, shellfish harvesting) and current water quality problems within the basin; determine the major factors and sources (i.e., point, nonpoint, habitat degradation) that contribute to the problems.
4. Prioritize the basin's water quality concerns and critical issues; ensure public participation and input from other government agencies and nongovernment groups.
5. Define the subbasin management units using basin hydrology, physiographic boundaries, problem areas, and critical issues.
6. Identify the need for additional information.
7. Collect additional information.
8. Analyze, integrate, and interpret the information collected; revisit steps 2 through 5 in light of new information.
9. Determine and evaluate the management options for each management unit in the basin.
10. Select final management approaches for the basin and targeted subbasins.
11. Complete the draft Whole-Basin Management Plan; perform additional modeling and other analyses to finalize wasteload allocations.
12. Distribute the draft plan for review and comment and conduct public hearings.
13. Revise the plan as appropriate in response to comments; facilitate adoption by the Environmental Management Commission.
14. Implement the management approaches, including point and nonpoint source controls.
15. Monitor the program's success, and update the plan every five years.

Recommended Reading

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CHAPTER 16

Runoff/Watershed Management Case Histories

This chapter presents several case histories that include important components of watershed management programs.

Florida's Watershed Management Program

Florida is blessed with a multitude of natural systems—longleaf pine-wiregrass hills of the panhandle, sinkhole and sand ridge lakes of the central ridge, the Everglades "River of Grass," and the coral reefs of the keys. Abundant surface water resources include over 20 major rivers and estuaries and nearly 8,000 lakes. Plentiful groundwater aquifers provide over 90 percent of the state's residents with drinking water. This, along with the state's favorable climate, explains why many consider the Sunshine State a favored vacation destination and why Florida has experienced phenomenal growth since the 1970s. Today, Florida is the fourth most populous state and still growing rapidly, although not at the rate of 900 people per day (300,000 per year) that occurred throughout the 1970s and 1980s.

However, Florida's natural systems—especially its surface and groundwater resources—are extremely vulnerable and easily damaged. This is partially the result of the state's sandy porous soils, karst geology, and abundant rainfall. Florida experienced the negative impacts of unplanned growth as early as the 1930s. The southeast coastal water supply was threatened by saltwater intruding into the fragile freshwater aquifer that supplied most of the potable water for a rapidly expanding population. By the 1970s, unplanned land use, development, and water use decisions were clearly altering the state. If left unchecked, this development could have led to profound, irretrievable loss of the very natural beauty that brought residents and tourists to Florida. Extensive destruction of wetlands, bulldozing of beach and dune systems, continued saltwater intrusion into freshwater aquifers, and extensive pollution of the state's rivers, lakes, and estuaries were only some of the negative impacts of this rapid growth.

Fortunately, Florida's citizens and elected officials educated themselves and began developing programs to protect and manage the state's natural resources. Florida's serious and comprehensive efforts to manage its land, water resources, and growth coincided with the increasing strength of the national environmental movement of the early 1970s. Florida's natural resources management programs, consisting of 25 individual laws and programs enacted over a 20-year period, make up Florida's watershed management program. In many cases, these laws have been integrated into existing laws or adopted as regulations by various state, regional, or local agencies.

The evolution of Florida's watershed management program has followed a typical sequence. Concern about a specific pollutant or problem creates a resource/environmental management program that usually begins by focusing on new sources (site basis). Over time, as new sources are controlled and the program administration and effectiveness increase, the focus shifts to cleaning up older sources (watershed or regional basis). The focus then shifts to integrating the program with similar ones to eliminate any duplication and improve efficiency and effectiveness. Figure 16.1 provides an overview of the interrelationships among the various programs and regulations outlined in the next section.

Following is a chronology of how Florida statutes and programs, the cornerstones of its overall watershed management efforts, were established and revised.

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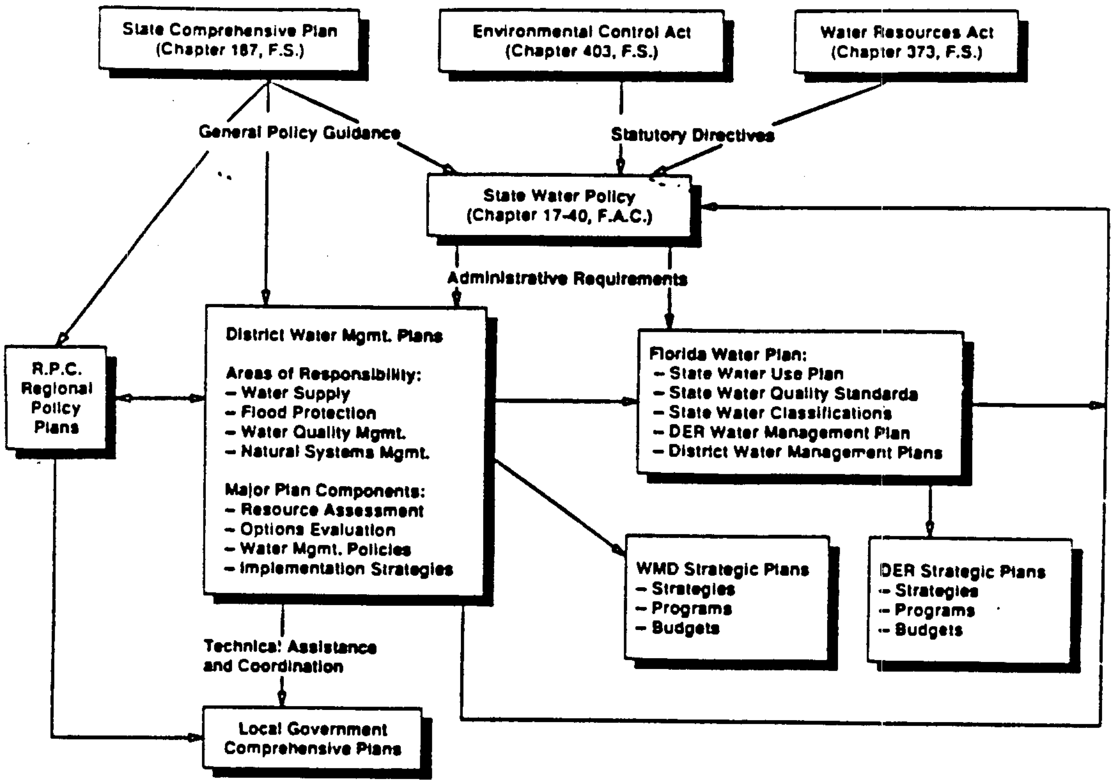
Figure 16.1—Functional relationships of Florida water planning programs.



Source: By author.

Evolution of Florida's Watershed Management Program

1970

- Chapter 370, Florida Statutes (F.S.). Created the Coastal Coordinating Council, the first state effort at integrating state and regional programs in protecting and using coastal resources. Initial efforts from 1970 to 1975 focused on a comprehensive resource-based coastal protection program.

1972

- Package of land and water planning, regulation, and acquisition programs.

  - Chapter 380, F.S. Created the Developments of Regional Impact (DRI) and Areas of Critical State Concern (ACSC) land planning and management programs.
  - Chapter 373, F.S. The Florida Water Resources Act established five regional water management districts (WMD); designated the Department of Pollution Control as the oversight agency for the WMDs; required the development of a state water plan; and allowed for the regulation of the water resource. WMDs, financed by ad valorem property taxing authority of up to 1 mil ($1/$1,000 value), set in the Florida constitution. The Northwest Florida WMD millage capped at .05 mil.
  - Chapter 259, F.S. The Land Conservation Act established a program, commonly known as the Environmentally Endangered Lands Program, which authorizes the state to purchase critical and sensitive lands. It was envisioned as a 10-year program, investing $200 million, and funded by the sale of state bonds.

1973

■ Chapter 403, F.S. The Florida Environmental Protection Act renamed the Department of Pollution Control as the Department of Environmental Regulation (DER) and broadened its powers, duties, and programs. This law, the state's general environmental protection act, is amended almost annually as new environmental concerns and needs arise and existing programs evolve.

1975

■ Chapter 163, F.S. The Local Government Comprehensive Planning Act (LGCPA), the state's first growth management legislation, was recommended by the first Environmental Land Management Study Committee (ELMS I). The law required all cities and counties to prepare a comprehensive plan and submit it to the state's land planning agency, the Department of Community Affairs, for review. This agency sends the plans to other state agencies for review and comment. However, the LGCPA contains no teeth—local governments are under no statutory requirement to revise their plans by incorporating comments and recommendations made by reviewing agencies. Furthermore, localities are not required to pass land development regulations to implement their plans.

1976

■ Implementation by EPA of section 208 of the 1972 Clean Water Act required development of areawide water quality management plans. This was the first national program to assess and control nonpoint sources of pollution. In Florida, millions of federal grant dollars allow the DER and 12 designated area agencies to undertake extensive research on nonpoint source impacts, sources, controls, control effectiveness, and costs This data provided the scientific basis to develop and implement a statewide rule in 1982 that requires runoff treatment for new development and redevelopment projects.

1978

■ Chapter 380, F.S. This added Part II to the Florida Coastal Management Act, which required establishing a program based on existing statutes and rules to receive federal approval under the federal Coastal Zone Management Act of 1972. After approval of the program, NOAA-Office of Coastal Zone Management federal grants funded many initiatives to better protect and manage coastal resources. One established an estuarine watershed management program that emphasized sediment mapping. This led to the development of innovative, reliable coastal sediment sampling, analytical, and assessment techniques.

1979

■ First components of the state's areawide water quality management plan, the agriculture nonpoint source plan, and the silviculture nonpoint source plan were submitted to and approved by U.S. EPA. These called for a nonregulatory approach, with a regulatory backstop, if best management practices required by farm conservation plans were not implemented or if the forestry BMPs required by the state's adopted silviculture BMP manual were not followed.

■ Chapter 17-4.248, Florida Administrative Code (FAC). The state's first stormwater rule, adopted by the state Environmental Regulation Commission (ERC) as a rule of the DER, was a temporary regulation until ongoing research on BMP design and effectiveness was completed. The rule's adoption was controversial, but data collected during section 208 program studies conclusively showed that runoff, especially from urban land uses and highways, is a pollutant and therefore should be controlled. Florida's continuing rapid growth made treatment of runoff imperative, with BMPs required for new runoff discharges that would be "a significant source of pollution."

■ Chapter 253, F.S. This was amended to establish the Conservation and Recreation Land (CARL) Trust Fund, which provided additional funding to purchase environmentally endangered lands and other lands deemed appropriate and in the public interest by the governor and cabinet.

1981

■ Through action taken by the governor and cabinet, the Save Our Coasts land acquisition program was established. The program proposed spending $200 million over 10 years to purchase coastal lands such as beaches, shorelines, and sensitive areas. Funding was provided by the sale of state bonds backed by documentary stamps as authorized in Chapter 375, F.S., which sets policy on how the Land Acquisition Trust Fund was to be administered.

■ Chapter 373, F.S. This was amended with the creation of the Save Our Rivers land acquisition program. Administered by the WMDs, this program proposed spending $320 million over 10 years to purchase wetlands, floodplains, and other lands necessary for water management, water supply, and the conservation and protection of water resources.

1982

■ Chapter 17-25, FAC. This policy was adopted by the ERC after two years of rule adoption workshops and 29 official rule drafts. The rule was technology rather than water-quality based, although the state's water quality standards remain as a backstop, should a runoff discharge cause violations. A performance standard of 80 percent average annual load reduction is recommended based on BMP effectiveness and cost data and to establish equity with the minimum treatment levels for point source discharges. The rule created design criteria for various types of BMPs, including retention, detention with filtration, and wet detention. The rule also created general permits for certain types of BMPs (e.g., retention, detention with filtration) built to the design criteria. The South Florida WMD implemented the rule allowing runoff treatment requirements to be merged with runoff quantity (flood control) requirements in one permit.

1984

■ Chapter 403, F.S. Revised to create section IX, known as the Henderson Wetlands Protection Act. This legislation expanded the authority of the DER to protect wetlands; established administrative procedures to allow landowners to obtain legally binding "wetland lines"; allowed DER to consider fish and wildlife habitat, endangered species, historic and archaeological resource, and other relevant concerns in wetland permitting; allowed certain wetlands to be incorporated into domestic wastewater and runoff management systems; transferred wetland regulation for agriculture and forestry activities to the WMDs; and required the WMDs to protect isolated wetlands and consider fish and wildlife habitat requirements.

■ The Southwest Florida WMD receives delegation of the stormwater quality permitting program from DER, thereby integrating these permits into the district's existing stormwater quality permitting program.

■ In the late 1970s and early 1980s, an extensive appraisal of Florida's growth management system concluded that the existing system was not working. Shaped by the Final Report of the Governor's Task Force on Resource Management (1980) and the second Environmental Land Management Study Committee (ELMS II), a totally new blueprint for managing growth emerged. The ELMS II Committee recommended a package of integrated state, regional, and local comprehensive planning; reforms to the Developments of Regional Impact law; and coastal protection improvements. The legislature responded by enacting several laws between 1984 and 1986.

■ Chapter 186, F.S. The State and Regional Planning Act mandated the governor's office to prepare and present a state comprehensive plan to the 1985 legislature. It also required the state's 11 regional planning councils to prepare regional plans and provided $500,000 for plan preparation.

1985

■ Chapter 187, F.S. The State Comprehensive Plan was envisioned to be a leadership document —the foundation of the entire planning process— with strong, measurable, strategic goals that would set the course for Florida's growth over the next 10 years. Each state agency was to prepare a functional plan, based on the state plan, upon which its budget appropriations would be made. Unfortunately, one of the most important elements of the state plan, the development and adoption of a capital plan and budget, was never prepared. However, the plan contained important goals and policies in 25 different areas, including water resources, coastal and marine resources, natural systems and recreation, air quality, waste management, land use, mining, agriculture, public facilities, and transportation.

Important and relevant goals included

- Ensuring the availability of adequate water supply;
- Maintaining functions of natural systems, and
- Maintaining/enhancing present surface and groundwater quality.

Important and relevant policies included

- Eliminating the discharge of inadequately treated wastewater and runoff;

- Protecting natural systems in lieu of structural alternatives and restoring modified systems;
- Promoting water conservation and the use and reuse of treated wastewater and runoff; and
- Establishing minimum flows and levels for surface waters to assure protection of natural systems.

1985-1986

■ Chapter 163, F.S. Amended with enactment of the Local Government Comprehensive Planning and Land Development Regulation Act of 1985. This law required all local governments to prepare local comprehensive plans and implement regulations consistent with the goals and policies of the state and regional plans. Numerous state and regional agencies were to review the local plans and submit their objections, recommendations, and comments to the Department of Community Affairs for transmittal to the local government. The amendment required that the local plans be revised to incorporate the objections, recommendations, and comments. Furthermore, local governments faced state sanctions that could result in the loss of state funding if adopted local plans were not consistent with the state and regional plans.

Florida's revised growth management system is built around three key requirements: consistency, concurrency, and compactness. The consistency requirement establishes the integrated policy framework, whereby the goals and policies of the state plan frame a system of vertical consistency. State agency functional plans and regional planning council plans must be consistent with the goals and policies of the state plan, while local plans must be consistent with the goals and policies of the state and appropriate regional plan. Local land development regulations (LDRs) must also be consistent with the local plans, goals, and policies. Horizontal consistency at the local level ensures that the plans of neighboring local governments are compatible. Consistency is the strong cord that holds the growth management system together.

Concurrency is the most powerful policy requirement built into the growth management system. It requires state and local governments to abandon their long-standing policy of deficit financing growth by implementing a pay-as-you-grow system. Once local plans and LDRs are adopted, a local government may approve a development only if the public facilities and services (i.e., infrastructure) needed to accommodate the proposed development can be in place concurrently with development impacts. Public facilities and services subject to the concurrency requirements are roads, runoff management, solid waste, potable water, wastewater, parks and recreation, and if applicable, mass transit. Level of service standards acceptable to the community must be established for each type of public facility.

Compact urban development goals and policies are built into the state comprehensive and regional plans. These policies include separating rural and urban land uses, discouraging urban sprawl, encouraging urban in-fill development, making maximum use of existing infrastructure, and encouraging compact urban development.

1986

■ Chapter 403.0893, F.S. This provision, the only surviving section of a runoff management bill developed over a 10-month process, attempted to put into statute a cost-effective, timely process to retrofit existing drainage systems to reduce the pollutant loadings discharged to waterbodies. Only the section creating explicit legislative authority for local governments to establish runoff utilities or special runoff management benefit areas was enacted.

■ The St. Johns River WMD adopted Chapter 40C-42, FAC, and the Suwannee River WMD adopted Chapter 40B-4, FAC. Adopting these regulations and adding staff to implement these programs allowed DER to delegate administration of its runoff treatment rule to these WMDs.

1987

■ Chapter 373, F.S. This new section, the Surface Water Improvement and Management (SWIM) Act, established six state priority waterbodies. It directed the WMDs, under DER supervision, to prepare a priority waterbody list and develop and adopt comprehensive watershed management plans to preserve or restore the waterbodies. While it provided $15 million from general revenue sources and required a match from the WMDs, it did not establish a dedicated funding source, making the program dependent upon uncertain annual legislative appropriations.

1988

■ Chapter 17-43, FAC. Under this provision, the ERC adopted the SWIM rule. The provision sets forth factors to consider in selecting priority waterbodies, specifying the format for SWIM

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plans to assure some consistency, and establishing administrative processes to develop and adopt SWIM plans by the WMDs and submitting them to DER for review and approval.

■ The State Nonpoint Source Assessment and Management Plan, prepared under section 319 of the Clean Water Act, was submitted to EPA and approved. This qualified the state for section 319 nonpoint source implementation grants for BMP demonstration projects and to refine existing nonpoint source management programs. This plan delineates the state's ecoregions based on river systems, selects ecoregion reference sites, and modifies EPA's Rapid Bioassessment Protocols and metrics for use in Florida.

1989

■ Chapters 373 and 403, F.S. These provisions, revised as part of the 1989 stormwater legislation, accomplished the following:

- Clarified the stormwater program's multiple goals and objectives;
- Set forth the institutional framework that involves a partnership among DER, the WMDs, and local governments;
- Defined the responsibilities of each entity;
- Addressed the need to treat agricultural runoff by amending Chapter 187, F.S., to add a policy in the agriculture element to "eliminate the discharge of inadequately treated agricultural wastewater and stormwater";
- Further promoted the watershed approach being used by the SWIM program;
- Unsuccessfully attempted to integrate the runoff program, SWIM program, and local comprehensive planning program;
- Established State Water Policy, an existing but little used DER rule, as the primary implementation guidance document for stormwater and all water resources management programs; and
- Created the State Stormwater Demonstration Grant Fund and provided $2 million as an incentive to local governments to implement runoff utilities.

1990

■ Chapter 17-40, FAC. State Water Policy underwent a total revision and reorganization to be used as a guide by all entities implementing water resource management programs and regulations. Section 17-40.420 included the goals, policies, and institutional framework for the state's runoff management program.

■ DER was designated as the lead agency with responsibility for setting program goals, providing overall program guidance, overseeing implementation of the program by the WMDs, and coordinating with EPA, especially the new NPDES runoff permitting program.

■ WMDs were named the chief administrators of the runoff regulatory program (i.e., quantity and quality). They prepare SWIM watershed management plans, which include establishing runoff pollutant load reduction goals, and provide technical assistance to local governments, especially in basin planning and developing runoff master plans.

■ Local governments were designated the front lines in the watershed management program since they determine land use and provide runoff facilities and other infrastructure. Under the policy, they are encouraged, but not required, to set up runoff utilities to provide a dedicated funding source for their programs. Their runoff responsibilities include preparing a runoff master plan to address needs imposed by existing land uses and needs created by future growth; operation and maintenance activities; capital improvements of infrastructure; and public education. They are encouraged to set up an operating permit system to annually inspect runoff systems to ensure that needed maintenance is performed.

Important goals included

- Preventing stormwater problems from new land use changes and restoring degraded waterbodies by reducing the pollution contributions from older runoff systems.
- Retaining sediment on-site during construction.
- Trying to assure that the runoff peak discharge rate, volume, and pollutant loading are no greater after a site is developed than before.

Important minimum treatment performance standards included

- 80 percent average annual load reduction for new runoff discharges to most waterbodies.
- 95 percent average annual load reduction for new stormwater discharges to "outstanding Florida waters," a special class of exceptionally high quality waterbodies.
- Reducing, on a watershed basis, the pollutant loading from older runoff systems to protect, maintain, or restore the beneficial uses of the receiving waterbody, according to the pollutant load reduction goal.

■ Chapter 375, F.S. This section was amended with the creation of Preservation 2000, a 10-year land acquisition program with a goal of spending $300 million per year. The legislation divided available annual funding among seven programs: CARL, Save Our Rivers, Florida Communities Trust, State Parks, State Forests, State Wildlife Areas, and Rails to Trails. Although the program was funded the first year by state bonds backed by an increase in the documentary stamp fee, the provision did not identify a long-term dedicated funding source. It made the program subject to annual legislative appropriations. Between 1972 and 1991, the state's land acquisition programs invested more than $1.5 billion to buy over 1.2 million acres (485,640 ha). Equally important, as a result of the state land acquisition programs, 14 Florida counties have created programs that currently commit up to $600 million for land conservation. Revenue sources for these local land acquisition programs include local option sales tax, impact fees, added property taxes, and local bonds.

1991

■ Chapter 40C-42, FAC. The St. Johns River WMD completely revised this provision to modify the design criteria for runoff treatment BMPs so they will achieve the minimum treatment levels set in the state water policy. Runoff reuse became essential for developments discharging to outstanding Florida waters.

■ Chapter 40C-44, FAC. The St. Johns River WMD adopted this provision to regulate certain agricultural pumped discharges (formerly regulated as industrial wastewater) and established design and performance criteria for these agricultural runoff management systems.

■ The Southwest Florida WMD initiated development of an agricultural runoff management program for certain types of agricultural activities, including row crops and citrus. The program included regulatory incentives to obtain technical assistance from USDA SCS or other qualified individuals to prepare and implement a farm-specific resource management plan that contains certain required BMPs.

1992

■ DER and the WMDs, in response to increasing demands on state waters and the increasing number of water quantity and quality problems, began developing district water management plans. Collectively, these district plans, together with the DER's plan, will create the state water management plan. These plans are based on the goals and policies set in state water policy and in the state comprehensive plan. For each of four major areas—water supply, water quality, flood protection, and natural systems protection—four key planning steps should occur: assess resources to identify current or anticipated problems, examine options, declare policy, and designate implementation strategies.

■ Section 314, Federal Clean Lake Program Lake Assessment Grant. This grant was obtained to delineate lake ecoregions, select lake ecoregion reference sites, and test/validate lake bioassessment sampling protocols and metrics.

1993

■ Chapters 373 and 403, F.S. These chapters were revised extensively and merge the Department of Environmental Regulation and Department of Natural Resources to create the Department of Environmental Protection (DEP), as a part of the Environmental Permit Streamlining bill. The goals of the streamlining bill were to eliminate duplication, especially in permitting; increase administrative and environmental effectiveness by increasing delegation of programs from DEP to the WMDs; and ensure greater program consistency and integration.

Key specific actions of the bill included

- Moving the Wetlands Protection Act from Chapter 403 to Chapter 373, F.S.

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This move delegated the wetland resource permits to the WMDs, except for certain projects that require other types of DEP permits.

- Merging the existing surface water/runoff management permit with the wetland resource permit to create an environmental resource permit.
- Redefining wetlands based on their hydrology, vegetation, and soils, and requiring the development of a single wetland delineation method to be used by DEP, WMDs, and local governments.

■ Recommendations of the third Environmental Lands Management Study Committee (ELMS III) were enacted into law, thereby amending several state laws. The act strengthens the state planning process by

- Requiring the governor to biannually review and analyze the state comprehensive plan and recommend any necessary revisions.
- Requiring the governor to prepare a new growth management portion of the state comprehensive plan. It will provide a more detailed and strategic state policy guidance for state, regional, and local governments to identify urban growth centers, set strategies to protect identified areas of state and regional environmental importance, and provide guidelines to determine where urban growth is appropriate and should be encouraged.

The governor's growth management document must be adopted by the legislature. However, to what extent local comprehensive plans, state agency strategic plans, and regional policy plans must be consistent with the state plan is unknown. The document is to be recommended by the governor and adopted as law by the 1994 legislature.

The act also provided greater flexibility and less requirements in local comprehensive plans for small cities and counties (less than 50,000); streamlined the plan amendment process by limiting the types of revisions requiring state review and approval; strengthened the local plan evaluation and appraisal process; terminated or made optional the DRI process in certain areas and revised the DRI process in other areas; and authorized a local option gas tax of up to 5 cents.

Recommendations

Florida has established a wide variety of laws, regulations, and programs at the state, regional, and local level. These are designed to protect, manage, and restore the state's incredibly valuable yet vulnerable natural resources, especially its water resources. Although these programs have helped reduce adverse impacts on natural resources resulting from the state's rapid and continuing growth over the past 20 years, many of Florida's natural resources have still been strained or degraded.

Some adverse effects were caused by activities that occurred before modern watershed management programs began, such as the channelization of the Kissimmee River and the creation of the vast drainage canal network south of Lake Okeechobee. Both of these conditions are contributing to the decline of Lake Okeechobee, the Everglades, and Florida Bay. Other adverse impacts directly related to 20 years of rapid growth and development are water supply and quality problems, declining habitat, and impacts on endangered species such as the manatee and the Florida panther.

Why are these adverse impacts still occurring, given the wide range of watershed management programs implemented in Florida? What can be done to reduce these effects and possibly restore already degraded areas? Following is a list of program deficiencies and recommendations to correct them:

1. While the statutes enacted by the legislature may be sound, governmental entities have insufficient resources to implement programs. The state's reliance on sales tax as a primary means to raise general revenues means that state revenues are tied closely to economic conditions. Relying on such sources during a recession, especially when the population is still growing, means that the state budget is nearly always in crisis. To compete for limited state resources and have adequate resources to achieve intended benefits, watershed management programs need dedicated sources of funding.
2. The statutes and programs are not fully integrated, leaving gaps in both land and water planning programs. In particular,

water and land planning and regulatory programs need better integration. The local government growth management program needs a close connection to state and regional water management programs. The requirements set forth in the state water policy and the district/state water management plans need to be incorporated by local governments in their land use planning programs. Local plans need to be consistent among all levels.

3. Greater emphasis must be placed on the long-term maintenance and operation of runoff management systems. Since these systems are part of the local infrastructure, local government must take a more active role. Establishing runoff operation permits as part of a runoff utility funded program is an excellent way of providing an economic incentive to a land owner to properly maintain and operate an on-site management system.

4. Greater emphasis must be placed on erosion and sediment control for construction sites and utility installation projects. Assuring the regular inspection of erosion prevention and sediment control practices is a major deficiency. A training and certification program for inspectors and contractor supervisors, similar to the Certified Construction Reviewer Program in Delaware, is needed.

5. Retrofitting existing drainage systems to reduce their pollutant loading is one of the biggest, most difficult, and most expensive challenges the state has faced. The state must develop new runoff treatment techniques that are not land intensive and fund demonstration projects to research new techniques.

6. While Floridians are among the nation's most educated citizens in water resources and runoff management issues, they need more education to provide support for watershed management programs. The state's environmental education program should establish a comprehensive natural resources management curriculum, beginning in kindergarten and continuing through high school. Additionally, because of the large number of people—especially retirees—moving to Florida, citizens need continuous education programs about the vulnerability and importance of Florida's natural resources.

Delaware's Sediment Control and Runoff Management Program

Prior to submitting any proposed legislation regarding runoff management or sediment control, representatives of the Delaware Department of Natural Resources and Environmental Control (DNREC) conducted an extensive educational program to document the serious nature of statewide water quantity and quality problems. This educational program was successful in that elected officials, impacted industries, and the general public acknowledged the need for a comprehensive approach to sediment control and runoff management. Statewide legislation was unanimously approved in four legislative committees and on the floor of both the state senate and house of representatives, due somewhat to its support by local conservation districts. In addition, the regulations providing the program details were approved with the assistance of a regulatory advisory committee after an extensive process and a public hearing with no negative comments.

The program's basic premise is that sediment control during construction and postconstruction, runoff quantity, and water quality control are components of an overall runoff management program that functions from the time that construction begins through the project's lifespan. The initial emphasis of the program, which began on July 1, 1991, was to prevent existing flooding or water quality from worsening. The intent is to limit further degradation until more comprehensive watershed approaches, as detailed in the state legislation and regulations, are adopted.

Program Structure

The structure of the sediment and runoff management program is based on the premise that ultimate program responsibility must rest with the state. In Delaware, DNREC is responsible for program implementation and is the ultimate approval authority. A local conservation district or other agency, such as a public works department, may request delegation of various program components, depending on its ability to implement them.

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Four program components may be delegated:

- Sediment control and runoff management plan approval
- Inspection during construction
- Postconstruction inspection of permanent runoff facilities
- Education and training

Individual conservation districts receive preference for program components because of their historic involvement in conservation. Essential program components must be in place before any agency is awarded delegation. Delegation is awarded for a maximum of three years. During that time, the state formally reviews the program to determine whether to award delegation for another three years.

Before a local building or grading permit is issued, the sediment control and runoff management plan review and approval process must be completed. State regulations contain criteria for plan review and approval, and DNREC has developed or approved design aids and handbooks. The delegated local agency handles day-to-day inspection responsibilities. If projects do not comply with the plan, responsibility is transferred to the state, which carries out progressive aggressive enforcement. Enforcement options include civil and criminal penalties.

Control Practices

Site control practices are grouped into two categories—temporary practices during construction and permanent practices for postconstruction runoff. Sediment control practices designed for temporary site control must comply with the Delaware Erosion and Sediment Control Handbook. This handbook details numerous practices available, depending on their applicability. The plan review process ensures that the sediment control practices are appropriately located.

In addition to the traditional structural controls, several requirements in the handbook are important in providing overall site control. Sites must be stabilized if the disturbed areas are not actively worked for more than 14 days. To facilitate project phasing, no more than 20 acres may be disturbed at any one time. This provision can be modified for a specific type of project.

Water quality regulations require that 80 percent of suspended solids be removed. Permanent runoff management control requires a pond with a permanent pool of water. Wet ponds also have an extended detention requirement—the first inch of runoff to be released over a 24-hour period—in addition to controlling peak flows from larger storms. Ponds with a normal pool are preferred over either normally dry extended detention ponds or infiltration practices because they have documented performance records and can better reduce downstream nutrient loadings. If properly designed, wet ponds can also be a community amenity. Constructed wetlands are also considered a primary runoff treatment system in upland areas. However, Delaware does not encourage using existing natural wetlands for runoff treatment.

Another site control option is using infiltration practices. These practices are allowed but not encouraged because of their potential to clog and pollute groundwater. On sites that use infiltration practices, upslope and downslope impacts must be carefully considered during the plan review process. Because it has many benefits, runoff infiltration is a necessary component of a runoff management program. However, the design must include critical safeguards for filtering runoff to prevent groundwater pollution.

Runoff filtration must also be a program component, either as a single practice or combined with other practices, primarily infiltration. Common filtration generally consists of vegetative filtering over filter strips or through swale systems. On highly impervious sites, vegetative filters are often impossible. In these situations, a sand filter can provide initial water quality treatment. A number of sand filter design variations may be applicable from site to site, but the design must adhere to specific criteria for the system to effectively remove pollutants.

Unique Features

The Delaware program has a number of unique features compared to other state and local programs. The regulations require that, after development, runoff management practices must reduce the suspended solid load by 80 percent. Florida is the only other state to require a similar performance criteria. Delaware defined this reduction criteria after reviewing nationwide performance practice. While that performance level can be achieved with present technology application, long-term removal rates that exceed 80 percent may require extraordinary measures, such as water reuse. This measure could be required locally, but it is not practical statewide.

The concept of delegating program components is fairly unusual. Delaware can delegate each aspect of program implementation, with DNREC acting as a safety net in case a conservation district or a local government fails to adequately implement its part of the program. The initial delegation concept was developed in Maryland to inspect sediment control. Delaware law and regulations expanded that concept to encompass all aspects of program implementation. The state interaction with local programs has quickly become a partnership, with the state providing technical expertise and educational training and the conservation districts and local governments managing the program.

The Delaware program is unique in its use of private inspectors. Land developers are required to provide inspections on projects over 50 acres or as required by the state or delegated inspection agency to assist the governmental inspection agency. Inspectors must attend and pass an inspection course, inspect active construction sites at least weekly, and submit a report of findings and recommendations to the developer/contractor and the inspection agency. Approximately 170 individuals had been approved as of March 1993. The inspection agency must still inspect the site periodically to ensure the adequacy of site controls, but private inspectors reduce the need for frequent oversight. If the private inspector fails to accurately record site conditions or notify the contractor/developer or inspection agency of deficiencies, the inspector's certification could be jeopardized and enforcement action taken against the contractor/developer.

Another increasingly popular requirement in state sediment control programs is that contractors must have one or more responsible individuals certified as having attended a sediment control and runoff management course. The four-hour Delaware course acquaints contractors with the importance of good site erosion and sediment control and runoff management and their legal responsibilities. The certification program is extremely popular with contractors and reduces the "we-they" problems of many regulatory programs. Over 2,000 individuals had been certified in Delaware as of December 1993.

Evolution

The next phase of the Delaware program addresses runoff management from a watershed perspective. The regulation's designated watershed concept, when coupled with land use planning, wetland restoration, and other nonstructural practices, reduces existing flooding problems and improves water quality. Under the concept, one watershed in each county is designated as a model. Various aspects of this watershed are studied, including hydrology, water quality, and stream habitat and diversity. The study also considers alternative land uses and runoff controls and their impact on water quality. From this watershed study, the state and local government recommend a watershed protection approach—a blueprint for future resource protection—in designated watersheds. As of 1993, one Delaware watershed had been designated for additional resource protection efforts.

To expand the initial program, funding must also be addressed. The Delaware law and regulations provide a framework to expand traditional mechanisms with more innovative funding. The regulations contain significant information on using runoff utilities (user fees) as an alternative to permit fees or general funding. The runoff utility complements the designated watershed concept as a way to fund watershed studies; plan, design, and implement practices; and maintain completed structures.

While maintaining commercial structures is not a significant problem, since one entity is generally responsible for overall site maintenance, the maintenance of residential structures has not been satisfactorily addressed. Residential maintenance is generally the responsibility of a community association; however, the responsibility must become public to ensure proper maintenance. Shifting that responsibility requires implementing a dedicated funding source, such as a runoff utility.

To ensure resource protection, the issue of land use and its relationship to water quantity and quality must evolve. Significant effort must be expended to educate local government officials about the importance of wetlands, open space, greenways, cluster development, and other options to conventional "cookie cutter" zoning. The designated watershed approach provides specific details on the benefits of alternative land use approaches and their impacts on water quality and aquatic resources.

An effective runoff management program must have a multifaceted approach and implementation. It must also dispel the erroneous assumption that total resource protection is achieved through structural controls implemented after the entire site has been developed.

Land use limitations, dedicated open space, vegetated buffer areas, and reduced impervious areas are all components of an overall resource protection strategy—a structural control strategy alone will only reduce the rate of resource decline. Structural controls should be implemented as a first step, but continued evolution is vital to achieve true resource protection.

New Jersey's Runoff Management and Soil Erosion/Sediment Control

One of the most densely populated states, New Jersey has developed its runoff management and soil erosion/sediment control programs over several decades. These programs, which are some of the most comprehensive in the country, are the result of a continuing effort by the state government to address a range of flooding and other runoff problems. Due to the state's density, these problems have occurred earlier and with greater severity than in other less developed states. The programs' development has come mainly from in-state concerns and interests.

Programs are administered by the New Jersey Department of Environmental Protection (NJDEP), formerly the New Jersey Department of Environmental Protection and Energy. An active program of public education and information, which the NJDEP recognizes as key to developing a successful program, is included.

Much of New Jersey's dense development lies within a broad corridor between the New York City and Philadelphia metropolitan areas. Outside this corridor, particularly in the state's northwest and extreme southern portions, development levels are significantly less. Much undisturbed land remains. Other extensive areas are devoted to agriculture, the source of the state's designation as the Garden State. However, intensive development pressures are caused by the state's attempt to produce housing and jobs for a growing population.

New Jersey is composed of 567 municipalities—grouped into 21 counties—which exercise land use planning authority. This municipal authority has evolved gradually since World War II and was formalized in the 1975 Municipal Land Use Law (MLUL). This state law requires each municipality to develop a land use master plan to be implemented, in part, through its planning board and zoning board of adjustment. These two boards, following municipal zoning and land development ordinances, review and approve virtually all land development activity within the municipality. The MLUL requires that all municipal master plans be updated and readopted every six years. County governments also exercise some degree of approval authority over land development through state enabling legislation that predates the MLUL by some 20 years. This legislation grants counties the power to regulate proposed land development that affects county roads or drainage facilities.

In recent years, the state has attained some land use authority, either directly or through regional agencies created by the state legislature. These agencies include the Hackensack Meadowlands Development Commission in the northeast, the Pinelands commission in the southeast, and the Delaware and Raritan Canal Commission in central New Jersey. Other state laws, including the Coastal Area Facility Review Act (CAFRA), the Wetlands Act of 1970 (pertaining to coastal wetlands), the Waterfront Development Law, the Flood Hazard Area Control Act (described as follows), and the Freshwater Wetlands Protection Act have also allowed state government to regulate either the extent or details of land development along the coast and within floodplains, coastal and inland wetlands, and other environmentally sensitive areas.

Floodplain Management Programs

One of the earliest efforts by the state government to address runoff quantity problems was a 1929 law that prohibited the construction of any bridge, culvert, wall, building, or similar structure within "the natural and ordinary high water mark of any stream" without receiving prior state approval. By "preserving the channel and providing for the flow of waters," this legislation would "safeguard the public against danger from the waters impounded or affected by such structure." The state expanded its authority over the years by passing additional laws, including chapter 19, Public Law 1962, which authorized the state to delineate and otherwise identify floodplains and flood hazard areas to minimize flood damage through improper development. The state gained more authority in 1972 when it was empowered to regulate virtually all land development activity within the delineated floodways of streams and assist municipalities with similar efforts within contiguous flood fringe areas.

The 1978 Flood Hazard Area Control Act granted further review authority to the state and municipalities, while also coordinating the state's floodplain management activities with those of the federal Flood Insurance Program. This law, applied through the state's Flood Hazard Area Regulations, requires strict environmental constraints regarding site discharges, ground disturbance, and loss of floodplain storage through the NJDEP's Stream Encroachment Permit process. A direct effect of the restrictions on filling floodplains is that natural stream corridors and even entire floodplains have been increasingly preserved. This preservation, further enhanced by the 1987 Freshwater Wetlands Protection Act, maintains flood storage capabilities, habitats, and other environmental benefits. The Stream Encroachment Permit process has given the NJDEP procedural and technical expertise in runoff regulations and, indirectly, is an effective public information and education program.

Soil Erosion and Sediment Control Programs

New Jersey's soil erosion and sediment control program has been in effect since the 1970s. The 1975 Soil Erosion and Sediment Control Act (c. 251, P.L. 1975) was based on the legislative finding that "sediment is a source of pollution and that soil erosion continues to be a serious problem throughout the state." The legislation also noted that "rapid shifts in land use from agricultural and rural to nonagricultural and urbanizing uses, construction of housing, industrial and commercial developments, and other land disturbing activities have accelerated the process of soil erosion and sediment deposition, resulting in pollution of the waters of the State and damage to domestic, agricultural, industrial, recreational, fish and wildlife, and other resource uses."

In response to these problems, the act required the state Soil Conservation Committee—a division of the New Jersey Department of Agriculture—and the state's 16 soil conservation districts (SCDs) to develop and implement a "statewide comprehensive and coordinated erosion and sediment control program to reduce the danger from stormwater runoff, to retard nonpoint pollution from sediment, and to conserve and protect the land, water, air and other environmental resources of the State." The program requires virtually all proposed land developments that disturb more than 5,000 sq ft (0.046 ha) of land to prepare and submit a Soil Erosion and Sediment Control Plan to the SCD for review and certification. Regulated land development activities include

- Any construction that requires a construction permit under the State's Uniform Construction Code (excluding the construction of a single residence not part of a larger subdivision);
- Demolition of one or more structures;
- Construction of a parking lot;
- Construction of a public facility;
- Operation of any mining or quarrying facility; and
- Clearing or grading land for other than agricultural or horticultural purposes.

The Soil Erosion and Sediment Control plans must be developed as required in the *Standards for Soil Erosion and Sediment Control in New Jersey*, a detailed technical manual published by the State Soil Conservation Committee (New Jersey Dep. Agric. 1987). Following certification of the plan, the SCD is further empowered to conduct necessary field inspections during site construction to ensure that all erosion and sediment control measures are properly installed and adequately maintained.

If the site fails to comply with the plan during construction, the SCD municipality can issue a stop-work order. After construction is complete, a certificate of occupancy can be withheld until the project achieves full compliance. Separate state legislation specifies that the "Attorney General, on his own initiative or the respective county counsel, with the approval of the [county] board of chosen freeholders, may provide any and all legal services to any district" (NJSA 4:24-17.7) The act also authorizes SCDs to "adopt a fee schedule and collect fees from applicants for the certification of plans and for on-site inspections of the execution of certified plans" provided that such fees "bear a reasonable relationship to the cost of rendering such services."

The soil erosion and sediment control program has been highly successful. The 20-year-old program has enabled New Jersey to fully comply with the NPDES requirements of the 1987 Clean Water Act pertaining to construction and mining activities with little if any modification. The program's success is due, in part, to the original enabling legislation, which established a highly effective regulatory threshold (i.e., 5,000 sq ft [0.046 ha] of disturbance). It also provided the local SCDs with sufficient technical support

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through the Soil Erosion and Sediment Control Standards, legal support through the stop-work order and certificate-of-occupancy authority, and financial support through the fee schedule authorization. Including construction inspection costs in the fee schedule has been particularly effective in insuring that necessary soil erosion and sediment control measures are properly installed and maintained.

Runoff Management Programs

While its development began more recently, New Jersey's program to address the quantitative and qualitative aspects of runoff has built upon the success of the state's earlier floodplain management and soil erosion/sediment control efforts. The program began with the 1981 Storm Water Management Act (c. 32, P.L. 1981). This act and subsequent regulations directed municipalities, counties, and the NJDEP to address runoff impacts in several ways.

The legislation requires the state's municipalities to develop comprehensive runoff management plans for new land development within their borders. Such plans are to be designed to

- Reduce artificially induced flood damage;
- Minimize increased runoff from any new land development where such runoff will increase flood damage;
- Maintain existing and proposed culverts, bridges, dams, and other structures;
- Induce water recharge, where practical, where natural storage and geologically favorable conditions exist;
- Prevent, to the greatest extent feasible, an increase in nonpoint source pollution that would otherwise degrade water quality and render it unfit for human consumption and detrimental to stream biota;
- Maintain the integrity of stream channels for their biological, drainage, and other functions;
- Reduce the impact of land development on stream erosion;
- Reduce soil erosion from construction sites; and
- Preserve and protect water supply facilities and other water resources.

This comprehensive plan is to be developed in two phases. The municipality should incorporate a Phase I Stormwater Management Plan into its overall land use master plan. It should be implemented through municipal ordinances applied to new land developments by the Planning Board and Zoning Board of Adjustment approval process according to the Municipal Land Use Law. A Phase I plan must be based, in part, on an assessment of the municipality's environmental, technical, and institutional needs and be consistent with existing county, regional, and state plans and requirements. It must address the runoff impacts of major developments within the municipality by requiring, with certain exceptions, that the following performance standards be met:

- **Runoff quantity.** Reduction of the peak 2, 10, and 100-year discharge rates from the site after development to predevelopment levels.
- **Runoff quality.** Extended detention of the runoff from either a 1.25 inch (3.175 cm)/2-hour or 1-year/24-hour storm event so that at least 10 percent of the total runoff volume from the site still remains in the extended detention basin after 18 hours for single family residential developments or 36 hours for all others.

According to the regulations, the following are considered to be major developments and, therefore, subject to the previously stated performance standards:

- Any site plan or subdivision that will ultimately create at least 1 acre (0.41 ha) of impervious surface.
- Feeding and holding areas for specified numbers of farm animals.
- Petroleum or chemical pipelines, storage, or distribution facilities.
- Solid waste storage, disposition, incineration, or landfill.
- Storage, distribution, or treatment of liquid or radioactive wastes.
- Quarries, mines, and borrow pits.
- Land application of sewage sludge effluents.

The NJDEP is currently developing technical revisions to the Phase I plan requirements, in part to better match current Clean Water and Coastal Zone Management Acts. Phase I plans address the runoff impacts of new or future developments. Under Phase II, both existing and future developments and impacts are to be addressed through "a detailed analysis of alternative stormwater management approaches on an integrated or regional basis. The plan will consist of a system of nonstructural and/or structural stormwater management programs to mitigate flooding and nonpoint source pollution." Unlike Phase I, Phase II plans are to be developed by counties and municipalities at their own discretion based on needs and resources. As of 1993, seven Phase II plans had been or were being completed by various counties and funded, in part, by grants from the NJDEP. Two additional Phase II plans have been developed cooperatively by the NJDEP and USDA SCS.

Another important aspect of the Storm Water Management Act regulations is the attention to runoff facility inspection and maintenance. According to the regulations, all municipal runoff management plans should provide for facility inspection and maintenance, either privately or publicly. In the case of private responsibility, the plans must provide the means for public agencies to perform emergency maintenance in case the owner defaults or chronically neglects the site. To help municipalities address inspection and maintenance, the NJDEP prepared and published the *Stormwater Management Facilities Maintenance Manual* (1989). This manual, as previously discussed, was developed as part of a demonstration study with Ocean County, New Jersey, and contains detailed information on ownership, planning and design, regulatory, and financial aspects of runoff management facility maintenance.

In addition, the NJDEP and the New Jersey Department of Agriculture are publishing a new best management practices manual for stormwater management and nonpoint source pollution control (in prep.). This manual provides more comprehensive guidance than has been practiced statewide in the past. The manual is based on the importance of addressing stormwater and nonpoint source control at the start of the land development process to develop the most effective and efficient solutions. The manual stresses integrating preventative practices—such as land use planning, density controls, innovative site design, pollutant source controls, and waste minimization—with more traditional structural measures in a systems approach. In addition, the manual emphasizes the need for this integrated management system to be applied on a regional or watershed basis, and not merely site by site.

The NJDEP is also developing a stormwater management and nonpoint source guidance document for local governments. It is intended to introduce citizens and local officials to the scientific, technical, and legal aspects of stormwater, nonpoint source, and sediment control to increase their knowledge and ability to develop more effective local programs.

In recent years, the NJDEP has expanded the scope of the state's programs in response to internal concerns, citizen interest, and federal laws and regulations. In particular, the state developed the Industrial Stormwater Permitting Program to address the permitting requirements for such activities in the 1987 Clean Water Act. At the present time, a general stormwater discharge permit is available to eligible industries in addition to individual permits.

In August 1988, the New Jersey legislature adopted the Sewage Infrastructure Improvement Act (NJSA 58:25-23, et seq.), an initiative designed to further address stormwater and nonpoint source pollution problems. The act provides the means for municipalities and other public entities to survey, locate, and eliminate sources of pollutants entering storm sewers, waterways, and waterbodies. Under the act, 94 municipalities in four counties along and near the Atlantic coast are required to map their stormwater and sanitary sewer systems, locate and correct any interconnections, perform quarterly monitoring of outfalls to saltwater bodies, and abate nonpoint source pollution. Approximately $10 million has been allocated by the legislature to assist municipalities in meeting the act's goals.

Finally, the NJDEP has undertaken numerous demonstration and public outreach projects throughout the state, primarily through the Clean Water Act's section 319 program. These projects include the following:

- Barnegat Bay Watershed Management Plan
- New Jersey Water Watch Program
- Musconetcong Watershed Nonpoint Source Demonstration Project
- Barnegat Bay Watershed Intensive Monitoring Project
- Whippany River Watershed Management Plan
- Clean Water Information Series

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PART III

APPENDIXES

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APPENDIX A

Delaware's Erosion and Sedimentation Control and Stormwater Management Law

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Chapter 40, Title 7, Delaware Code

§4001. LEGISLATIVE FINDINGS AND STATEMENT OF POLICY

(a) Legislative Findings. The General Assembly finds that erosion and sedimentation continue to present serious problems throughout the State, and that the removal of a stable ground cover in conjunction with the decrease in the infiltration capability of soils resulting from the creation of additional impervious areas such as roads and parking lots has accelerated the process of soil erosion and sediment deposition resulting in pollution of the waters of the State. This loss damages domestic, agricultural, industrial, recreational, fish and wildlife and other resource uses. The General Assembly further finds that accelerated stormwater runoff increases flood flows and velocities, contributes to erosion, sedimentation, and degradation of water quality, overtaxes the carrying capacity of streams and storm sewers, greatly increases the costs of public facilities in carrying and controlling stormwater, undermines flood plain management and flood control efforts in downstream communities, reduces groundwater recharge, and threatens public health, welfare, and safety.

(b) Statement of Policy. In consideration of these legislative findings, it is declared to be the policy of this Chapter to strengthen and extend the present erosion and sediment control activities and programs of this State for both rural and urban lands and to provide for the control and management of stormwater runoff consistent with sound water and land use practices. These activities will reduce to the extent possible any adverse effects of stormwater runoff on the water and lands of the State. This policy, to be carried out by establishing and implementing through the Department of Natural Resources and Environmental Control, hereinafter referred to as the "Department," in cooperation with conservation districts, counties, municipalities and other local governments and subdivisions of this State, and other public and private entities, a statewide comprehensive and coordinated erosion and sediment control and stormwater management program to conserve and protect land, water, air and other resources of the State. This program shall be consistent with, and coordinated with other environmental programs implemented by the Department such as wetlands protection and groundwater protection.

§4002. DEFINITIONS

The following words, terms and phrases, when used in this Chapter, shall have the meaning ascribed to them in this Section, except where the context clearly indicates a different meaning:

(1) "Certified Construction Reviewer" means an individual who has passed a departmental sponsored or approved training course and who provides on-site construction review for sediment control and stormwater management in accordance with regulations promulgated under this Chapter.

(2) "Designated Watershed or Subwatershed" means a watershed or subwatershed proposed by a conservation district, county, municipality, or State agency and approved by

the Department. The Department may establish additional requirements due to existing water quantity or water quality problems. These requirements shall be implemented on an overall watershed or subwatershed master plan developed for water quality and/or water quantity protection.

(3) "Land Disturbing Activity" means any land change or construction activity for residential, commercial, silvicultural, industrial, and institutional land use which may result in soil erosion from water or wind or movement of sediments or pollutants into State waters or onto lands in the State, or which may result in accelerated stormwater runoff, including, but not limited to, clearing, grading, excavating, transporting and filling of land.

(4) "Person" means any State or federal agency, individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission board, public or private institution, utility, cooperative, municipality or other political subdivision of this State, any interstate body, or any other legal entity.

(5) "Responsible Personnel" means any foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a construction project.

(6) "Sediment and Stormwater Management Plan" or "plan" means a plan for the control of soil erosion, sedimentation, stormwater quantity, and water quality impacts which may result from any land disturbing activity.

(7) "State Waters" means any and all waters, public or private, on the surface of the earth which are contained within, flow through or border upon the State of Delaware or any portion thereof.

(8) "Stormwater" means the runoff of water from the surface of the land resulting from any form of precipitation and including snow or ice melt.

(9) "Stormwater Management" means:

(a) for water quantity control, a system of vegetative, structural, and other measures that controls the volume and rate of stormwater runoff which may be caused by land disturbing activities or activities upon the land; and

(b) for water quality control, a system of vegetative, structural and other measures that controls adverse effects on water quality that may be caused by land disturbing activities or activities upon the land.

(10) "Stormwater Utility" means the establishment of an administrative organization that has been created for the purposes of funding sediment control, stormwater management or flood control planning, design, construction, maintenance, and overall resource needs by authorized and imposed charges.

§4003. DUTIES OF PERSONS ENGAGED IN LAND DISTURBING ACTIVITIES

(a) After July 1, 1991, unless exempted, no person shall engage in land disturbing activities without submitting a sediment and stormwater management plan to the appropriate plan approval authority and obtaining a permit to proceed.

(b) Projects which do not alter stormwater runoff characteristics may be required to provide water quality enhancement even if the predevelopment runoff characteristics are unchanged. Criteria will be detailed in the regulations regarding level of water quality control and variance procedures.

(c) Each land developer shall certify, on the sediment and stormwater management plan submitted for approval, that all land clearing, construction, development, and drainage will be done according to the approved plan.

(d) All approved land disturbing activities shall have associated therein at least one individual who functions as responsible personnel.

§4004. APPLICABILITY

(a) The provisions of this Chapter shall not apply to agricultural land management practices unless the conservation district or the Department determines that the land requires a new or updated soil and water conservation plan, and the owner or operator of the land has refused either to apply to a conservation district for the development of such a plan, or to implement a plan developed by a conservation district.

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(b) Unless a waiver is granted the construction of agricultural structures such as broiler houses, machine sheds, repair shops, and other major buildings shall require approval of a sediment and stormwater management plan, by the appropriate plan approval agency, prior to the initiation of construction.

(c) Utility projects that disturb less than 5,000 square feet are not subject to the provisions of this Chapter.

§4005. PROGRAM FUNDING AND FINANCIAL ASSISTANCE

(a) The Department, conservation districts, counties, or municipalities are authorized to receive from federal, State, or other public or private sources financial, technical or other assistance for use in accomplishing the purposes of this Chapter. The Department may allocate, as necessary or desirable, any funds received to conservation districts, counties, or municipalities for the purpose of effectuating this Chapter.

(b) The conservation districts, counties, and municipalities shall have authority to adopt a fee system to help fund program implementation. That fee system shall be implemented by the designated plan approval agency to fund overall program management, plan review, construction review, enforcement needs, and maintenance responsibilities. In those situations where the Department becomes the designated plan approval agency, the Department may assess a plan review and inspection fee. That fee shall not exceed $80.00 per disturbed acre per project. There shall be no duplication of fees by the various implementing agencies for an individual land disturbing activity and the fee schedule shall be based upon the costs to the Department, conservation districts, counties, or municipalities to implement and administer the program.

(c) Authority is also granted to the Department, conservation districts, counties or municipalities to establish a stormwater utility as an alternative to total funding under the fee system. The stormwater utility shall be developed for the designated watersheds and may fund such activities as long range watershed master planning, watershed retrofitting, and facility maintenance. This fee system shall be reasonable and equitable so that each contributor of runoff to the system, including State agencies, shall pay to the extent to which runoff is contributed. Criteria for the implementation of the stormwater utility shall be established in regulations promulgated under this Chapter. The implementation of a stormwater utility will necessitate the development of a local utility ordinance prior to its implementation.

§4006. STATE MANAGEMENT PROGRAM

(a) The Department shall, in cooperation with appropriate State and federal agencies, conservation districts, other governmental subdivisions of the State, and the regulated community develop a State Stormwater Management Program. This program shall take into consideration both quantity and quality of water, and shall be integrated with, and made a part of the amended State Erosion and Sediment Control Program to create a Sediment and Stormwater Program.

(b) In carrying out this Act, the Department shall have the authority to

(1) Provide technical and other assistance to districts, counties, municipalities, and State agencies in implementing this Chapter;

(2) Develop and publish, as regulation components, minimum standards, guidelines and criteria for delegation of sediment and stormwater program components, and model sediment and stormwater ordinances for use by districts, counties, and municipalities;

(3) Review the implementation of all components of the statewide sediment and stormwater program that have been delegated to either the conservation districts, counties, municipalities, or other State agencies in reviews to be accomplished at least once every three (3) years;

(4) Require that appropriate sediment and stormwater management provisions be included in all new erosion and sediment control plans developed pursuant to this Chapter;

(5) Cooperate with appropriate agencies of the United States or other states or any interstate agency with respect to sediment control and stormwater management;

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(6) Conduct studies and research regarding the causes, effects and hazards of stormwater and methods to control stormwater runoff;

(7) Conduct and supervise educational programs with respect to sediment control and stormwater management;

(8) Require the submission to the Department of records and periodic reports by conservation districts, tax ditch organizations, county and municipal agencies as may be necessary to carry out this Act;

(9) Review and approve designated watersheds for the purpose of this Act;

(10) Establish a maximum life of three years for the validation of approved plans. The regulations shall specify variances which expand this time limitation in specific situations; and

(11) Establish a means of communication, such as a newsletter, so that information regarding program development and implementation can be distributed to interested individuals.

(c) The Department shall develop such regulations in conjunction with and with substantial concurrence of a regulatory advisory committee, appointed by the Secretary, which shall include representatives of the regulated community and others affected by this Act. The recommendations of this committee shall be presented at all public workshops and hearings related to the adoption of the regulations implementing this Act. Prior to final promulgation of regulations under this Act, the Secretary shall explain, in writing, any differences between the advisory committee recommendations and the final regulations. The regulations may include, but are not limited to, the following items:

(1) Criteria for the delegation of program elements;

(2) Types of activities that require a sediment and stormwater management permit;

(3) Waivers, exemptions, and variances;

(4) Sediment and stormwater plan approval fees and performance bonds;

(5) Criteria for distribution of funds collected by sediment and stormwater plan approval fees;

(6) Criteria for implementation of a stormwater runoff utility;

(7) Specific design criteria and minimum standards and specifications;

(8) Permit application and approval requirements;

(9) Criteria for approval of designated watersheds;

(10) Criteria regarding attendance and completion of departmental sponsored or approved training courses in sediment and stormwater control that will be required of certified construction reviewers and responsible personnel;

(11) Construction review; and

(12) Maintenance requirements for sediment control during construction and stormwater management structures after construction is completed.

(d) The Department may adopt, amend, modify, or repeal rules or regulations after public hearing to effectuate the policy and purposes of this Chapter. The conduct of all hearings conducted pursuant to this Chapter and the promulgation process shall be in accordance with the relevant provisions of Chapter 60 of this Title.

§4007. LOCAL SEDIMENT AND STORMWATER PROGRAMS

(a) Pursuant to regulations promulgated by the Department, each conservation district, county, municipality, or State agency may adopt, and submit to the Department for approval, one or more components of a sediment and stormwater program for the area within its jurisdiction.

(b) Requests for delegation of program elements shall be submitted within six months of the promulgation of State regulations, and by January 1 of subsequent years if delegation is desired at a future date. The Secretary shall grant or deny such a request on or before April 1 of the year for which delegation is sought.

(c) Delegation, once applied for, shall become effective on July 1 and shall not exceed three (3) years, at which time delegation renewal is required.

(d) A district, county, municipality, or State agency may develop the program in cooperation with any other governmental subdivisions.

(e) Initial consideration regarding delegation of program elements shall be given to the conservation districts, since the conservation districts, having unique capabilities and area-wide responsibilities, are in an ideal position to coordinate and implement local sediment and stormwater programs.

§4008. INTERIM PROGRAM

(a) Prior to July 1, 1991, requirements for sediment control shall be as provided in existing erosion and sediment control regulations promulgated September 26, 1980. Also, until July 1, 1991, any State or locally developed regulation or criterion for stormwater management shall remain in effect at the discretion of the implementing authority.

(b) Projects approved prior to July 1, 1991, but which are under construction after July 1, 1991, shall be subject to the penalty provisions contained in Section 4015 of this Chapter.

§4009. FAILURE OF CONSERVATION DISTRICTS, COUNTIES, MUNICIPALITIES, OR STATE AGENCIES TO IMPLEMENT DELEGATED PROGRAM ELEMENTS

(a) If, at any time, the Department finds that a conservation district, county, municipality, or State agency has failed to implement program elements that the Department has delegated, the Department shall provide written notice of violation to the conservation district, county, municipality or State agency.

(b) Within 60 days of receipt of the notice of violation, the conservation district, county, municipality or State agency shall report to the Department the action which it has taken to comply with the requirements set forth in the violation notice.

(c) If after 120 days of receipt of the notice of violation, the conservation district, county, municipality, or State agency has failed to comply satisfactorily with the requirements set forth in the notice of violation, the Department may suspend or revoke the delegated authority.

(d) If at any time, a program element delegation is being considered for suspension or revocation, an opportunity for a hearing before the Secretary or his designee shall be provided prior to such suspension or revocation.

§4010. STATE AND FEDERAL PROJECTS

After July 1, 1991, a State or federal agency may not undertake any land clearing, soil movement, or construction activity unless the agency has submitted a sediment and stormwater management plan to the Department and received its approval. The only variation to this requirement shall be when delegation of the plan approval process has been granted by the Department to a specific State or federal agency.

§4011. DESIGNATED WATERSHEDS OR SUBWATERSHEDS

(a) Watersheds or subwatersheds approved as designated watersheds or subwatersheds by the Department shall have the regulatory requirements clearly specified through a watershed approach to nonpoint pollution control or flood control. The watershed approach shall result in a specific plan, developed or approved by the Department, for the designated watershed or subwatershed that contains the following information:

(1) Stormwater quantity or quality problem identification;

(2) The overall needs of the watershed, not just the additional impacts of new development activities;

(3) Alternative approaches to address the existing and future problems;

(4) A defined approach which includes the overall costs and benefits;

(5) A schedule for implementation;

(6) Funding sources and amounts; and

(7) A public hearing process prior to Departmental approval.

(b) Upon approval of the designated watershed or subwatershed plan, all projects undertaken in that watershed or subwatershed shall have stormwater requirements placed upon them that are consistent with the designated watershed or subwatershed plan.

§4012. CONSTRUCTION REVIEW AND ENFORCEMENT

(a) With respect to approved sediment and stormwater plans, the agency responsible for construction review during and after construction completion shall ensure that periodic reviews are undertaken, implementation is accomplished in accordance with the approved plans, and the required measures are functioning in an effective manner. Notice of such right of construction review shall be included in the sediment and stormwater management plan certification. The agency responsible for construction review may, in addition to local enforcement options, refer a site violation to the Department for additional action.

(b) Referral of a site violation to the Department may initiate a departmental construction review of the site to verify site conditions. That construction review may result in the following actions:

(1) Notification through appropriate means to the person engaged in a land disturbing activity and the contractor to comply with the approved plan within a specified time frame.

(2) Notification of plan inadequacy, with a time frame for the person engaged in a land disturbing activity to submit a revised sediment and stormwater plan to the appropriate plan approval agency and to receive its approval with respect thereto.

(c) Failure of the person engaged in the land disturbing activity or the contractor to comply with departmental requirements may result in the following actions in addition to other penalties as provided in this Chapter.

(1) The Department shall have the power to issue a cease and desist order to any person violating any provision of this Chapter by ordering such person to cease and desist from any site work activity other than those actions necessary to achieve compliance with any administrative order.

(2) The Department may request that the appropriate plan approval agency refrain from issuing any further building or grading permits to the person having outstanding violations until those violations have been remedied.

§4013. APPROVAL OF CERTIFIED CONSTRUCTION REVIEWERS

(a) Based on criteria established by the Department through regulation and any additional criteria established by the agency implementing the plan review and construction elements of the sediment and stormwater program, the person engaged in a land disturbing activity may be required to provide for construction review by a certified construction reviewer.

(b) Individuals functioning as certified construction reviewers must attend and pass a departmental sponsored or approved construction review training course. The Department will establish, through regulation, the length of time for which the certification will last and procedures for renewal. The construction reviewers shall also function under the direction of a registered professional engineer licensed to practice engineering in the State of Delaware.

(c) The responsibility of the certified construction reviewer will be to ensure the adequacy of construction pursuant to the approved sediment and stormwater management plan.

(d) The certified construction reviewer shall be responsible for the following items:

(1) Provision of a construction review of active construction sites on at least a weekly basis, as determined on a case-by-case basis by the plan review and construction review agencies, or as required by regulations promulgated pursuant to this Chapter;

(2) Within five calendar days, informing the person engaged in the land disturbing activity, and the contractor, by a written construction review report of any violations of the approved plan or inadequacies of the plan. The plan approval agency shall be informed, if the approved plan is inadequate, within five working days. In addition, the appropriate construction review agency shall receive

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copies of all construction review reports; and

(3) Referral of the project to the Department for appropriate enforcement action if the person engaged in the land disturbing activity fails to address the items contained in the written construction review report. Verbal notice shall be made to the Department within two working days and written notice shall be provided to the Department within five working days.

(e) If the Secretary or his designee determines that a certified construction reviewer is not providing adequate site control or is not referring problem situations to the Department, the Secretary or his designee may suspend or revoke the certification of the construction reviewer.

(f) In any situation where a certified construction reviewer's approval is being suspended or revoked, an opportunity for hearing before the Secretary or his designee shall be provided. During any suspension or revocation, the certified construction reviewer shall not be allowed to provide construction reviews pursuant to this Chapter.

(g) The failure to assign a Departmental approved certified construction reviewer to a land disturbing activity, when required by the approved plan, will place that project in violation of this Chapter and result in appropriate administrative and/or enforcement action.

§4014. TRAINING OF RESPONSIBLE PERSONNEL

After July 1, 1991, any applicant seeking sediment and stormwater plan approval shall certify to the appropriate approval agency that all responsible personnel involved in the construction project will have a certificate of attendance at a departmentally sponsored or approved training course for the control of sediment and stormwater before initiation of any land disturbing activity. The certificate of attendance shall be valid until the Department notifies the individual or announces in local newspapers that recertification is required due to a change in course content.

§4015. PENALTIES

(a) Any person who violates any rule, regulation, order, condition imposed in an approved plan or other provision of this Chapter shall be fined not less than $200 or more than $2,000 for each offense. Each day that the violation continues shall constitute a separate offense. The Justice of the Peace Courts shall have jurisdiction of offenses brought under this subsection.

(b) Any person who intentionally, knowingly, and after written notice to comply, violates or refuses to comply with any notice issued pursuant to Section 4013(2) of this Chapter shall be fined not less than $500 or more than $10,000 for each offense. Each day the violation continues shall constitute a separate offense. The Superior Court shall have jurisdiction of offenses brought under this subsection.

§4016. INJUNCTIONS

The Court of Chancery shall have jurisdiction to enjoin violations of this Chapter. The appropriate program element authority, the Department, or any aggrieved person who suffers damage or is likely to suffer damage because of a violation or threatened violation of this Chapter may apply to the Chancery Court for injunctive relief. Among any other appropriate forms of relief, the Chancery Court may direct the violator to restore the affected land or water impacted area to its original condition.

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APPENDIX B

Delaware Sediment and Stormwater Regulations

Department of Natural Resources and Environmental Control
Effective Date January 23, 1991 — Amended March 11, 1993

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Section 1 — Scope

1. Stormwater runoff may reasonably be expected to be a source of pollution to waters of the State, and may add to existing flooding problems. The implementation of a statewide sediment and stormwater program will prevent existing water quantity and water quality problems from becoming worse, and in some cases, reduce existing problems.

2. Sediment and stormwater approvals are required for land changes or construction activities for residential, commercial, silvicultural, industrial, or institutional land use which are not exempted or waived by these Regulations. Requirements under these Regulations do not apply to agricultural land management practices unless the Conservation District or the Department determines that the land requires a soil and water conservation plan, and the owner or operator of the land has refused either to apply to a Conservation District for the development of such a plan, or to implement a plan developed by a Conservation District.

3. The Department intends that, to the extent possible, the provisions of these Regulations be delegated to either the Conservation Districts, local governments, or other State agencies. Those program provisions which are subject to delegation include sediment and stormwater management plan approval, inspection during construction, post-construction inspection, and education and training. Initial consideration regarding delegation of program components shall be given to the Conservation Districts.

4. The implementation of a stormwater utility represents a comprehensive approach to program funding and implementation. The activities which may be undertaken by a stormwater utility include not only assessment, collection, and funding activities, but also carrying out provisions of adopted stormwater management plans. These provisions may include contracting for such services as project construction, project maintenance, project inspection, and enforcement of installation and maintenance requirements imposed with respect to approved land disturbing activities.

Section 2 — Definitions

As used in these regulations, the following terms shall have the meanings indicated below:

1. "Adverse Impact" means a negative impact to land or waters resulting from a construction or development activity. The negative impact includes increased risk of flooding; degradation of water quality; increased sedimentation; reduced groundwater recharge; negative impacts on aquatic organisms; negative impacts on wildlife and other resources, and threatened public health.

2. "Agricultural Land Management Practices" means those methods and procedures generally accepted by the Conservation Districts and used in the cultivation of land in order to further crop and livestock production and conservation of related soil and water resources.

3. "Applicant" means a person, firm, or governmental agency who executes the necessary forms to obtain approval or a permit for a land disturbing activity.

4. "Appropriate Plan Approval Agency" means the Department, Conservation District, county, municipality, or State agency that is responsible in a jurisdiction for review and approval of sediment and stormwater management plans.

5. "As-Built Plans or Record Documents" means a set of engineering or site drawings that delineate the specific permitted stormwater management facility as actually constructed.

6. "Certified Construction Reviewer" means those individuals, having passed a Departmental sponsored or approved training course, who provide on-site inspection for sediment control and stormwater management in accordance with these regulations.

7. "Delegation" means the acceptance of responsibility by a Conservation District, county, municipality, or State agency for the implementation of one or more elements of the statewide sediment and stormwater management program.

8. "Department" means the Department of Natural Resources and Environmental Control.

9. "Designated Watershed or Subwatershed" means a watershed or subwatershed proposed by a Conservation District, county, municipality, or State agency and approved by the Department. The Department may establish additional requirements in these watersheds and subwatersheds due to existing

water quantity or water quality problems. These requirements shall be implemented on an overall watershed or subwatershed master plan that is developed for water quality and/or water quantity protection.

10. "Detention Structure" means a permanent stormwater management structure whose primary purpose is to temporarily store stormwater runoff and release the stored runoff at controlled rates.

11. "Develop Land" means to change the runoff characteristics of a parcel of land in conjunction with residential, commercial, industrial, or institutional construction or alteration.

12. "Developer" means a person undertaking, or for whose benefit, activities covered by these regulations are commenced and/or carried out.

13. "Drainage Area" means that area contributing runoff to a single point measured in a horizontal plane, which is enclosed by a ridge line.

14. "Easement" means a grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes, and which must be included in the conveyance of land affected by such easement.

15. "Erosion and Sediment Control" means the control of solid material, both mineral and organic, during a land disturbing activity, to prevent its transport out of the disturbed area by means of air, water, gravity, or ice.

16. "Exemption" means those land development activities that are not subject to the sediment and stormwater requirements contained in these regulations.

17. "Grading" means excavating, filling (including hydraulic fill) or stockpiling of earth materials, or any combination thereof, including the land in its excavated or filled condition.

18. "Infiltration" means the passage or movement of water through the soil profile.

19. "Land Disturbing Activity" means a land change or construction activity for residential, commercial, silvicultural, industrial, and institutional land use that can result in soil erosion from water or wind or movement of sediments or pollutants into State waters or onto lands in the State, or in accelerated stormwater runoff. These activities include but are not limited to clearing, grading, excavating, transporting and filling of land.

20. "Off-site Stormwater Management" means the design and construction of a stormwater management facility that is necessary to control stormwater from more than one land disturbing activity.

21. "On-site Stormwater Management" means the design and construction of stormwater management practices that are required for a specific land disturbing activity.

22. "Person" means any State or federal agency, individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, municipality or other political subdivision of this State, any interstate body or any other legal entity.

23. "Redevelopment" means a land disturbance activity that alters the use of land but does not necessarily alter the predevelopment runoff characteristics.

24. "Responsible Personnel" means a foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a construction project.

25. "Sediment" means soils or other superficial materials transported and/or deposited by the action of wind, water, ice or gravity as a product of erosion.

26. "Sediment and Stormwater Management Plan" means a plan for the control of soil erosion, sedimentation, stormwater quantity, and water quality impacts resulting from any land disturbing activity.

27. "Stabilization" means the prevention of soil erosion by surface runoff or wind through the establishment of a soil cover through the implementation of vegetative or structural measures. Examples include, but are not limited to, straw mulch with temporary or permanent vegetation, wood chips, and stone or gravel ground cover.

28. "State Waters" means any and all waters, public or private, on the surface of the earth which are contained within, flow through or border upon the State or any portion thereof.

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28. "Stormwater" means the runoff of water from the surface of the land resulting from precipitation or snow or ice melt.

29. "Stormwater Management" means:

    A. for water quantity control, a system of vegetative, structural, and other measures that may control the volume and rate of stormwater runoff which may be caused by land disturbing activities or activities upon the land; and

    B. for water quality control, a system of vegetative, structural, and other measures that control adverse effects on water quality that may be caused by land disturbing activities or activities upon the land.

30. "Stormwater Utility" means an administrative organization that has been established for the purposes of funding sediment control, stormwater management or flood control planning, design, construction, maintenance, and overall resource needs by authorized and imposed charges.

31. "Tidewater" means water that alternately rises and falls due to the gravitational attraction of the moon and sun and is under the regulatory authority of Delaware Code, Title 7, Chapter 72. Examples of tidewaters include the Atlantic Ocean, the Delaware Bay, and the Delaware Inland Bays.

32. "Variance" means the modification of the minimum sediment and stormwater management requirements for specific circumstances where strict adherence of the requirements would result in unnecessary hardship and not fulfill the intent of these regulations.

33. "Waiver" means the relinquishment from sediment and stormwater management requirements by the appropriate plan approval authority for a specific development on a case-by-case review basis.

34. "Water Quality" means those characteristics of stormwater runoff from a land disturbing activity that relate to the chemical, physical, biological, or radiological integrity of water.

35. "Water Quantity" means those characteristics of stormwater runoff that relate to the rate and volume of the stormwater runoff to downstream areas resulting from land disturbing activities.

36. "Watershed" means the total or partial drainage area contributing stormwater runoff to a single point.

Section 3 — Exemptions, Waivers, and Variances

1. The following activities are exempt from both sediment control and stormwater management requirements established by these regulations:

    A. Agricultural land management practices, unless the local Conservation District or the Department determines that the land requires a new or updated soil and water conservation plan, and the owner or operator of the land has refused either to apply to a Conservation District for the development of such a plan, or to implement a plan developed by a Conservation District;

    B. Developments or construction that disturb less than 5,000 square feet;

    C. Land development activities which are regulated under specific State or federal laws which provide for managing sediment control and stormwater runoff. An example of this exemption would be specific permits required under the National Pollutant Discharge Elimination System when discharges are a combination of stormwater and industrial or domestic wastewater or which must comply with Parts 122, 123, and 124 of Title 40 of the Code of Federal Regulations. The Department shall ensure that all land developments which are regulated under specific State or federal laws are coordinated with delegated plan approval agencies to ensure compatibility of requirements;

    D. Projects that are emergency in nature and necessary to protect life or property such as bridge, culvert, or pipe repairs and aboveground or underground electric and gas utilities or public utility restoration. The emergency nature of a project may preclude prior plan review and approval, but subsequent inspection may necessitate sediment control or site stabilization in accordance with the provisions of this Chapter. The appropriate plan approval agency shall be notified orally or in writing within 48 hours of the initiation of such emergency activity.

The appropriate plan approval agency shall determine and approve of the emergency nature of a project. If the nature of the emergency will require more than 120 days to accomplish construction, formal approval shall be obtained for sediment control and stormwater management. These activities must still comply with other State, federal, and local requirements.

2. Appropriate Plan Approval Agencies may grant waivers from the stormwater management requirements of these regulations for individual developments provided that a written request is submitted by the applicant containing descriptions, drawings, and any other information that is necessary to evaluate the proposed development. A separate written waiver request shall be required if there are subsequent additions, extensions, or modifications that would alter the approved stormwater runoff characteristics to a development receiving a waiver.

   A. A project may be eligible for a waiver of stormwater management for both quantitative and qualitative control if the applicant can demonstrate that

      (1) The proposed project will return the disturbed area to a predevelopment runoff condition and the predevelopment land use is unchanged at the conclusion of the project; or

      (2) The proposed project consists of a linear disturbance of less than six (6) feet in width; or

      (3) The project is for an individual residential detached unit or agricultural structure, and the total disturbed area of the site is less than one acre; or

      (4) The proposed project is for agricultural structures in locations included in current soil and water conservation plans that have been approved by the appropriate Conservation District.

   B. A project may be eligible for a waiver or variance of stormwater management for water quantity control if the applicant can demonstrate that

      (1) The proposed project will not generate an increase in the 2-year post-development peak discharge rate of more than ten (10) percent above the 2-year predevelopment peak discharge rate and will have no adverse impact on the receiving wetland, watercourse, or waterway; or

      (2) Provisions will be made or exist for a nonerosive conveyance system to tidewater by either a closed drainage system or by open channel flow that has adequate capacity to contain the runoff events being considered as a requirement of these regulations; or

      (3) The location of a project within a watershed would aggravate downstream flooding by the imposition of peak control requirements.

      (4) The plan approval agency may grant a written variance from any requirement of these regulations if there are exceptional circumstances applicable to the site such that strict adherence to the provisions of these regulations will result in unnecessary hardship and not fulfill the intent of these regulations. A written request for variance shall be provided to the plan approval agency and shall state the specific variances sought and the reasons for their granting. The plan approval agency shall not grant a variance unless and until sufficient specific reasons justifying the variance are provided by the applicant.

Section 4 — Departmental Responsibilities

1. The Department is responsible for the implementation and supervision of the sediment and stormwater program established by Chapter 40, Title 7, Delaware Code. This responsibility shall include, but not be limited to, authority for the following actions:

   A. Provide technical and other assistance to Conservation Districts, counties, municipalities, federal, and State agencies in implementing this Chapter;

   B. Develop and publish, as regulation components, minimum standards, guidelines and criteria for delegation of sediment

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and stormwater program components, and model sediment and stormwater ordinances for use by Conservation Districts, counties, State agencies, and municipalities;

C. Review the implementation of all components of the statewide sediment and stormwater management program that have been delegated to either the Conservation Districts, counties, municipalities, or other State agencies in reviews to be accomplished at least once every three years;

D. Require that appropriate sediment and stormwater management provisions be included in all new erosion and sediment control plans developed pursuant to these regulations;

E. Cooperate with appropriate agencies of the United States or other states or any interstate agency with respect to sediment control and stormwater management;

F. Conduct studies and research regarding the causes, effects, and hazards of stormwater and methods to control stormwater runoff;

G. Conduct and supervise educational programs with respect to sediment control and stormwater management;

H. Require the submission to the Department of records and periodic reports by Conservation Districts, tax ditch organizations, county, and municipal agencies as may be necessary to carry out these regulations;

I. Review and approve designated watersheds;

J. Establish a maximum life of three years for the validation of approved plans. These regulations shall specify variances which expand this time limitation in specific situations; and

K. Establish a means of communication, such as a newsletter, so that information regarding program development and implementation can be distributed to interested individuals.

2. Matters of policy, procedures, standards, criteria, approvals, inspection, or enforcement relating to the Sediment and Stormwater Chapter shall be established by the Department subject to the jurisdiction of the Secretary of the Department. Sediment and stormwater programs or portions of programs which are delegated to the Conservation Districts, counties, municipalities, or State agencies shall include sediment and stormwater criteria consistent with the standards, procedures, and regulations of the Department.

   A variation of requirements by the delegated agency on a specific watershed will not be valid unless approved by the Department. All State and federal development in the watershed shall be reviewed subject to the same variations and requirements by the delegated State agency or Department as appropriate.

3. In situations where public notification and comment are required before an action is taken by the Department, the Regulatory Advisory Committee shall have an opportunity to review the proposed Departmental action and provide input to the Department regarding the action.

Section 5 — Criteria for Delegation of Program Elements

1. Conservation Districts, counties, municipalities, and State agencies may seek delegation of four program elements relating to the implementation of the statewide sediment and stormwater program. Delegation may be granted by the Secretary for review and approval of sediment and stormwater management plans, inspection during construction, subsequent maintenance inspection, and education and training. Program elements that are delegated shall be implemented according to Chapter 40 and these regulations.

2. The Secretary, or his designee, shall grant delegation of one or more program elements to any Conservation District, county, municipality, or State agency seeking delegation that is found capable of providing compliance with Chapter 40 and these regulations. The final decision regarding delegation shall be made only after an opportunity has been provided for public review and comment. Initial consideration regarding delegation of program elements shall be given to the Conservation Districts. The Conservation Districts, having unique capabilities and areawide responsibilities are in ideal positions to coordinate and implement local sediment and stormwater programs.

3. Requests for delegation of more than one program element may be accomplished by the submission of one request for all the elements requested. A concern by the Department over one element will not jeopardize delegation of other requested program elements.

4. To be considered capable of providing compliance with Chapter 40 and these regulations, applications for delegation of program elements shall contain the following requisite items.

   A. Requests for delegation of plan approval responsibility shall include the following information:

      (1) Ordinance or program information detailing the plan approval process,

      (2) Plan review check lists and plan submission requirements,

      (3) Sediment and stormwater criteria, including waiver and variance procedures, that meet minimum standards established by these regulations,

      (4) Adequate personnel allocations and expected time frames for plan review which meet the requirements of Section 8(9), and

      (5) Assurance that plan reviewers will attend Departmental training programs in related fields such as wetlands identification, subaqueous permits requirements, etc.

   B. Requests for delegation of inspection during construction shall include the following information:

      (1) Inspection and referral procedures,

      (2) Time frames for inspection of active land disturbing activities,

      (3) Inspection forms,

      (4) Assurance of adequate personnel allocations or a timetable to obtain adequate personnel,

      (5) Criteria for the Certified Construction Reviewer if utilized, and

      (6) Procedures and time frames for processing complaints.

   C. Requests for delegation of maintenance inspection responsibility shall include the following information:

      (1) Inspection and referral procedures,

      (2) Inspection forms,

      (3) Time frames, not exceeding one year, for inspection of completed stormwater management structures, and

      (4) Assurance of adequate personnel allocation or a timetable to obtain adequate personnel.

   D. Requests for delegation of education and training responsibility shall include the following information:

      (1) Types of educational and training activities to be accomplished,

      (2) Frequency of activities,

      (3) Names and backgrounds of those individuals conducting the training, and

      (4) Procedures and timetables to notify the Department of educational programs.

5. A Conservation District, county, municipality, or State agency which has been granted delegation of one or more program elements may establish alternative requirements which are compatible with or are more stringent than Departmental requirements. These alternative requirements may be implemented only when prior Departmental approval has been granted. These alternative requirements shall apply in lieu of the provisions of these regulations in the specific program element that has been delegated. Alternative requirements shall be implemented only after public notice has been provided which would allow for public review and comment prior to Departmental approval.

6. Delegation of authority for one or more program elements may be granted for a maximum time frame of three years. After three years a new application to the Department must be made. Over the time frame for which delegation has been granted, the Department will evaluate delegation implementation, coordinate review findings with the delegated authority, and determine if the new delegation should be granted.

7. A Conservation District, county, municipality, or State agency requesting or renewing delegation shall submit a written request to the Secretary on or before January 1 of the year immediately preceding the fiscal year for which delegation or renewal of delegation is sought.

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8. The Secretary shall, in writing, grant or deny delegation on or before April 1 of the year during which delegation is sought. The Secretary may not deny a requested delegation unless opportunity has been afforded to the appropriate officials to present arguments. Delegation shall be effective July 1 of that year and extend no more than three years, unless renewed. In the event that the Department does not act on the renewal request by April 1, the delegated authority submitting the request would be entitled to continue operating for a subsequent three year time period unless action is taken by the Department to suspend the program.

9. If the Secretary determines that a delegated program falls below acceptable standards established by these regulations, delegation may be suspended after opportunity is afforded for a hearing. During a period of suspension, the program element shall revert to the Department for implementation. Funds set aside by a delegated agency, that were collected through fees established by the plan approval agency, shall be transferred to the Department for use if delegation is suspended.

10. A delegated authority may subdelegate program elements, with Departmental concurrence, to a stormwater utility or other responsible entity or agency.

11. The Department shall maintain, and make available upon request, a listing of the current status of delegation for all jurisdictions within the State.

Section 6 — Permit Fees, Maintenance Fees, and Performance Bonds

1. The establishment of permit fees, not involving stormwater utilities, shall be in accordance with the following items:

   A. Delegation of program elements will depend, to a large extent, on funding and personnel commitments. If the delegated jurisdiction has a source of funding that is provided through State General or local revenues, then the implementation of the delegated component will not necessitate the imposition of a permit fee to cover the cost of the delegated program component.

   B. In the event that one component of an overall sediment and stormwater management program is not funded through the use of general or special funds, a non-refundable permit fee will be collected at the time that the sediment and stormwater management plan or application for waiver or variance is submitted or approved. The permit fee will provide for the unfunded costs of plan review, administration and management of the permitting office, construction review, maintenance inspection, and education and training. The plan review or permit approval agency, whether delegated or the Department, shall be responsible for the collection of the permit fee.

   Unless all program elements in a county or municipality have been delegated to a single agency, the funds collected not supporting the plan review function shall be distributed to the appropriate agencies.

   C. The number of needed personnel and the direct and indirect expenses associated with those personnel shall be developed by the agencies requesting delegation in a specific jurisdiction in conjunction with and with the concurrence of the Department. Those expenses will then form the basis for determining unit plan approval costs.

   D. Prior to plan approval, a fee may be assessed by the appropriate plan approval agency for those activities approved prior to July 1, 1991, for which construction will initiate after July 1, 1991.

   E. Where the Department becomes the designated plan approval agency, the Department may assess a plan review and construction review fee. That fee shall not exceed $80.00 per disturbed acre per project.

   F. The use of Certified Construction Reviewers for sediment control and the submission of "As Built or Record Document" certification regarding stormwater management construction may reduce the inspection requirements for the delegated agency but may not eliminate that inspection requirement. Periodic overview inspections will still be necessary to ensure construction management.

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2. The imposition of a financial guarantee, based on existing local authority, may be required by the plan approval agency to ensure that construction of the stormwater management practices was accomplished according to the approved sediment and stormwater management plan. The developer, when required, shall submit to the plan approval agency a surety or cash bond, or irrevocable letter of credit prior to the issuance of any building or grading permit for construction of any land disturbing activity that requires a stormwater management facility. The amount of the security shall not exceed 150 percent of the total estimated construction cost of the stormwater management facility. The financial guarantee so required shall include provisions relative to forfeiture for failure to complete work specified in the approved stormwater management plan, compliance with all the provisions of these regulations, and other applicable laws and regulations, and any time limitations. The financial guarantee, fully or partially, shall not be released without a final inspection of the completed work and, when required, after submission of "As Built or Record Document" plans, and after written confirmation by the design engineer that construction was accomplished according to the approved plans. A partial release of the financial guarantee shall be allowed only to the extent that the work already accomplished would warrant such release.

3. A maintenance fee may be required on approvals granted for stormwater management structures that will be maintained by a Conservation District, county, or municipality. A fee mechanism shall be established prior to the final release of any required financial guarantee or final approval of the completed stormwater management structure by the designated construction review agency.

Section 7—Criteria for Implementation of a Stormwater Utility

The implementation of a stormwater utility will necessitate the development of a local utility ordinance prior to its implementation. There are essential components that an ordinance must contain to function as a funding mechanism for stormwater management and those components shall include, but not be limited to, the following items:

1. The financing of a stormwater utility with a user charge system must be reasonable and equitable so that each user of the stormwater system pays to the extent to which the user contributes to the need for the stormwater system, and that the charges bear a substantial relationship to the cost of the service. The use of county and municipal taxpayer rolls and accounting systems are allowed for the assessment and collection of fees.

2. The intent of the utility must be clearly defined regarding program components that are to be funded through the utility. Those components may include but not be limited to the following activities:

   A. Preparation of long range watershed master plans for stormwater management,

   B. Annual inspections of all stormwater management facilities, both public and private,

   C. Undertaking regular maintenance, through contracting or other means, of stormwater management structures that have been accepted for maintenance,

   D. Plan review and inspection of sediment control and stormwater management plans and practices, and

   E. Retrofitting designated watersheds, through contracting or other means, to reduce existing flooding problems or to improve water quality.

3. The authority for the creation of the stormwater utility and the imposition of charges to finance sediment and stormwater activities is conferred in Chapter 40, Title 7, Delaware Code. The application of a stormwater utility by means of a local ordinance shall not be deemed a limitation or repeal of any other powers granted by State statute.

4. The creation of a stormwater utility shall include the following components:

   A. The boundaries of the utility, such as watersheds or jurisdictional boundaries as identified by the local governing body,

   B. The creation of a management entity,

   C. Identification of stormwater problems,

   D. Method for determining utility charges,

E. Procedures for investment and reinvestment of funds collected, and

F. An appeals or petition process.

5. As established by local ordinance, the local governing agency shall have responsibility for implementing all aspects of the utility including long range planning, plan implementation, capital improvements, maintenance of stormwater facilities, determination of charges, billing, and hearing of appeals and petitions. The local agency also will have responsibility for providing staff support for utility implementation.

   In the event that an agency or department other than the one in which the utility is located is best equipped to undertake a particular task, the local governing agency shall ensure that appropriate interagency charges are determined such that all costs of stormwater management are reflected in the utility budget and that utility charges finance all aspects of stormwater management.

6. With respect to new stormwater management facilities constructed by private developers, the local governing agency shall develop criteria for use in determining whether these will be maintained by the utility or by the facility owner. Such criteria may include whether the facility has been designed primarily to serve residential users and whether it has been designed primarily for purposes of stormwater management. In situations where it is determined that public maintenance is not preferable, standards shall be developed to ensure that inspection of facilities occurs annually and that facilities are maintained as needed.

7. The use of charges is limited to those purposes for which the utility has been established, including but not limited to: planning; acquisition of interests in land including easements; design and construction of facilities; maintenance of the stormwater system; billing and administration; and water quantity and water quality management, including monitoring, surveillance, private maintenance inspection, construction inspection, and other activities which are reasonably required.

Section 8 — Permit Application and Approval Process

1. After July 1, 1991, unless a particular activity is exempted by these regulations, a person may not disturb land without an approved sediment and stormwater management plan from the appropriate plan approval agency. A grading or building permit may not be issued for a property unless a sediment and stormwater management plan has been approved that is consistent with the following items:

   A. Chapter 40, Title 7, Delaware Code, relating to erosion and sediment control and stormwater management, and

   B. These regulations, or duly adopted county or municipal ordinances that are adopted as a part of the delegation process and relate to the intent of these regulations.

2. A sediment and stormwater management plan or an application for a waiver shall be submitted to the appropriate plan approval agency by the developer for review and approval for a land disturbing activity, unless otherwise exempted. The sediment and stormwater management plan shall contain supporting computations, drawings, and sufficient information describing the manner, location, and type of measures in which stormwater runoff will be managed from the entire development. The appropriate plan approval agency shall review the plan to determine compliance with the requirements of these regulations prior to approval. The approved sediment and stormwater management plan shall serve as the basis for water quantity and water quality control on all subsequent construction.

3. The sediment and stormwater management plan shall not be considered approved without the inclusion of an approval stamp with signature and date, on the plans by the appropriate plan approval agency.

4. All sediment and stormwater management plans submitted for approval shall contain certification by the owner or developer that clearing, grading, construction, or development will be accomplished pursuant to the plan and that responsible personnel involved in the land disturbance will have a Certification of Training at a Departmental sponsored or approved training program for the control of erosion and sediment control before initiation of the project. The Certification of Training for responsible personnel requirement may be waived by the appropriate plan ap-

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proval agency on any project involving silviculture or fewer than four residential homes.

5. All sediment and stormwater management plans shall contain certification by the owner or developer of the right of the Department or delegated inspection agency to conduct onsite inspections.

6. A grading or building permit issued by a local jurisdiction may be suspended or revoked after written notice is given to the permittee by the responsible delegated agency or the Department for any of the following reasons:

   A. Violations of the conditions of the sediment and stormwater management plan approval;

   B. Changes in site runoff characteristics upon which a waiver was granted;

   C. Construction not in accordance with the approved plans;

   D. Noncompliance with correction notice or stop work order issued for the construction of the sediment control practices or the stormwater management facilities;

   E. An immediate danger exists in a downstream area in the opinion of the appropriate plan approval or inspection agency, or the Department; or

   F. Failure to submit stormwater management "As Built or Record Document" plans, when required, at the completion of the project.

7. Approved plans remain valid for 3 years from the date of an approval, unless specifically extended or renewed by the appropriate plan approval agency. The basis for extension or renewal may include, but not limited to, the following items:

   A. Failure to initiate the approved project for reasons acceptable to the appropriate plan approval agency such as funding or other agency permit delays; or

   B. Time duration for a type of activity that typically exceeds three years.

8. Projects which have been approved prior to July 1, 1991, and where site clearing has not been initiated on the project within two years, shall be resubmitted to the appropriate plan approval agency for review and approval subject to the requirements of these regulations.

9. Upon receipt of a completed application for sediment and stormwater management, the appropriate plan approval agency shall accomplish its review within 30 calendar days, and have either the approval or review comments transmitted to the applicant. If that 30 day time frame cannot be met, the appropriate plan approval agency shall notify the applicant of the reasons for delay, and an expected time frame not to exceed an additional 30 days, when that review will be accomplished.

Section 9 — Criteria for Designated Watersheds

The concept of designated watersheds is intended, not only to prevent existing water quantity and water quality problems from getting worse, but also to reduce existing flooding problems and to improve existing water quality or meet State Water Quality Standards in selected watersheds. Criteria is established for designated watersheds and that criteria will depend on whether the specific problems of the watershed are water quantity or water quality oriented. Water quantity and water quality concerns will be considered in all designated watersheds, but the overall emphasis for each designated watershed will depend on its existing and anticipated problems.

1. To initiate consideration of a watershed for Designated Watershed or Subwatershed status, a watershed shall be recommended by a Conservation District, county, municipality, or State agency, to the Department. Upon recommendation to the Department, all involved agencies at the local level will be contacted and their input received prior to any watershed study being initiated.

2. Included with the recommendation of a watershed for Designated Watershed or Subwatershed status to the Department shall be an identification of the specific problems that exist in the watershed so that the pursuit of a watershed study is warranted. Inclusion in these regulations as a Designated Watershed or Subwatershed requires approval by the Department that a significant water quantity or water quality problem exists that would necessitate this joint State, District, and local government involvement. Also, inclusion of a watershed as a Designated Watershed or Subwatershed will necessitate a public hearing

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process. The process of problem identification shall be based on the following information:

A. To initiate a watershed study based on water quality considerations the following information must be submitted:

(1) Existing water quality data that has been collected as a result of the overall statewide water quality inventory process, or

(2) Other water quality data collected through specific sampling that was accomplished in the watershed, or

(3) Submission of a water quality assessment that was accomplished using a qualitative collection method of benthic macroinvertebrates.

B. To initiate a watershed study based on flooding or water quantity considerations the following information must be submitted:

(1) Estimated annual flood damage to either private, residential, commercial, industrial, or public properties, or

(2) Number of residences or industries in the floodplain, or

(3) The history of flooding in the watershed, or

(4) Measures already taken to minimize or reduce flooding, or

(5) Dangers to public health and welfare.

3. Upon modification of these regulations to include a watershed as a Designated Watershed or Subwatershed an advisory group will be established that will guide the overall watershed study. The advisory group will be appointed by the Secretary and will include State, District, and local representatives in addition to representatives of the regulated community and others affected by the results of the study.

4. The general components contained in the actual watershed studies shall be the following items:

A. Stormwater quantity or water quality problem identification,

B. The overall needs of the watershed including the additional impacts of new development activities,

C. Alternative approaches to address the existing and future problems,

D. A selected approach that includes the overall costs and benefits,

E. Schedule for implementation,

F. Funding sources that are available for the actual implementation of study recommendations, and

G. A public hearing process prior to final Departmental approval.

5. The following goals are to be obtained through the implementation of the Designated Watershed or Subwatershed program:

A. Reduction of existing flooding or water quality impacts,

B. Prevention of future flooding or water quality impacts, and

C. Minimization of economic and social losses.

6. Specific plan components of a water quality watershed study shall include, but not be limited to, the following items:

A. The limits of the watershed,

B. An inventory of existing water quality data,

C. An inventory of areas having significant natural resource value as defined in existing State or local studies as they may be impacted by the construction or location of stormwater control structures,

D. An inventory of areas of historical and archaeological value identified in existing State or local studies as they may be impacted by the construction or location of stormwater control structures,

E. A map or series of maps of the watershed showing the following information:

(1) Watershed topography,

(2) Significant geologic formations,

(3) Soils information,

(4) Existing land use based on existing zoning,

(5) Proposed land use based on expected zoning or comprehensive plans,

(6) Location of tidal and nontidal wetlands, and

(7) Locations where water quality data were obtained.

F. An evaluation of water quantity concerns so that flooding does not become a problem in the watershed.

7. Specific components of a water quantity based study shall include, but not be limited to, the following items:

A. The limits of the watershed,

B. An inventory of historic flood damage sites, including frequency and damage estimates,

C. An inventory of areas of significant natural resource value as noted in existing State and local studies as they may be impacted by the construction or location of stormwater control structures,

D. An inventory of areas of historical and archaeological value identified in existing State and local studies as they may be impacted by the construction or location of stormwater control structures,

E. A map or series of maps of the watershed showing the following information:

(1) Watershed topography,

(2) Soils information,

(3) Existing land use based on existing zoning,

(4) Proposed land use based on expected zoning or comprehensive plans,

(5) Locations of tidal and nontidal wetlands,

(6) Locations of existing flooding problems including floor and corner elevations of structures already impacted, and

(7) 100-year floodplain delineations, water surface profiles, and storm hydrographs at selected watershed location.

F. An evaluation of water quality concerns so that water quality degradation does not become a problem in the watershed.

8. The initiation of studies for Designated Watersheds or Subwatersheds depends on the availability of funding for the study. Once a watershed has been designated, the Department will make every effort to secure funding through federal, State, or local means.

9. The Department is designated as the agency responsible for administering designated watershed or subwatershed studies with the advice of the advisory group appointed by the Secretary. Recommendations based on the results of the watershed study will only be made with the overall consent of the advisory group.

10. The formal results of the Designated Watershed or Subwatershed study will require formal acceptance by the local Conservation District Board of Supervisors and the local governing body of the appropriate county or municipality.

11. Implementation of the results of the Designated Watershed or Subwatershed study will necessitate the development and implementation of a dedicated funding source such as a stormwater utility to ensure design, construction, and maintenance of needed structures is accomplished.

12. Those watersheds or subwatersheds designated due to existing water quantity or water quality problems include the following:

A. Dover/Silver Lake/St. Jones River and all drainage areas upstream of the Silver Lake dam.

Section 10 — Specific Design Criteria and Minimum Standards and Specifications

1. General submission requirements for all projects requiring sediment and stormwater management approval include the following information:

A. A standard application form,

B. A vicinity map indicating north arrow, scale, and other information necessary to locate the property or tax parcel,

C. A plan at an appropriate scale accompanied by a design report and indicating at least:

(1) Name and address of

(a) The owner of the property where the project is proposed;

(b) The land developer; and

(c) The applicant.

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(2) The existing and proposed topography, as required on a case-by-case basis.

(3) The proposed grading and earth disturbance including:

(a) Surface area involved; and

(b) Limits of grading including limitation of mass clearing and grading whenever possible.

(4) Stormwater management and stormwater drainage computations, including:

(a) Pre- and postdevelopment velocities, peak rates of discharge, and inflow and outflow hydrographs of stormwater runoff at all existing and proposed points of discharge from the site,

(b) Site conditions around points of all surface water discharge including vegetation and method of flow conveyance from the land disturbing activity, and

(c) Design details for structural controls.

(5) Erosion, sediment control, and stormwater management provisions including:

(a) Provisions to preserve top soil and limit disturbance;

(b) Details of site grading, and;

(c) Design details for structural controls which includes diversions and swales.

D. Federal Emergency Management Agency flood maps and federal and State protected wetlands, where appropriate.

E. The appropriate plan approval agency shall require that plans and design reports be sealed by a qualified design professional that the plans have been designed in accordance with approved sediment and stormwater ordinances, regulations, standards and criteria. The appropriate plan approval agency may waive this requirement on a case-by-case basis.

F. Additional information necessary for a complete project review may be required by the appropriate plan approval agency as deemed appropriate. This additional information may include items such as public sewers, water lines, septic fields, wells, etc.

2. Specific requirements for the erosion and sediment control portion of the sediment and stormwater management plan approval process include, but are not limited to, the following items. The appropriate plan approval agency may modify the following items for a specific project or type of project. Modification for a specific type of project will require the concurrence of the Department before that modification may be applied and that modification shall be subject to public review and comment prior to adoption.

A. All plans shall include details of temporary and permanent stabilization measures including placement of the following statement on all plans submitted for approval. Following soil disturbance or redisturbance, permanent or temporary stabilization shall be completed within 14 calendar days as to the surface of all perimeter sediment controls, topsoil stockpiles, and all other disturbed or graded areas on the project site.

These requirements do not apply to those areas which are shown on the plan and are currently being used for material storage, or for those areas on which actual earth moving activities are currently being performed.

B. All erosion and sediment control plans shall comply with the Delaware Erosion and Sediment Control Handbook, dated 1989 and approved supplements. The supplements shall be subject to public review and comment prior to their incorporation in the Erosion and Sediment Control Handbook.

C. A sequence of construction shall be contained on all plans describing the relationship between the implementation and maintenance of sediment controls, including permanent and temporary stabilization and the various stages or phases of earth disturbance and construction. The sequence of construction shall, at a minimum, include the following activities:

(1) Clearing and grubbing for those areas necessary for installation of perimeter controls;

(2) Construction of perimeter controls;

(3) Remaining clearing and grubbing;

(4) Road grading;

(5) Grading for the remainder of the site;

(6) Utility installation and whether storm drains will be used or blocked until after completion of construction;

(7) Final grading, landscaping, or stabilization; and

(8) Removal of sediment controls.

D. The plans shall contain a description of the predominant soil types on the site, as described by the appropriate soil survey information available through the local Conservation District.

E. Unless an exception is approved on a case-by-case basis or an exception is approved for a specific type of activity by the appropriate plan approval agency, not more than 20 acres may be cleared at any one time. Once grading is initiated in one 20-acre section, a second 20-acre section may have stumps, roots, brush, and organic material removed. This will necessitate the phasing of construction on sites in excess of 20 acres to minimize areas exposed of ground cover and reduce erosion rates. Grading of the second 20-acre section may not proceed until temporary or permanent stabilization of the first 20-acre section is accomplished.

3. Specific requirements for the permanent stormwater management portion of the sediment and stormwater management plan approval process include, but are not limited to, the following items. The appropriate plan approval agency may modify the following items for a specific project or type of project. Modification for a specific type of project will require the concurrence of the Department before the modification may be applied and the modification for a type of project shall be subject to public review and comment.

A. It is the overall goal of the Department to address stormwater management on a watershed by watershed basis to provide a cost effective water quantity and water quality solution to the specific watershed problems. These regulations will provide general design requirements that must be adhered to in the absence of Designated Watershed or Subwatershed specific criteria.

B. All hydrologic computations shall be accomplished using the most recent USDA Soil Conservation Service Technical Releases 20 or 55. The storm duration for computational purposes shall be the 24-hour rainfall event. For projects south of the Chesapeake and Delaware Canal, the Delmarva Unit Hydrograph shall be incorporated into the design procedure.

C. Stormwater management requirements for a specific project shall be based on the entire area to be developed, or if phased, the initial submittal shall control that area proposed in the initial phase and establish a procedure and obligation for total site control.

D. Water quantity control is an integral component of overall stormwater management. Control of peak discharges will, to some extent, prevent increases in flooding. The following design criteria for peak flow control is established for water quantity control purposes, unless a waiver is granted based on a case-by-case basis:

(1) Projects in New Castle County that are located north of the Chesapeake and Delaware Canal shall not exceed the post-development peak discharge for the 2, 10, and 100-year frequency storm events at the pre-development peak discharge rates for the 2, 10, and 100-year frequency storm events.

(2) Projects in New Castle County that are located south of the Chesapeake and Delaware Canal, Kent County, and Sussex County shall not exceed the postdevelopment peak discharge for the 2 and 10-year frequency storm events at the predevelopment peak discharge rates for the 2 and 10-year frequency storm events.

(3) Watersheds, other than Designated Watersheds or Subwatersheds, that have well documented water quantity problems may have more stringent, or modified, design criteria that is responsive to the specific needs of that watershed. Modified criteria for that watershed must receive Departmental approval, and all projects reviewed and approved by the appropriate plan approval agency shall

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meet or exceed the modified criteria. Proposed modification of criteria for a watershed shall be subject to public review and comment prior to implementation.

E. Water quality control is also an integral component of stormwater management. Control of water quality on-site will prevent further degradation of downstream water quality. The following design criteria are established for water quality protection unless a waiver or variance is granted on a case-by-case basis.

   (1) In general, the preferred option for water quality protection shall be ponds. Ponds having a permanent pool of water must be considered before a pond having no permanent pool. Infiltration practices shall be considered only after ponds have been eliminated for engineering or hardship reasons as approved by the appropriate plan approval agency.

   (2) Water quality ponds having a permanent pool shall be designed to release the first 1/2 inch of runoff from the site over a 24-hour period. The storage volume of the normal pool shall be designed to accommodate, at least, 1/2 inch of runoff from the entire site.

   (3) Water quality ponds, not having a normal pool, shall be designed to release the first inch of runoff from the site over a 24-hour period.

   (4) Infiltration practices, when used, shall be designed to accept, at least, the first inch of runoff from all streets, roadways, and parking lots.

   (5) Other practices may be acceptable to the appropriate plan approval agency if they achieve an equivalent removal efficiency of 80 percent for suspended solids.

F. All ponds that are constructed for stormwater management shall be designed and constructed in accordance with the USDA Soil Conservation Service Small Pond Code 378, dated September 1990, as approved for use in Delaware.

G. Any pond utilized for water supply purposes, or for irrigation, must obtain approval from the Department for that use pursuant to Chapter 60.

H. Where ponds are the proposed method of control, the developer shall submit to the approving agency, when required, an analysis of the impacts of stormwater flows downstream in the watershed for the 100-year frequency storm event.

   The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development, with and without the pond, on downstream dams, highways, structures, or natural points of constricted streamflows past which the timing effects would be considered negligible. The results of the analysis will determine the need to modify the pond design or to eliminate the pond requirement. Lacking a clearly defined downstream point of constriction, the downstream impacts shall be established, with the concurrence of the approving agency, downstream of a tributary of the following size:

   (1) The first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

   (2) The first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

I. Where existing wetlands are intended as a component of an overall stormwater management system, the following criteria shall apply:

   (1) The only disturbance to the wetland, for the purposes of these regulations, shall be that disturbance caused by the stormwater management pond embankment placement and construction; or

   (2) The applicant can demonstrate that the intended or functional aspects of the stormwater management facility and wetlands are maintained or enhanced, or the construction in the wetland for stormwater management is the only reasonable alternative.

   (3) All other necessary State and federal permits can be obtained.

J. Designs shall be in accordance with standards developed or approved by the

Department, which are subject to public review and comment.

K. Ease of maintenance must be considered as a site design component. Access to the stormwater management structure must be provided for in the design, and land area adjacent to the structure must be set aside for disposal of sediments removed from the structure when maintenance is performed. The land set aside for pond maintenance shall be sized as follows:

(1) The set aside area shall accommodate at least 2 percent of the stormwater management basin volume to the elevation of the 2-year storage volume elevation;

(2) The maximum depth of the set aside volume shall be one foot;

(3) The slope of the set aside area shall not exceed 5 percent; and

(4) The area and slope of the set aside area may be modified if an alternative area or method of disposal is approved by the appropriate plan approval agency.

L. A clear statement of defined maintenance responsibility shall be established during the plan review and approval process.

M. All ponds shall have a forebay or other design feature to act as a sediment trap. A reverse slope bench must be provided one foot above the normal pool elevation for safety purposes and all embankment ponds, having a normal pool, shall have a drain installed to facilitate maintenance.

N. The use of infiltration practices for the disposal of stormwater runoff is classified by the U.S. EPA as an underground injection control practice, class V injection well. The appropriate plan approval agency shall forward a copy of all such approvals and the results of all construction inspections to the Department's Underground Injection Control program manager.

O. Infiltration practices have certain limitations on their use on certain sites. These limitations include the following items:

(1) Areas draining to these practices must be stabilized and vegetative filters established prior to runoff entering the system. Infiltration practices shall not be used if a suspended solids filter system does not accompany the practice. If vegetation is the intended filter, there shall be, at least, a 20-foot length of vegetative filter prior to stormwater runoff entering the infiltration practice;

(2) The bottom of the infiltration practice shall be at least three feet above the seasonal high water table, whether perched or regional, determined by direct piezometer measurements which can be demonstrated to be representative of the maximum height of the water table on an annual basis during years of normal precipitation, or by the depth in the soil at which mottling first occurs;

(3) The infiltration practice shall be designed to completely drain of water within 48 hours.

(4) Soils must have adequate permeability to allow water to infiltrate. Infiltration practices are limited to soils having an infiltration rate of at least 1.02 inches per hour.

Initial consideration will be based on a review of the appropriate soil survey, and the survey may serve as a basis for rejection. On-site soil borings and textural classifications must be accomplished to verify the actual site and seasonal high water table conditions when infiltration is to be utilized.

(5) Infiltration practices greater than three feet deep shall be located at least 20 feet from basement walls;

(6) Infiltration practices designed to handle runoff from impervious parking lots or driveways shall be a minimum of 150 feet from any public or private water supply well;

(7) The design of an infiltration practice shall provide an overflow system with measures to provide a nonerosive velocity of flow along its length and at the outfall; and

(8) The slope of the bottom of the infiltration practice shall not exceed 5 percent. Also, the practice shall not be installed in fill material as piping

along the fill/natural ground interface may cause slope failure.

(9) Unless allowed on a specific project, infiltration practices will be used primarily for water quality enhancement only.

(10) An infiltration practice shall not be installed on or atop a slope whose natural angle of incline exceeds 20 percent.

P. A regional approach to stormwater management is an acceptable alternative to site specific requirements. As a substitute control practice, regional stormwater management structures shall be required to meet the following items:

(1) They shall have a contributory drainage area not in excess of 400 acres unless, on a case-by-case basis, a larger drainage area is approved by the appropriate plan approval agency;

(2) They shall have a permanent pool of water and provide for 24-hour detention of the first inch of stormwater runoff from the entire upstream watershed; and

(3) All other necessary approvals have been obtained that could be cause for site rejection.

Q. The predevelopment peak discharge rate shall be computed assuming that all land uses in the site to be developed are in good hydrologic condition.

Section 11 — General Permit Criteria

1. A general permit involves completion and submission of a form by a land owner, developer, or agent to the appropriate plan approval agency for signature. The minimum criteria for the form will be developed by the Department, and may be expanded upon by the appropriate plan approval agency. The form will contain standard conditions for erosion and sediment control that must be implemented on sites where a specific control plan is not required. The appropriate plan approval agency shall approve general permit requests within 5 calendar days of receipt.

2. The inclusion of an activity into the general permit classification does not relinquish that activity from the requirements of Chapter 40. Rather, the general permit precludes that activity from the necessity of a specific plan review for each individual project.

3. Approval of a general permit does not relieve the applicant from the conditions that are a part of the general permit approval regarding the implementation of control practices as required by the general permit. Failure to implement control practices pursuant to conditions included in the general permit may necessitate appropriate enforcement action as provided in Chapter 40 and these regulations.

4. Those activities eligible for general permits include the following:

   A. Individual detached residential home or agricultural structure construction where the disturbed area for construction will be less than one acre in size. Two or more contiguous lots being developed concurrently by the same land developer will not be eligible for the general permit.

   B. Forest harvest operations.

   C. Highway shoulder and side swale maintenance.

   D. The repair, maintenance, and installation of above and underground utilities.

   E. Commercial and industrial projects for erosion and sediment control only when the total disturbed area of the project is less than 1/2 acre in size.

   F. Modification or reconstruction of a tax ditch by a tax ditch organization when that tax ditch is not intended to serve new development, and which will not increase water quantity or adversely impact water quality, or change points of discharge so as to adversely affect the waters of the State.

5. The appropriate plan approval agency may place more restrictive conditions upon the general permits approval including the requirement for site specific plans for any general permits category. The imposition of more specific requirements for categories of projects shall be approved by the Department, and shall be subject to public review and comment prior to their imposition.

Section 12 — Certified Construction Reviewer Requirements

1. Projects reviewed and approved by the Department for sediment control and stormwater management, in general, shall have a certified construction reviewer when the disturbed area of the project is in excess of 50 acres. In addition any project, regardless of its size, may be required by the Department, or the appropriate plan approval agency, to have a certified construction reviewer on a case-by-case basis.

2. The Department or the appropriate inspection agency may require that any project, already under construction, have on site a certified construction reviewer if, on that project, significant sediment control or stormwater management problems necessitate more frequent inspections.

3. The certified construction reviewer shall function under the direction of a registered professional engineer licensed to practice engineering in the State of Delaware.

4. Individuals designated as certified construction reviewers shall attend and pass a Departmental sponsored or approved construction review training course. The course content will contain, at a minimum, information regarding the following items:

   A. Basic hydrology and hydraulics;

   B. Soils information including texture, limitations, erodibility, and classifications;

   C. Types of vegetation, growing times, and suitability;

   D. Erosion, sediment control, and stormwater management practices;

   E. Inspection and problem referral procedures;

   F. Aspects of State law, regulations, local ordinances, and approval procedures; and

   G. Sediment and stormwater management plan content.

5. The time frame for certification shall not exceed five years unless extended by the Department.

6. The responsibility of the certified construction reviewer will be to ensure the adequacy of construction pursuant to the approved sediment and stormwater management plan.

7. The certified construction reviewer shall be responsible for the following items:

   A. Provision of a construction review of active construction sites on at least a weekly basis;

   B. Within five calendar days, informing the person engaged in the land disturbing activity, and the contractor, by a written construction review report of any violations of the approved plan or inadequacies of the plan. The plan approval agency shall be informed, if the approved plan is inadequate, within five working days. In addition, the appropriate construction review agency shall receive copies of all construction review reports; and

   C. Referral of the project through the delegated inspection agency to the Department for appropriate enforcement action if the person engaged in the land disturbing activity fails to address the items contained in the written construction review report. Verbal notice shall be made to the Department within two working days and written notice shall be provided to the Department within five working days.

8. If the Secretary or his designee determines that a certified construction reviewer is not providing adequate site control or is not referring problem situations to the Department, the Secretary or his designee may suspend or revoke the certification of the construction reviewer.

9. In any situation where a certified construction reviewer's approval is being suspended or revoked, an opportunity for hearing before the Secretary or his designee shall be provided. During any suspension or revocation, the certified construction reviewer shall not be allowed to provide construction reviews pursuant to these regulations. The minimum time of suspension or revocation shall be 6 months.

Section 13 — Contractor Certification Program

1. The Department shall require certification of responsible personnel for any foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a

construction project. Responsible personnel are not required on any project involving silviculture or fewer than four residential homes. Responsible personnel shall obtain certification by completing a Department sponsored or approved training program. Enrollment of existing and future responsible personnel is the responsibility of employers. Response to a Department notice of training and certification in accordance with the provisions of item 3 of this section shall serve as an application for training. The Department shall notify employers of responsible personnel as to the date and location of training programs for attendance by responsible personnel and other interested persons.

2. After July 1, 1991, any applicant seeking sediment and stormwater plan approval shall certify to the appropriate plan approval agency that all responsible personnel involved in the construction project will have a certificate of attendance at a Departmental sponsored or approved training course for the control of sediment and stormwater before initiation of any land disturbing activity. The certificate of attendance shall be valid until the Department notifies the individual or announces in local newspapers that recertification is required due to a change in course content.

3. After July 1, 1991, employers of responsible personnel may receive interim certification for responsible personnel during the period before attendance at a Departmental sponsored or approved training course by submitting an enrollment form to the Department. Interim certification shall be valid until the scheduled date of attendance for training of responsible personnel. These enrollment forms are available from the Department and the Conservation Districts.

Section 14 — Construction Review and Enforcement Requirements

1. The land developer shall request, at least 24 hours ahead of time, that the appropriate inspection agency approve work completed at the stages of construction outlined in the sequence of construction contained on the approved plans. Any portion of the work which does not comply will be promptly corrected by the developer after written notice by the appropriate inspection agency. The notice shall set forth the nature of corrections required and the time frame within which corrections must be made.

2. The land developer shall notify the appropriate inspection agency before initiation of construction and upon project completion when a final inspection will be conducted to ensure compliance with the approved sediment and stormwater management plan.

3. The responsible inspection agency shall, for inspection purposes, do all of the following items:
   - A. Ensure that the approved sediment and stormwater management plans are on the project site and are complied with;
   - B. Ensure that every active site is inspected for compliance with the approved plan on a regular basis;
   - C. Prepare and leave on site, or forward to the contractor, a written report after every inspection that describes:
     - (1) The date and location of the site inspection;
     - (2) Whether the approved plan has been properly implemented and maintained;
     - (3) Approved plan or practice deficiencies; and
     - (4) The action taken.
   - D. Notification of on-site personnel or the owner/developer in writing when violations are observed, describing the
     - (1) Nature of the violation;
     - (2) Required corrective action; and
     - (3) Time period for violation correction.

4. The Department may investigate complaints or refer any complaint received to the local inspection agency if the activity is located in a jurisdiction that has received delegation of sediment and stormwater management inspection. In conjunction with a referral, the Department may also initiate an on-site investigation after notification of the local inspection agency in order to properly evaluate the complaint. The Department shall take enforcement action when appropriate, and notify the local inspection agency in a timely manner of any enforcement actions taken.

5. The Department, at its discretion and upon notification to either the owner, developer, or contractor, may visit any site to determine the

adequacy of sediment and stormwater management practices. In the event that the Department conducts site inspections, the appropriate inspection agency shall be notified prior to the initiation of any enforcement action. The appropriate inspection agency shall establish a time frame to obtain site compliance. This notification shall, in no way limit the right to the Department to take action subsequent to any provision of these regulations or Chapter. Formal procedures for interaction between the Department and the appropriate inspection agency on site inspection and referral will be developed on an individual basis.

6. The appropriate plan approval agency may require a revision to the approved plans as necessary due to differing site conditions. The appropriate plan approval agency shall establish guidelines to facilitate the processing of revised plans where field conditions necessitate plan modification. Where changes to the approved plan are necessary those changes shall be in accordance to the following:

   A. Major changes to approved sediment and stormwater management plans, such as the addition or deletion of a sediment basin, shall be submitted by the owner/developer to the appropriate plan approval agency for review and approval.

   B. Minor changes to sediment and stormwater management plans may be made in the field if approved by the construction reviewer and documented in the field review report. The appropriate inspection agency shall develop a list of allowable field modifications for use by the construction reviewer.

7. Stormwater management construction shall have inspections accomplished at the following stages:

   A. Infiltration practices shall be inspected at the commencement, during, and upon completion of construction;

   B. All ponds shall be inspected at the following stages:

      (1) Upon completion of excavation to sub-foundation and where required, installation of structural supports or reinforcement for structures, including, but not limited to

         (a) Core trenches for structural embankments,

         (b) Inlet-outlet structures and anti-seep structures, watertight connectors on pipes, and

         (c) Trenches for enclosed storm drainage facilities.

      (2) During placement of structural fill, concrete, and installation of piping and catch basins;

      (3) During backfill of foundations and trenches;

      (4) During embankment construction; and

      (5) Upon completion of final grading and establishment of permanent vegetation.

8. The agency responsible for construction review may, in addition to local enforcement options, refer a site violation to the Department for additional enforcement action.

9. Referral of a site violation to the Department may initiate a Departmental construction review of the site to verify site conditions. That construction review may result in the following actions:

   A. Notification through appropriate means to the person engaged in a land disturbing activity and the contractor to comply with the approved plan within a specified time frame; and

   B. Notification of plan inadequacy, with a time frame for the person engaged in a land disturbing activity to submit a revised sediment and stormwater plan to the appropriate plan approval agency and to receive its approval with respect thereto.

   The Department shall notify the local inspection agency in a timely manner of what enforcement action is taken on the site.

10. Failure of the person engaged in the land disturbing activity or the contractor to comply with Departmental requirements may result in the following actions in addition to other penalties as provided in Chapter 40.

   A. The Department shall have the power to issue a cease and desist order to any person violating any provision of Chapter 40

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and these regulations by ordering such person to cease and desist from any site work activity other than those actions necessary to achieve compliance with any administrative order.

B. The Department may request that the appropriate plan approval agency refrain from issuing any further building or grading permits to the person having outstanding violations until those violations have been remedied.

Section 15 — Maintenance Requirements

1. For erosion and sediment control, all practices shall be maintained in accordance with requirements specified in the Delaware Sediment and Erosion Control Handbook dated 1989 or as directed by the construction reviewer.

2. Prior to the issuance of any building or grading permit for which stormwater management is required, the responsible plan approval agency shall require the applicant or owner to execute an inspection and maintenance agreement binding on all subsequent owners of land served by the private stormwater management facility. Such agreement shall provide for access to the facility at reasonable times for regular inspection by an inspection agency and for an assessment of property owners to ensure that the stormwater management structure is maintained in proper design working condition.

3. The Department encourages, and will provide technical assistance to, any Conservation District or local jurisdiction who chooses to assume the maintenance responsibility for stormwater management structures on, at least, residential lands. Public maintenance provides a reasonable assurance that maintenance will be accomplished on a regular basis.

4. The owner or person responsible shall perform or cause to be performed preventive maintenance of all completed stormwater management practices to ensure proper functioning. The responsible inspection agency shall ensure preventive maintenance through inspection of all stormwater management practices. The inspections shall occur at least once each year.

5. Inspection reports shall be maintained by the responsible inspection agency on all detention and retention structures and those inspection reports shall include the following items:

   A. The date of inspection;

   B. The name of the inspector;

   C. The condition of

      (1) Vegetation,

      (2) Fences,

      (3) Spillways,

      (4) Embankments,

      (5) Reservoir area,

      (6) Outlet channels,

      (7) Underground drainage,

      (8) Sediment load, or

      (9) Other items which could effect the proper function of the structure.

   D. Description of needed maintenance.

6. Responsible inspection agencies shall provide procedures to ensure that deficiencies indicated by inspections are rectified. The procedures shall include the following:

   A. Notification to the person responsible for maintenance of deficiencies including a time frame for repairs;

   B. Subsequent inspection to ensure completion of repairs; and

   C. Effective enforcement procedures or procedures to refer projects to the Department if repairs are not undertaken or are not done properly.

Section 16 — Penalties

1. Any person who violates any rule, order, condition imposed in an approved plan or other provision of these regulations shall be fined not less than $200 or more than $2,000 for each offense. Each day that the violation continues shall constitute a separate offense. The Justice of the Peace Courts shall have jurisdiction of offenses brought under this subsection.

2. Any person who intentionally, knowingly, and after written notice to comply, violates or refuses to comply with any notice issued pursuant to these regulations shall be fined not less than $500 or more than $10,000 for each

offense. Each day the violation continues shall constitute a separate offense. The Superior Court shall have jurisdiction of offenses brought under this subsection.

Section 17 — Hearings

The conduct of all hearings conducted pursuant to these regulations shall be in accordance with the relevant provisions of Delaware Code, Title 7, Chapter 60.

Section 18 — Severability

If any section, subsection, sentence, clause, phrase, or portion of these regulations are for any reason held invalid or unconstitutional by any court or competent jurisdiction, such provision and such holding shall not affect the validity of the remaining portions of these regulations.

APPENDIX C

Additional Resources

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017-2398

Delaware Department of Natural Resources and Environmental Control
Division of Soil and Water Conservation
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

King County Resource Planning Section
3600 136th Place, SE, 4th Floor
Bellevue, WA 98006-1400

King County Surface Water Management Division
400 Yesler Way, 4th Floor
Seattle, WA 98104

Metropolitan Washington Council of Governments
Department of Environmental Programs
777 North Capitol Street, NE, Suite 300
Washington, DC 20002

Municipality of Metropolitan Seattle
Water Resources, 8th Floor Exchange Building
821 Second Avenue
Seattle, WA 98104

New Jersey Department of Environmental Protection (formerly New Jersey Department of Environmental Protection and Energy)
Office of land and Water Planning, CN 423
Trenton, NJ 08625

North Carolina Department of Natural Resources and Community Development of Land Resources
Land Quality Section
P.O. Box 27687
Raleigh, NC 27611

Puget Sound Estuary Program
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Puget Sound Water Quality Authority
217 Pine Street, Suite 1100
Seattle, WA 98101

Rhode Island Resource Conservation and Development Area
5586 Post Road, Box 6
East Greenwich, RI 02818

Technical Services Section
Municipal Liquid and Industrial Waste Management Branch
Ministry of the Environment
777 Broughton Street, 2nd Floor
Victoria, BC V8V 1X5, Canada

Terrene Institute
1717 K Street, NW
Suite 801
Washington, DC 20006

University of Washington
Engineering Professional Programs, XD-15
Seattle, WA 98195

Urban Drainage and Flood Control District
2480 West 26th Avenue, Suite 156B
Denver, CO 80211-5500

U.S. Environmental Protection Agency
Assessment Branch
Environmental Research Laboratory
Athens, GA 30613

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U.S. Environmental Protection Agency
Assessment and Watershed Protection Division
Watershed Branch
(WH-553)
401 M Street, SW
Washington, DC 20460

U.S. Environmental Protection Agecny
Permits Division
NPDES Program Branch
401 M Street, SW
Washington, DC 20460

U.S. Geological Survey
Books and Open File Reports Section
Federal Center, Box 25425
Denver, CO 80225

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APPENDIX D

Abbreviations

ACP	Agricultural Conservation Program
AETA	apparent effects threshold approach
APHA	American Public Health Association
API	American Petroleum Institute
ASCS	Agricultural Stabilization and Conservation Service
AVS	acid volatile sulfide
BMP	best management practice
BRRL	British Road Research Laboratory
CN	curve number
CP	coalescing plate
CRP	Conservation Reserve Program
CWA	Clean Water Act
EMC	event-mean concentration
EqPA	equilibrium partitioning approach
ESC	erosion and sediment control
GIS	geographic information system
HEC	Hydrologic Engineering Center
HSG	hydrologic soil groups
HSPF	Hydrologic Simulation Program—Fortran
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
ILLUDAS	Illinois Urban Drainage Area Simulation
I_{wb}	Index of Well-Being
LGCPA	Local Government Comprehensive Planning Act
MLRA	major land resource area
NASQAN	National Stream Quality Accounting Network
NEH	National Engineering Handbook
NOEL	no observed effects level
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NSTPA	national status and trends program approach
NURP	Nationwide Urban Runoff Program
OSDS	onsite wastewater disposal system
PEL	probable effects level
PNA	polynuclear aromatic hydrocarbons
QC	quality control
RC&D	Resource Conservation and Development Program

RBP	rapid bioassessment protocol
SAB	Science Advisory Board
SBA	sediment background approach
SCS	Soil Conservation Service
SLCA	screening level concentration approach
SQAG	sediment quality assessment guideline
SQTA	sediment quality triad approach
SSBA	spiked sediment bioassay approach
STORM	Storage, Treatment, Overflow, and Runoff Model
SWMM	Stormwater Management Model
SWP	state water policy
TC	time of concentration
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TRA	tissue residue approach
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WATSTORE	National Water Data Storage and Retrieval System
WLF	water level fluctuation
WRP	Wetlands Reserve Program

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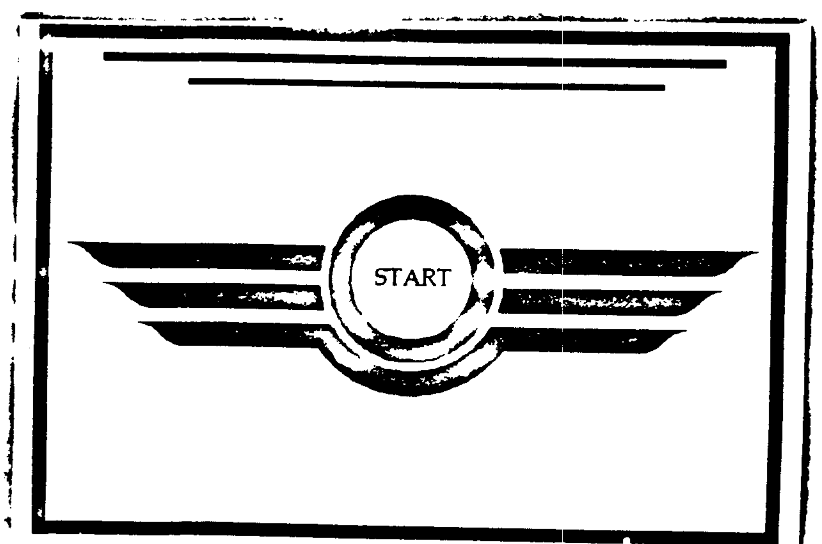
Poison Runoff

A Guide to State and Local Control of Nonpoint Source Water Pollution

PAUL THOMPSON

NRDC



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Poison Runoff

A Guide to State and Local Control of Nonpoint Source Water Pollution

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Poison Runoff

A Guide to State and Local Control of Nonpoint Source Water Pollution

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Advisory Committee

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William Cox	Virginia Polytechnic Institute and State University
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Eugene Lamb	National Association of Conservation Districts
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* While the Advisory Committee provided valuable advice and assistance in preparing this report, the opinions expressed herein are those of NRDC and do not necessarily represent the views of individual Advisory Committee members.

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Finally, the staff and Board of the NRDC extend their deepest appreciation to Gerald P. McCarthy and the Virginia Environmental Endowment for making this report possible.

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Preface

Poison Runoff is the product of two years of research made possible by a generous grant from the Virginia Environmental Endowment. The report was developed based on an analysis of hundreds of personal and telephone interviews, articles, reports and government publications. Through this report NRDC hopes to make a serious contribution to efforts to control what is euphemistically called "nonpoint source" pollution—and what we have more aptly labelled "poison runoff."

It has been known for many years that the sediment, nutrients, bacteria and toxics generated by various land use activities contaminate both our surface waters and our groundwater. Agriculture, urban development, silviculture, mining and livestock grazing continue to contribute to the decline in the quality of our nation's waters. In fact, many consider the contamination from these diffuse sources to be more significant today than pollution from industrial and sewage treatment plant outfalls. Waters such as the Chesapeake Bay literally are being choked to death by poison runoff.

While our understanding of the severity of this diffuse disaster has improved significantly, public response to the problem largely has not. For the third time since the passage of the Clean Water Act in 1972, the federal government is attempting to improve state and local control of poison runoff. Given our poor record in addressing this major water quality problem, it is clear that a serious search is needed for new solutions. *Poison Runoff* represents such a search.

Over the years, some consensus has emerged regarding the basic principles that should guide our efforts to control "non-point" source pollution to achieve the nation's water quality goals. Today many of these principles are being used successfully in state and local programs scattered across the country. But until now, no single publication has discussed all of these principles and described all of these programs in a single place.

Poison Runoff identifies these principles and documents and describes these successful programs. More important, *Poison*

Runoff discusses how to combine these ideas into a comprehensive program to attack the problem.

The report indicates that there is wide disparity in the stringency and effectiveness of nonpoint source management programs in this country. Although many people view poison runoff as a management problem with no real "preferred alternative" solution, our research indicated that some program approaches clearly are more effective than others. Therefore, the principles represented in this report form the foundation for the "minimum standards" that should be reflected in state programs to control poison runoff. A successful program need not contain *all* of the elements included in this report. Nor should a good program be limited to these ideas. But by following the basic principles identified in "Poison Runoff," and by drawing from the exemplary programs identified, state and local governments can begin to fight this serious water quality problem more effectively.

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How to Use This Report

Beyond the value of *Poison Runoff* as a general reference for persons interested in nonpoint source management, it also can be used by government officials and involved citizens to develop or to evaluate the adequacy of state and local programs (and program proposals) to control poison runoff. These programs include individual control activities as well as a state's overall effort to manage diffuse water pollution sources statewide—notably the Nonpoint Source Management Plan developed by each state pursuant to Section 319 of the Clean Water Act.

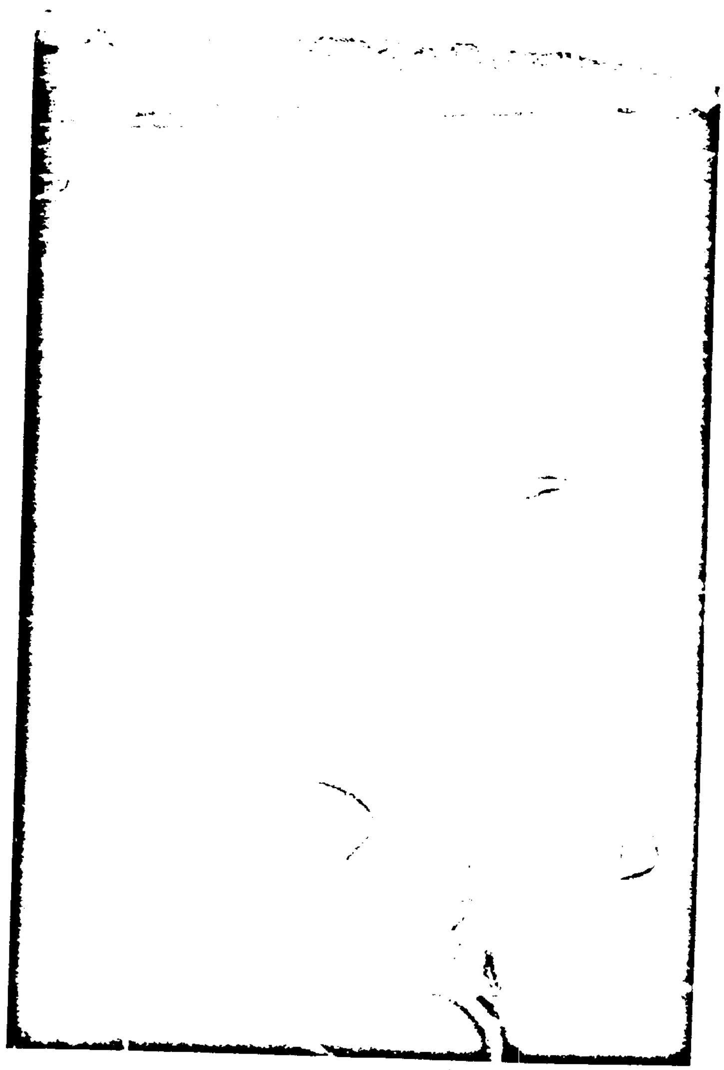
To use this report to evaluate specific state and local programs, first familiarize yourself with the various chapter titles, which correspond to the fundamental building blocks of a comprehensive program to control poison runoff. Those persons only interested in a specific aspect of a state's overall program (*e.g.*, agricultural pollution control programs) should locate the chapter in the report that corresponds with the program component in question.

For the most thorough discussion of that particular program component, the entire chapter should be reviewed. The first part of each chapter discusses the important issues concerning the component. It spells out the management principles essential to effective poison runoff control. The next part of each chapter describes current state, regional and local programs that illustrate one or more of these principles. Readers desiring speedier answers can turn to the final part of each chapter, which provides recommendations that summarize the findings for the particular program component discussed in the chapter.

Individual recommendations, examples and principles can be used to "dissect" each program component of concern. In so doing, the reader will be able both to identify the strengths and the weaknesses of the program, and to shed light on how it can be improved. Notes at the end of each chapter will lead the reader to additional sources of information.

Those persons interested in evaluating a state's overall effort to control poison runoff can follow the same procedure for each chapter in the report. As an example, the Case Study at the end of *Poison Runoff* uses the procedure outlined above to evaluate the Virginia Nonpoint Source Management Plan submitted to the U.S. Environmental Protection Agency in August, 1988.

Finally, a set of questions is presented after the final chapter of the report that summarizes all of the basic principles addressed throughout. By answering those questions, the reader will create a rough outline of the strengths and weaknesses of a state's or locality's poison runoff control program (or component). Thus, this summary can serve as the reader's own evaluation blueprint.



Vast land areas often contribute to the degradation of individual rivers, lakes or coastal areas.

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Chapter One

A Framework for Controlling Poison Runoff

Introduction

A large body of research during the last decade has produced evidence that nonpoint sources contribute a major share of many serious pollutants to our lakes and streams. Without controls, nonpoint source pollution will prevent achievement in a portion of water in at least 37 States of our 1983 goal of fishable and swimmable waters.

There is little doubt that nonpoint sources have a direct, serious impact on the uses Americans make of water. Nonpoint source pollution has appeared in community after community as a pathway for toxic and hazardous pollutants with direct effects on human health. We view with increasing concern the frequent findings of heavy metals in urban and mining runoff, and pesticides and herbicides in agricultural runoff. In many urban areas, nonpoint pollution has significantly raised the cost of providing safe domestic drinking supplies.

In many rural areas, nonpoint sources have contaminated family wells and livestock water supplies. Saline pollution, which is also nonpoint in nature, significantly impairs yields of many irrigated crops in western States....

> The country stands today at a crossroad in its progress toward the 1983 goals—while we have taken giant steps to clean up point source pollution, similar progress on nonpoint source control is lacking. The job of controlling nonpoint sources will not be easy. The political and economic problems to be solved in applying nonpoint controls ("best management practices" or "BMPs") are substantial. Although many State and local governments have already led the way by enacting sediment control, cost-sharing, forest practices or mine-drainage laws on their own initiative, many areas are not controlling nonpoint problems.... In the past eight years, we have just begun to fathom the true depths of our water problems.

This clear, compelling description of the nonpoint source problem—and the call for swift action—was delivered by the EPA Administrator at a Congressional hearing. The Administrator was Douglas Costle; the year, 1979.[1]

Nearly a full decade later the country still stands at the same crossroad, having taken barely a step forward. The severity of the poison runoff problem and the need for constructive, effective action is just as great, if not greater, than it was when these words were written.

By now the statistics have grown all too familiar: according to the most recent national survey, nonpoint sources accounted for approximately 65% of the stream miles for which States reported impairments of water quality;[2] 76% of impaired lake acres were attributed by the States to nonpoint sources.[3] In fact, the trend for lakes appeared to be worsening from 1984 (when the previous national survey was issued) to 1986; and nonpoint pollutants continue to be "by far the leading cause of use impairment" in U.S. lakes.[4] In estuarine waters, too, pollution from nonpoint sources is the largest single cause of the impairments cited by the States—accounting for 45% of the problem.[5] And the downward trend in estuarine water quality is still more pronounced than the trend for lakes.[6] Finally, ground water

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contamination from agricultural activities was reported to be a problem by 79% of the States reporting on water quality.[7]

This epidemic of poison runoff includes a wide range of pollutants that stem from a broad range of activities. When thinking of erosion and other types of runoff from agriculture and construction sites, many people think only of soil particles and sediment. While this type of pollution alone can have drastic effects,[8] poison runoff also contains a wide range of even more insidious contaminants. A study conducted by Resources for the Future for the U.S. Geological Survey, the National Oceanographic and Atmospheric Administration, and EPA found that, of 16 common water pollutants studied, a number came principally from diffuse sources:[9]

Pollution	Poison Runoff Contribution
Iron	95%
Total Nitrogen	90%
Fecal coliform bacteria	90%
Chemical oxygen demand	70%
Oil	70%
Zinc	70%
Phosphorus	66%
Lead	57%
Chromium	50%

The high levels of nutrients (primarily nitrogen and phosphorus) in urban and agricultural runoff promotes excess growth of algae in lakes and estuaries—a process known as eutrophication. Algal blooms deplete the oxygen available for fish and other aquatic organisms, literally choking the life out of water bodies.

Poison runoff also contains pollutants that are acutely toxic to fish and wildlife, and that pose a threat to human health when they contaminate drinking water, fish and shellfish. Agricultural runoff (and groundwater infiltration) contains pesticides and other chemicals. At least 67 toxic pollutants have been detected in runoff from urban areas,[10] including heavy metals, pesticides, spilled petroleum and other chemical products, and other toxic organic pollutants. Runoff from construction sites

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Nonpoint Source Pollution - A Pointless Euphemism

Since the Clean Water Act uses the term *nonpoint sources* to describe land use activities that cause sediment, nutrient, bacterial and toxic water quality contamination, the use of the term (as well as its equally meaningless abbreviation—*NPS*) in programmatic as well as research literature has become every bit as ubiquitous as the pervasive problem it describes. The public, the politicians and the water quality managers have given this "diffuse disaster" a low priority in the past. Labeling our leading cause of water pollution with such a passive, undirected, "non-term" helps to perpetuate the notion that the problem is too vague, ill-defined and insignificant to warrant high priority. Therefore, wherever possible, this report largely replaces the use of the terms "nonpoint source" and "NPS" with "poison runoff" in order to describe more accurately its impact on aquatic (and in many cases human) life. It should be noted that, like "nonpoint source," "poison runoff" can be, and often is, used as a "catch-all" phrase to include the impacts of diffuse sources of water pollution on groundwater as well as surface water.

can be contaminated with construction chemicals, such as pesticides, petroleum products, solvents, asphalt, acids and salts.[11] Water contaminated by active and abandoned mining sites can be polluted by toxic metals such as lead, arsenic, zinc, cadmium, mercury and cobalt, as well as acid mine drainage.[12]

The purpose of "Poison Runoff," however, is not to document the gravity of this growing pollution problem. Numerous studies already have quantified the effects of diffuse sources of water pollution, and the costs of this pervasive poison in terms of water quality degradation, lost farm productivity, recreational resource impacts and wildlife habitat destruction, to name but a few.[13]

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Nor is it the purpose of this report to try to persuade readers that the time has come to take action to control poison runoff. That decision has already been made—by Congress and by the majority of the states. This decision is reflected in the language of the Clean Water Act:

> it is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of [the Clean Water Act] to be met through the control of both point and nonpoint sources of pollution.[14]

Rather, the pages that follow are directed to decisionmakers and interested citizens who already have made up their minds that the time has come to confront and overcome the problems of poison runoff—people who are looking for creative and effective ways to implement solutions.

Admittedly, it will not be easy to eliminate pollution from agricultural and urban runoff, from mining and forestry, from grazing and construction and a host of other activities. The sources of this pollution are numerous and diverse. Poison runoff can stem from virtually every human activity—hence, from virtually every person. And major gaps exist in our knowledge and understanding of how much pollution derives from each source, the effects of this pollution, and the best control strategies.

This report does not claim that all of these scientific uncertainties about pollution transport, fate, effect and control have been resolved; instead, it gives guidance on how to make the most of the information presently available, while continuing to gather and refine the scientific database. Particularly when it comes to *preventing further water quality degradation*, additional study cannot be an excuse for more delay. And the size and ubiquity of the nonpoint source problem justify speedier and more aggressive—not hesitant and half-hearted—corrective action.

Poison Runoff answers many of the common questions that officials and citizens face about what should be the structure and content of local and state programs designed to control the land use activities that cause water pollution. In the pages that follow we describe what we hope is a comprehensive master plan for state and local officials, and interested citizens who want to develop and implement an effective, efficient and comprehensive program to control pollution generated by diffuse sources. We believe that if water quality management officials and others in state and local government follow the recommendations in this report, they will be well on the way to protecting our rivers, lakes and coastal waters from the pervasive effects of poison runoff.

Contaminated runoff cannot be controlled absent strong support for the principles and ideas contained in this report. Even the most effective "paper" programs can be rendered impotent without support from politicians and program administrators. In fact, some of the most promising programs described in this report have been hampered by a lack of enforcement or emphasis in some other vital program area due to state or local political circumstances. These pitfalls also must be considered (although they are not the subject of this report) by the grass roots organizer, the interested voter, and the intrepid public official charged with implementing an effective program.

Report Organization

The road to program failure is paved with unfocused goals and poorly-planned good intentions. *Poison Runoff* is intended to help avert such failures–to pave the way to effective control by walking decisionmakers and citizens through the many steps that lead to development of a program that is designed to comply with the requirements of the Clean Water Act (CWA) by achieving state water quality objectives. These steps include (1) determining precisely what the goals of effective control must be; (2) developing, implementing and enforcing the most effective tools and strategies to control polluted runoff from each type of source; and (3) combining these control strategies for each type of pollutant source into an effective, comprehensive and coordinated statewide plan.

A clearly articulated program goal is the key starting point for controlling poison runoff, and that is where *Poison Runoff* begins. To set the stage, decisionmakers need to focus on the exact nature of their mandate.

The Clean Water Act, the nation's most important water pollution control law, provides the states with both the clear

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mandate and the legal authority for dealing with poison runoff. We therefore begin this report with a description of the Clean Water Act, and what it requires that states do to control poison runoff. Part One includes a "road map" of the CWA's requirements for controlling poison runoff (Chapter Two), which makes clear that the achievement of "fishable and swimmable" water quality must be the overriding management goal of each state's effort to control diffuse sources of pollution.

It is no secret that, to date, federal and state nonpoint source control programs have not succeeded in achieving this water quality goal. In Chapter Two we also present a brief general review of the existing poison runoff control framework under the CWA. This review pinpoints the deficiencies that have hampered success, and explains why it is not appropriate for state and local decisionmakers to expect federal action alone, or simple state and local implementation of existing federal programs, to substitute for effective new programs at the state and local level. In so doing, we establish a firm basis for the development of state programs that build effectively on beneficial aspects of existing federal programs, but are not hamstrung by the limitations of those programs.

State and local control of poison runoff requires a high degree of coordination and organization. Different governmental entities, such as water quality, agriculture, and transportation agencies, must work together. In addition, different levels of government–federal, state, regional and local–must coordinate and plan together. Municipal and county governments often are needed as partners in the control of poison runoff, as are logging, mining and grazing interests.

A state's control program must weave the various actors and managers together. In essence, it should consist of two major elements: (1) a series of *effective, efficient program components* to address each major type of source, and (2) *a planning and implementation infrastructure* that brings those components together to achieve the statewide goal of meeting water quality protection goals.

Addressing these two basic elements of an effective state program presents a classic chicken-or-egg dilemma: it is hard to say which one must come first, and neither one can do the job alone. In this report we address the specific components first. *Poison Runoff* covers the specific components before the planning and implementation discussion, largely because decisionmakers may find it easier to translate the planning and implementation suggestions into action if they already have the specific program components before them. Part Two of *Poison Runoff* addresses these key components in six chapters. The first three chapters in Part Two describe the best ways to control particular types of nonpoint source pollution:

Chapter Three - Agriculture;
Chapter Four - Land Use and Urban Runoff; and
Chapter Five - Silviculture, Mining and Grazing.

The next three chapters in Part Two address specific management tools for poison runoff control programs:

Chapter Six - Data Collection and Use;
Chapter Seven - Funding; and
Chapter Eight - Legal Considerations.

Part Three of *Poison Runoff* consists of two chapters designed to help decisionmakers plan and implement the components described in Part Two—to put all the components together into a unified, effective program. In the first chapter we describe the essential process of tying management of diffuse sources to the achievement of water quality goals, through reliance on the state's water quality standards program. In the next chapter we describe how to implement the program through the coordinated, integrated operation of state, regional and local institutions.

Some states and localities have developed innovative approaches to meet many of these difficult challenges—both the challenges of controlling specific types of pollution (covered in Part Two), and the challenges of planning for and implementing their overall management programs (Part Three). Wherever possible we present examples and anecdotal accounts of programs with effective management or planning components that could be adapted and adopted in other states and localities.

Where no single outstanding example exists, we cull from existing programs the most successful elements that can be built upon by decisionmakers. At the end of Part Three, we synthesize the recommendations developed throughout this report into a brief section of Evaluation Questions and Recommendations. Part Four consists of an application of these evaluation questions and recommendations to a particular state: we conduct an in-depth case study of the state of Virginia's program to control poison runoff.

Virginia was selected for NRDC's case study because approximately half of the Commonwealth is located in the watershed of the Chesapeake Bay, one of America's most productive—and most critically threatened—estuarine watersheds. Virginia also serves as a valuable case study because it is facing many of the problems associated with the management of diffuse sources of water pollution that all states will need to confront: it has some regions that are predominantly agricultural, as well as densely populated (and rapidly growing) urban areas. In addition, its Chesapeake Bay shoreline is being threatened with rapid overdevelopment. In the case study we make specific program recommendations for the state of Virginia, thereby offering decisionmakers from other states a clear model of how to apply the Evaluation Questions to their own circumstances effectively. The same exercise can be conducted by citizens who want to prepare a constructive critique of the nonpoint source program in their state or locality.

Once the reader has considered the many issues presented in this report, we hope that he or she will be prepared to analyze a state's or locality's present set of nonpoint source programs, by posing the key questions presented in *Poison Runoff:* Is the program specifically designed to achieve water quality goals based on the process required under the CWA? Does it require or encourage the most effective on-the-ground control methods? Are all of the necessary players (from state agencies to local zoning officials to the public) involved? Does it consist of a sensible mix of educational, technical assistance, regulatory and planning elements? Does it have adequate funding? Is it enforceable? Decisionmakers then should be equipped to make the adjustments necessary to improve their control of poison runoff so that they can meet the "fishable and swimmable" goals of the Clean Water Act.

Notes - Chapter One

1. *Implementation of the Federal Water Pollution Control Act (Nonpoint Pollution and the Areawide Waste Treatment Management Program): Hearings before the Subcomm. on Oversight and Review, House Comm. on Pub. Works and Transp.*, 96th Cong., 1st Sess. (1979) 528-529 (Statement of Douglas Costle, Administrator, U.S. EPA).

2. U.S. EPA, *National Water Quality Inventory–1986 Report to Congress*, Washington, D.C. (October 14, 1987), at 18-20.

3. *Id.* at 30.

4. *Id.*

5. *Id.* at 42.

6. *Id.* at 41.

7. *Id.* at 60. *See generally* U.S. EPA, *Pesticides in Groundwater Data Base-1988 Interim Report*, Washington D.C., December, 1988.

8. Sediment can cause not only instream violations of water quality standards for turbidity, total suspended solids or settleable solids, but also can smother spawning beds and have other adverse effects on aquatic systems.

9. U.S. EPA, *Report to Congress: Nonpoint Source Pollution in the U.S.*, Washington, D.C., January, 1984, at 1-14.

10. U.S. EPA, *Results of the Nationwide Urban Runoff Program (Volume I - Final Report)*, December, 1983, at 6-46 - 6-56. For example, lead, zinc and copper were found in 90%-94% of the samples taken during the NURP Study; 50-75% of the samples contained chromium and arsenic; 20-49% contained cadmium, nickel and cyanide; and 10-19% contained antimony, beryllium and selenium. *Id.* at 6-51.

11. U.S. EPA, January 1984, *supra* note 9, at 2-26.

12. *Id.* at 2-19 - 2-23.

13. Including state and local assessments, there exists a vast record documenting water quality contamination caused by polluted runoff. In addition to the reports cited above, for an approximation of the range and diversity of runoff poisoned by nutrients, toxics, sediment, etc., *see also* Feliciano, Donald V., *Agricultural Effects on Groundwater Quality*, Congressional Research Service, October 10, 1986; California Assembly Office of Research, *The Leaching Fields: A Nonpoint Threat to Groundwater*, March, 1985; Hallberg, George R., "Agricultural Chemicals in Groundwater: Extent and Implications," *American Journal of Alternative Agriculture*, Winter, 1987, at 3-13; Papendick, Robert I., *et al.*, "Environmental Consequences of Modern Production Agriculture: How Can Alternative Agriculture Address These Issues and Concerns?," *American Journal of Alternative Agriculture*, Winter, 1986, at 3-10; U.S. General Accounting Office, *Wetlands: The Corps of Engineers' Administration of the Section 404 Program*,

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July, 1988; U.S. EPA, *Chesapeake Bay Program Technical Studies: A Synthesis*, Washington D.C., September, 1982; Idaho Department of Health and Welfare, *Idaho Water Quality Status Report and Nonpoint Source Assessment* (draft), May 1988; Gips, Terry, *Breaking the Pesticide Habit - Alternatives to 12 Hazardous Pesticides*, International Alliance for Sustainable Agriculture, 1987; Montana Department of Health and Environmental Sciences, *Nonpoint Sources of Water Pollution in Montana*, May 1988.

14. Clean Water Act § 101(a)(7); 33 U.S.C. § 1251(a)(7). The Clean Water Act is the common term for the Federal Water Pollution Control Act (FWPCA). While predecessor laws date back to 1948 (P.L. 80-845), the FWPCA was enacted substantially in its present form in 1972 (P.L. 92-500). Major amendments were enacted in 1977 (P.L. 95-217), 1981 (P.L. 97-117) and 1987 (P.L. 100-4). The "CWA" is used here to refer to the Act as amended in 1972 and thereafter. The policy cited in the text was added to the CWA as part of the new nonpoint source pollution control provision contained in the 1987 Water Quality Act (WQA) amendments, WQA § 316(b), which is discussed in detail in Chapter Two.

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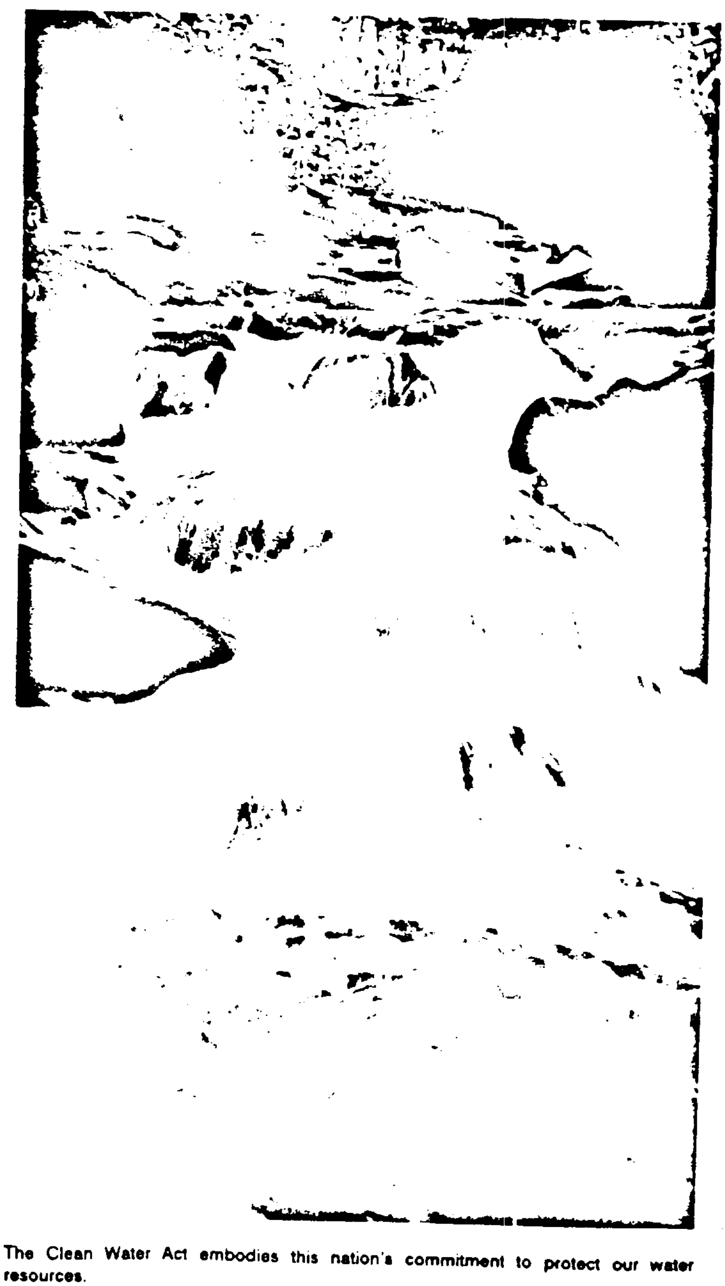

The Clean Water Act embodies this nation's commitment to protect our water resources.

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Chapter Two

Nonpoint Source Pollution Control Under the Clean Water Act

Introduction

The federal Clean Water Act (CWA)[1] establishes the fundamental mandate for states to control water pollution, including pollution from nonpoint sources. While many other federal, state, and local laws and regulations are critical to the control of poison runoff,[2] the CWA and its implementing regulations establish the benchmark against which all of these programs must be measured.

The 1987 Water Quality Act (WQA) amendments to the CWA[3] added a number of new provisions addressing poison runoff. In particular, the WQA created new section 319 of the Clean Water Act, which requires states to develop comprehensive programs for the control of poison runoff. However, long before the 1987 amendments were enacted the CWA and EPA's implementing regulations already required states to control the water pollution generated by various types of land use.

In fact, while the 1987 amendments have been billed as a major new mandate,[4] they provided little in the way of additional *substantive authority or requirements* for controlling poison runoff. But the 1987 changes did reinvigorate control efforts by setting firm new deadlines for adoption of management programs, by highlighting the important role of programs to control this ubiquitous problem in restoring the Nation's surface and ground waters, by formalizing existing requirements in more precise statutory language, and by authorizing increased resources for control programs. Recent increases in efforts by EPA and the states to address poison runoff largely have been in response to the 1987 amendments.

This chapter includes a description of the fundamental legal requirements for nonpoint source control programs set forth in the CWA and in EPA regulations implementing the Act. Statutory and regulatory requirements in place before the 1987 amendments are described first, since the States may be able to draw on existing programs as a starting point for compliance with section 319. The specific changes included in the 1987 amendments are described next. The chapter concludes by distilling key legal principles from the CWA that should guide state development and implementation of programs to control poison runoff.

Nonpoint Source Control Requirements Before the 1987 CWA Amendments

Since 1972 the CWA has required that EPA and the states devise comprehensive programs to control water pollution from both point and nonpoint sources. Section 102(a) of the CWA requires the development of "comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters."[5] Similarly, section 201(c) of the CWA provides:

> To the extent practicable, waste treatment management shall be on an areawide basis and provide control or treatment of *all point and nonpoint sources* of pollution, including in place or accumulated pollution sources.[6]

While the CWA has permitting provisions for the control of pollution from point sources,[7] the means to enforce the control of poison runoff are considerably less precise.

Point sources are defined in the law as follows:

> The term "point source" means any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.[8]

(The last sentence excluding irrigation return flows was added in 1987.) By implication, a "nonpoint source" is *any* source of pollutants not included in the definition of point source.[9] As we explain below, the legal requirements and authority for control of poison runoff are linked to the basic goals and requirements of the CWA.

The Water Quality Standards Process

The most fundamental objective of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[10] While the CWA sought to achieve this fundamental objective by establishing a national goal of eliminating the discharge of *all* pollutants into the nation's waters by 1985,[11] this lofty goal has proven elusive. In practice, success in cleaning up the nation's surface waters (*i.e.*, moving towards the zero discharge goal) is measured by reference to *state water quality standards*, which are developed, implemented and enforced under section 303 of the CWA.[12]

Water quality standards consist of two components: (1) beneficial designated uses for all waters, such as protection of fish and aquatic life or public drinking water supply; and (2) water quality criteria necessary to protect each designated use.[13] Water quality criteria set specific instream water quality measurements necessary to protect designated uses, and include both general narrative requirements and numeric criteria for individual pollutants.[14] In addition, water quality standards must include an "antigradation" provision designed to ensure that clean waters stay clean.[15]

In general, the CWA gives individual states considerable discretion in setting water quality standards. However, there are two major underlying requirements.[16] First, Congress established a minimum goal for allowable designated uses:

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> it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983.[17]

This requirement is commonly known as "fishable and swimmable waters." Second, water quality criteria necessary to protect designated uses must be based on purely scientific factors, rather than such considerations as economic or technological feasibility.[18] Where state water quality standards are inadequate, EPA is required to promulgate substitute federal standards.[19]

As interpreted by EPA, state water quality standards serve a dual purpose: "establishing the water quality goals for a specific water body and serving as the regulatory basis for establishment of water quality-based treatment controls and strategies ...."[20] These dual purposes, particularly the "regulatory" purpose, are critical to nonpoint source control programs for two reasons. First, compliance with water quality standards is the fundamental goal of all water quality programs. *Therefore, all programs to control poison runoff should—indeed, must—be designed to achieve compliance with water quality standards.*[21]

Second, *water quality standards form the principal legal authority for controlling pollution generated by various land use activities.* While point sources of pollution are subject to mandatory control requirements that exist independent of water quality goals,[22] controls on diffuse sources are grounded in the mandate to meet water quality standards.[23] This link is explained below.

Implementing Water Quality Standards

The primary tool for meeting, or implementing, water quality standards is set forth in section 303 of the CWA. Under section 303(d)(1)(A), states must identify all waters for which technology-based effluent limitations on point sources alone are not enough to ensure compliance with water quality standards.[24] Next, for each such water, states must calculate a "total maximum daily load" (TMDL) of pollutants (for each pollutant criterion violated) "at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety...."[25] Finally, each state must incorporate these

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TMDLs into its "continuing planning process" under section 303(e) of the Act.[26] As with the water quality standards themselves, EPA is required to review state TMDLs, and to promulgate a federal TMDL where a state TMDL is inadequate.[27]

TMDLs were supposed to apply to nonpoint sources through the operation of each state's comprehensive water quality management plan prepared under section 208 of the Act.[28] Comprehensive water quality management plans under section 208 must consider poison runoff from a number of sources, including agriculture, silviculture, mining, construction, salt-water intrusion, land and subsurface disposal of pollutants, and other sources.[29] As part of the 208 "planning process," guidelines for identifying nonpoint sources of pollution and for devising methods to control poison runoff, were published by EPA.[30] EPA also dispersed funds to designated state 208 planning agencies.

EPA's regulations further clarify the link between compliance with water quality standards and control of poison runoff. EPA defines the TMDL process as follows: "Loading capacity" is the maximum amount of pollution that a water can receive without violating water quality standards;[31] "Load allocation" (LA) is the portion of loading capacity that is to be "allocated" to nonpoint source polluters or to natural background sources;[32] the "Wasteload allocation" (WLA) is the portion of loading capacity to be "allocated" to point source discharges.[33] The TMDL is the sum of all LAs and WLAs.[34] In short:

> *Nonpoint Source Loads* plus *Background Sources* (LA) plus *Point Source Loads* (WLA) can never exceed the receiving water's Total Maximum Daily Load (TMDL).

Under EPA's regulations, states not only must identify waters that do not meet water quality standards and determine by how much those standards are exceeded; they also must allocate allowable loadings between point sources and nonpoint sources/natural background sources, and further must distinguish nonpoint sources from natural background wherever possible. And the regulations further require states to allocate controls on pollutant loadings among WLAs for point sources and LAs for nonpoint sources.[35]

The requirement that water quality standards be met by controlling nonpoint sources is clarified further in EPA's regulations for state water quality management plans. The regulations reiterate that states must include in their water quality management plans "best management practices" (BMPs) for poison runoff,[36] and more expressly relate its control requirements to achieving water quality standards:

> The plan *shall* describe the regulatory and nonregulatory programs, activities and Best Management Practices (BMPs) which the agency has selected as the means to control nonpoint source pollution *where necessary to protect or achieve approved water uses.*[37]

Still more significant is the requirement in EPA's rules that control strategies for poison runoff *include regulatory programs* where necessary to meet water quality standards, or where non-regulatory approaches are "inappropriate".[38]

Recent federal court opinions confirm that, even under the pre-1987 CWA, water quality standards apply to discharges from nonpoint sources. The Ninth Circuit Court of Appeals held in two separate cases that water quality standards must be considered in assessing the broad, nonpoint source effects of forestry operations.[39] Similarly, the Fourth Circuit recently upheld a decision by EPA to condition a grant for sewage treatment plant construction on a requirement to protect floodplain areas from development.[40] EPA reasoned that development in floodplains would cause nonpoint source runoff, and adversely affect the adjoining waters. The Court upheld EPA's action based on the Agency's broad authority to implement the comprehensive water quality goals of the Clean Water Act, including the goal of restoring and maintaining the chemical, physical and biological integrity of the nation's waters.

To summarize, the pre-1987 requirements of the CWA and EPA regulations may have an undeserved reputation for lack of fortitude.[41] Under EPA's preexisting regulations, states were required to establish water quality standards for all waters. Standards had to be set at levels necessary to meet fishable and swimmable uses wherever attainable. States were required to identify all waters where water quality standards were not met after applying effluent limitations on point sources. In these cases, additional water quality controls had to be imposed on point sources through more stringent limits, and on nonpoint sources through BMPs and other control strategies included in section 208 management plans. Finally, where nonregulatory approaches to reduce poison runoff were not adequate, states were supposed to resort to regulatory programs.

Implementation of the Pre-1987 Law

As explained above, comprehensive areawide water quality management plans under CWA § 208 were supposed to play a major role in overall water quality management, and in particular, in addressing pollution from contaminated runoff. The statute and EPA regulations provided ample authority for states to control poison runoff. In general, however, the areawide plans were not effective, and poison runoff generally remained unchecked.

Some problems in the 208 program sprang from deficiencies in the law itself. Most important was the fact that the program stressed planning rather than plan implementation.[42] While the CWA clearly required compliance with water quality standards regardless of whether pollution derived from point or nonpoint sources, no specific controls were mandated for nonpoint sources, as they were for point sources. Thus, while section 208 provided states with adequate *authority* to control poison runoff, it did not clearly *require* adequate program *implementation*. Many 208 plans simply remained on the shelves after they were completed.

Congress, too, deserves its share of the blame. Funding for 208 activities was spotty beginning in 1973, and was discontinued altogether in 1981.[43] As a result, to the extent they have been funded at all, poison runoff control programs have been funded by the states primarily through general revenues (*i.e.*, without dedicated sources of funding) and at levels that are relatively low in relation to other comparable environmental programs. Programs to control soil erosion and poison runoff are typically funded in the $1-5 million/year range.[44]

But the failure of 208 planning also resulted in part due to EPA's failure to carry out its statutory responsibilities. The issuance of EPA guidance documents and regulations often was

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delayed, and administration support for the program was limited and poorly coordinated.[45] Moreover, EPA failed to use its existing statutory authority effectively to require greater state efforts to control poison runoff. For example, under section 303(e)(2), EPA may not approve an NPDES program[46] for any state that lacks an approved continuing planning process, including all elements of an applicable section 208 plan—and a 208 plan must include poison runoff controls. Yet EPA did not use this authority effectively to require the proper implementation of section 208 plans. Similarly, EPA has made little use of its authority to force states to develop adequate wasteload allocations.[47]

In 1983, when legislation to address the void left by the collapse of 208 programs was being considered, EPA's official position was that the agency had no direct role in controlling poison runoff.[48] EPA did not support any federal grants to state or local nonpoint source management officials. And the Reagan administration actively opposed the provision of the 1987 amendments which created the Section 319 poison runoff control program, and authorized $400 million in federal funding over a five year period.[49] In light of this lethargic EPA attitude towards implementation of the 208 program and other efforts to control poison runoff, it is no wonder that the pre-1987 law was not effective.

Additional Requirements in the 1987 Water Quality Act

Despite the extensive existing requirements for controlling poison runoff described above, progress in reducing this pollution has been very slow.[50] The figures cited in the previous chapter demonstrate that, at least on the national level, the past ten years have seen little progress in reducing the impacts of this pervasive poison. Not satisfied with the progress that had been made,[51] Congress concluded that there was a need to strengthen—or at least to clarify—existing control requirements in the CWA.[52]

In the 1987 WQA, therefore, Congress addressed poison runoff head on with the adoption of *section 316*. Section 316 of

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the WQA has a number of subsections, each of which augments the CWA's focus on the problem of diffuse sources of water pollution.

Subsection (a) created a new *section 319* of the CWA. *Section 319* requires that each state develop and submit to EPA a comprehensive management plan to address poison runoff. (This provision will be described in greater detail later in the chapter.)

Subsection (b) highlights the control of poison runoff as one of the major goals of the CWA:

> it is the national policy that programs for the control of nonpoint source pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.[53]

Subsections (c) and (d) provided additional grant funds for states and EPA to address nonpoint source pollution.[54] And subsection (e) amended section 304(k)(1) of the CWA to require that EPA enter into agreements with other agencies for "maximum utilization" of federal programs in order to control poison runoff.

The Requirements of CWA § 319

The bulk of the requirements added by the WQA are contained in new CWA § 319. In many cases, CWA § 319 restates, clarifies, or redefines existing requirements under preexisting law and regulations. But some new authority is added as well.

States are directed to identify waters that, "without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain applicable water quality standards or the goals and requirements of this Act."[55] This requirement, in effect, restates the law's pre-existing requirements, as implemented by EPA's regulations. However, it does require that states more precisely identify those waters that do not meet water quality goals due in large part to diffuse sources.

Each State also must identify specific subcategories of nonpoint sources, or even "particular nonpoint sources" that add "significant pollution" to each of the designated waters.[56] Again, this requirement echoes the law's preexisting requirements,[57] albeit in a more precise and pointed fashion. For each source of poison runoff identified, CWA § 319 requires the state to develop a detailed management plan to address the resulting pollution problem, including BMPs and other regulatory and nonregulatory programs.[58]

A related new incentive is a provision allowing downstream states that are on the receiving end of poison runoff to ask EPA to convene a "management conference" to bring the offending upstream sources under control.[59]

EPA also plays a critical role. Section 319 requires that EPA review and approve each state's nonpoint source assessment *and* management plan.[60] Where a state fails to submit a timely *assessment*–presumably a timely and *adequate* assessment–EPA is required to prepare such an assessment by August 1, 1989.[61] By contrast, the Act falls short of authorizing EPA to promulgate a federal *management plan* for controlling poison runoff.[62] Instead, when EPA disapproves a state management plan, the state has an additional 3 months to promulgate a revised plan.[63] The Act is silent on the ramifications of a second inadequate submission, except that states with inadequate plans are not eligible for CWA § 319 grant funds.[64]

EPA also issued guidance that states were to follow when preparing the assessments and management programs called for in the Act, in order to be eligible for federal funds.[65] EPA continues to provide technical assistance and other information to state and local nonpoint source management officials through publications, workshops, and informal meetings.[66]

Since the 1987 Water Quality Act was passed, the Administration has made little or no effort to obtain funding from Congress for its implementation. While EPA's Office of Water has been working to develop guidance to the States concerning the listing of impaired waters and the development of management plans in order to implement Section 319, the agency's failure to seek or obtain any federal financing for the States has sent a strong, negative message to state and local officials.

Nor has the pace of EPA's oversight of state water quality standard-setting kept pace with the need to address poison runoff. Although EPA officials recognize the relationship of

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water quality standards to poison runoff,[47] few federal criteria directly applicable to nonpoint source pollution impacts have been developed and, as a consequence, the states have little federal guidance on which to base their own standard-setting. As a general matter, in the two years since enactment of the 1987 amendments EPA has continued to display its historical hesitancy to dictate poison runoff control approaches to the states, and has shied away from asserting a forceful leadership role in the development of State nonpoint source management programs.

One key example is EPA's implementation of the new requirements of section 319, which authorizes EPA to *disapprove* inadequate state management plans.[48] Instead of using this leverage to send states a firm message that the time has come to increase vastly attention to poison runoff control, EPA's guidance to the states on implementation of section 319 requirements places few meaningful "teeth" in the approval/disapproval process. Virtually no mention is made in EPA guidance of the need to develop new water quality standards, Load Allocations or water quality-based controls. Nor does EPA direct the states to rely on other sources of authority (such as use of the antidegradation standard to mandate the development of nonpoint controls) to bring about effective state program development.[49]

In sum, even in the best of all possible worlds the federal nonpoint source management role still would comprise only the first level of what must be a multi-tiered effort to control the pervasive problem of poison runoff.

While federal efforts can be of great use to state and local governments when effectively implemented, no federal program can or should purport to tackle the whole poison runoff problem—or even any single aspect of the problem—from start to finish. States need to be fully informed about what help is available from the federal government, so that they can take advantage of federal programs and integrate those programs into their comprehensive state management strategy. But states also must be keenly aware of what is *not* provided by the federal government, for it is here that the lion's share of state and local efforts will be needed.

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Distinctions Between Pre- and Post- 1987 Nonpoint Source Requirements

While in many respects CWA § 319 largely restates existing requirements, there are a number of significant differences advanced by the new provision. Most importantly, CWA § 319 strengthens the *substantive standard for nonpoint source control program effectiveness.* CWA § 208 requires control of diffuse sources "to the *extent feasible.*"[70] Reflecting that tone, EPA's water quality standards regulations require control programs to be "cost effective and reasonable" before states can justify lower designated stream uses, or before states can allow degradation of streams with high water quality.[71] By contrast, CWA § 319(a)(1)(C) demands that states reduce nonpoint source pollution "to the *maximum extent practicable* ..." (emphasis added).[72] This will demand a higher level of control and a more stringent standard of proof before degradation or downgrading can be permitted.

CWA § 319 also strengthens the regulatory link between poison runoff and groundwater contamination. As with poison runoff, many preexisting sections of the CWA are relevant to groundwater protection requirements, but little had been done to implement the mandate.[73]

Under the 1987 amendments section 319(b)(2)(A) now specifically requires states to develop BMPs "taking into account the impact of the practice on ground water quality." The Senate Report explained:

> States are required to consider the impact of management practices on groundwater quality. Because of the intimate hydrologic relationship that often exists between surface and groundwater, it is possible that measures taken to reduce runoff of surface water containing contaminants may increase transport of these contaminants to groundwater. The State should be aware of this possibility, when defining best management practices, especially in aquifer recharge areas.[74]

Other changes made by section 319, while largely procedural, nevertheless are potentially significant. First, section 319 reasserts many existing requirements of the CWA and EPA regulations in a single section, and requires states to develop a separate management plan to address poison runoff, instead of incorporating control efforts as one of many aspects of their other planning responsibilities.[75] To this extent, it may stimulate more detailed, comprehensive plans.

But more important, section 319 imposes specific deadlines. Completed lists of affected waters and management plans were required to be submitted to EPA by August, 1988.[76] And Congress required that states incorporate into their plans specific milestones and internal deadlines, stressing that schedules should "provide for utilization of [BMPs] at the *earliest practicable date.*"[77]

Section 319(b)(4) also seems to impose a more site-specific approach on planning by requiring states to develop and to implement their management programs, to the maximum extent practicable, on a "watershed-by-watershed basis."[78] Arguably, this requirement already existed in the mandate of section 303 and 40 CFR Part 130 to calculate TMDLs on a water by water basis. But again, Congress' effort to consolidate this requirement with respect to nonpoint sources in particular may stimulate a more focused effort.

Conclusions and Recommendations

Based on the above analysis, the CWA and EPA regulations establish the following fundamental legal principles that each State should use as its guide in developing and implementing its poison runoff control plans:

1. Management plans must be designed to achieve compliance with state water quality standards. This includes both the attainment of all existing designated uses, and upgrading designated uses where additional controls will allow higher beneficial uses to be met. Control programs should also be incorporated fully into each state's antidegradation program.

2. Control plans must identify all surface water segments that are not attaining designated uses or the minimum fishable and swimmable goals of the CWA, and in which nonpoint sources contribute any significant amount of pollution.

3. Control of diffuse sources of water pollution should be accomplished through a comprehensive planning and management approach. Management plans under section 319 should draw upon, and incorporate where possible, existing information and programs developed under sections 208 and 303 of the CWA.

4. For each affected waterbody, plans to control poison runoff should calculate the total pollutant load reductions necessary to achieve designated uses and the minimum fishable and swimmable goals of the CWA. Based on the total load reductions, states should calculate specific load reductions for poison runoff necessary to meet these uses and goals, and demonstrate how these reductions will be achieved.

5. Where nonregulatory programs are not adequate or feasible, regulatory programs must be developed to achieve the calculated load reductions.

6. Management programs must reduce poison runoff "to the maximum extent practicable."

7. BMPs and other controls must be achieved at the "earliest practicable date."

8. Wherever possible, management programs must be developed on a watershed-by-watershed basis.

9. Management programs must consider the effect of various control strategies and practices on groundwater contamination.

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Notes - Chapter Two

1. 33 U.S.C. § 1251 *et seq.* See Chapter One, note 14 for the history of this law.

2. Many of these other legal authorities will be addressed elsewhere in this report.

3. Water Quality Act of 1987, P.L. 100-4, 101 Stat. 7 (hereinafter cited as "1987 amendments" or "WQA").

4. *See* Water Pollution Control Federation, *The Clean Water Act of 1987,* 1987, at 41 ("important new authority to manage and control ... nonpoint sources of pollution").

5. 33 U.S.C. § 1252(a).

6. 33 U.S.C. § 1281(c) (emphasis added).

7. *See, e.g.,* CWA §§ 301, 304, 307, and 402, 33 U.S.C. §§ 1311, 1314, 1317, 1342.

8. CWA § 502(14), 33 U.S.C. § 1362(14).

9. *See National Wildlife Federation v. Gorsuch,* 693 F.2d 156, 171-172 (D.C. Cir. 1982).

10. CWA § 101(a), 33 U.S.C. § 1251(a). The Act includes a broad array of programs and tools to accomplish this objective, including funding for public sewage treatment plants (CWA Title II, commonly known as the Construction Grants Program, and Title VI, the State Revolving Loan Fund program for State funding of such plants); grants, studies and demonstration projects (CWA §§ 104-116, 33 U.S.C. §§ 1254-1266); increasingly strict controls on "point sources" of pollution (*e.g.,* CWA §§ 301(b) and 304(l), 33 U.S.C §§ 1311(b) and 1314(l)); and comprehensive water quality planning efforts (CWA §§ 208 and 303(e), 33 U.S.C. §§ 1288, 1313(e)). For a more complete description of the CWA, *see* Rodgers, William H., *Environmental Law, Air and Water,* West Publishing Co., St. Paul, Minnesota, 1986, at Vol II., ch. 4.

11. CWA § 101(a)(1), 33 U.S.C. § 1251(a)(1).

12. CWA § 303, 33 U.S.C. § 1313.

13. CWA § 303(c)(2)(A), 33 U.S.C. § 1313(c)(2)(A); 40 CFR § 131.6.

14. 40 CFR § 131.11. Water quality standards are adopted by states to "protect the public health or welfare, enhance the quality of water and serve the purposes of [the Act]." CWA § 303(c)(2), 33 U.S.C. § 1313(c)(2); 40 CFR §131.2. For a far more detailed explanation of the water quality standards program, *see Citizen's Handbook on Water Quality Standards,* Natural Resources Defense Council, May, 1987.

15. 40 CFR § 131.12. Antidegradation applies equally to point and nonpoint sources. U.S. EPA, *Questions and Answers on: Antidegradation,* August, 1985, at 6.

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16. Other minimum requirements for state water quality standards, such as implementation methods and an antidegradation program, are set forth in 40 CFR Part 131. EPA reviews state water quality standards for compliance with the minimum requirements of the Act and its own regulations, and must disapprove nonconforming standards. CWA § 303(c)(3), 33 U.S.C. § 1313(c)(3).

17. CWA § 101(a)(2), 33 U.S.C. § 1251(a)(2).

18. 40 CFR § 131.11. Under the Clean Water Act, economic and technological feasibility are considered in determining *how* to meet water quality standards, and to a lesser extent, in deciding what designated uses were attainable by 1983. *See* 40 CFR § 131.10(g)(6).

19. CWA § 303(c)(3), 33 U.S.C. § 1313(c)(3).

20. 40 CFR § 130.3; *see also* 40 CFR §§ 130.1(b), 131.2.

21. In fact, the degree to which poison runoff can be controlled dictates whether or not designated uses of individual waters are considered attainable:

> At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits ... and cost-effective and reasonable best management practices for nonpoint source control. 40 CFR §§ 131.10(d), 131.10(h)(2); 33 U.S.C. § 1315(b)(1).

In effect, a state cannot legally decide that the minimum fishable/swimmable goal of the Clean Water Act is not attainable in a particular surface water unless the state has developed a poison runoff control program that controls nonpoint sources to the maximum extent practicable, and *still* is unable to achieve fishable/swimmable water quality. Similarly, under EPA's antidegradation regulation, even where water quality is better than necessary to protect designated instream uses, allowing further degradation is prohibited unless, among other requirements, the state assures the achievement of "all cost effective and reasonable best management practices for nonpoint source control." 40 CFR § 131.12(a)(2); 33 U.S.C. § 1313(e).

22. CWA § 301, 402; 33 U.S.C. §§ 1311, 1342; *Crown Simpson Pulp Co. v. Costle*, 642 F.2d 323, 326-327 (9th Cir. 1981).

23. Of course, states are always free to impose more stringent controls than expressly required by the Clean Water Act. CWA § 510, 33 U.S.C. § 1370. Described above are provisions that *require* states to address poison runoff.

24. 33 U.S.C. § 1313(d)(1)(A). In addition, periodic state reports to EPA must identify the extent to which water quality standards are met. These reports must include a "description of the nature and extent of nonpoint sources of pollution," and recommendations on how to control poison runoff. CWA § 305(b)1), 33 U.S.C. § 1315(b)(1).

25. 33 U.S.C. § 1313(d)(1)(C).

26. 33 U.S.C. § 1313(e)(3)(c).

27. CWA § 303(d)(2); 33 U.S.C. § 1313(d)(2).

28. 33 U.S.C. § 1288.

29. CWA § 208(b)(2)(F)-(K), 33 U.S.C. § 1288(b)(2)(F)-(K). The specific poison runoff control requirements in section 208 are admittedly vague. For example, agriculturally and silviculturally related poison runoff must be identified "if appropriate," and pollution from these sources must be controlled "to the extent feasible ...." CWA § 208(b)(2)(F), 33 U.S.C. § 1288(b)(2)(F). Some leverage is added by CWA § 208(e), which requires that no discharge permit can be issued to a point source which is in conflict with a comprehensive water quality management plan. 33 U.S.C. § 1288(e); 40 CFR § 130.12(a). Thus, where an activity requires an NPDES permit under section 402 of the CWA and also involves poison runoff (such as a mining site), BMPs and other control measures can be enforced against the activity through the NPDES permit.

30. CWA § 304(f), 33 U.S.C. § 1314(f). These guidelines, developed pursuant to 40 CFR 131, consisted of documents published between 1976 and 1978 for use by state and areawide planning agencies that were involved in preparing water quality management plans to address poison runoff associated with construction, agriculture, silviculture, mining and hydrologic modification. *See, e.g.,* U.S. EPA, *Nonpoint Source Control Guidance, Agricultural Activities,* Washington D.C., February, 1978.

31. 40 CFR § 130.2(e).

32. 40 CFR § 130.2(f). The regulation requires that "[w]herever possible, natural and nonpoint source loads should be distinguished." *Id.*

33. 40 CFR § 130.2(g).

34. 40 CFR § 130.2(h).

35. 40 CFR §§ 130.7(b)-(c).

36. 40 CFR § 130.6(c)(4)(iii).

37. 40 CFR § 130.6(c)(4)(i) (emphasis added).

38. 40 CFR § 130.6(c)(4)(ii).

39. *Oregon Natural Resources Council v. U.S. Forest Service,* 834 F.2d 842, 851-852 (9th Cir. 1987); *Northwest Indian Cemetery Protective Assn. v. Block,* 795 F.2d 688, 697 (9th Cir. 1986).

40. *Shanty Town Associates Limited Partnership v. EPA,* 843 F.2d 782, 791-793 (4th Cir. 1988).

41. If so, the inadequate attention paid to poison runoff before the 1987 Amendments may have resulted more from a lack of serious EPA enforcement of existing requirements than from loopholes in the law.

42. Copeland, Claudia and Jeffrey A. Zinn, *Agricultural Nonpoint Pollution Policy: A Federal Perspective,* Congressional Research Service, December 1, 1986, at 9.

43. *Id.* at 8-11.

44. *See generally* NACD RCA Notes (No. 64), *Update to the Handbook of State and Local Cost Sharing*, August 25, 1987. This should be contrasted with the $160 billion (constant 1982 dollars) spent from 1972-1984 by federal, state and local governments (including over $40 billion in federal grants) to build, operate and maintain wastewater treatment plants through the CWA construction grants program. U.S. EPA, *National Water Quality Inventory–1986 Report to Congress*, November, 1987, at 109, 129.

45. Copeland and Zinn, 1986, *supra* note 42, at 8.

46. Where no state NPDES program exists, the program must be run by EPA under CWA § 402, 33 U.S.C. § 1412.

47. A recent report highlighted rampant state noncompliance with the requirement to calculate TMDLs, and EPA's failure to enforce that requirement. *See generally* U.S. General Accounting Office, *Water Pollution–More EPA Action Needed to Improve the Quality of Heavily Polluted Waters*, January, 1989. Citizens have had to drag EPA into court even to force TMDLs for point sources. *Scott v. City of Hammond*, 741 F.2d 992, 997-998 (5th Cir. 1984). In fact, EPA is currently being sued for failing to require that Idaho adopt adequate water quality standards and water quality-based controls applicable to NPS pollution. *Idaho Conservation League et al. v. EPA*, Civ. No. 87-1326 (D.Id. October 21, 1988).

48. *Briefing Book for CWA Reauthorization Hearing - Status of Nonpoint Source Pollution Control Planning and Implementation*, from James Meek, U.S. EPA to Frederic A. Eidsness, Jr., May 20, 1983, Tab B, at 1.

49. 133 Cong. Rec. S54-55, 567-568 (daily ed. January 6, 1987) (statement of Sen. Dole).

50. U.S. EPA, November, 1987, *supra* note 44, at 20, 80-81, 118-124. This report is submitted biennially pursuant to CWA § 305(b), 33 U.S.C. § 1315(b).

51. *See Amending the Clean Water Act, Hearings Before the Subcomm. on Env't and Pub. Wks.*, 99th Cong. 1st Sess., *reprinted in A Legislative History of the Water Quality Act of 1987 (Public Law 100-4) Including Public Law 97-440; Public Law 97-117; Public Law 96-483; And Public Law 96-148*, November, 1988, at 1665 (remarks of Sen. Mitchell) [hereinafter cited as *1987 Legis. Hist.*]; *see also 1987 Legis. Hist.* at 2069 (remarks of Admin. Ruckleshaus).

52. Congress had previously identified NPS pollution as a major concern. *See* H.R. Rep. No. 911, 92d Cong. 2d Sess. 105-106 (1972) *reprinted in A Legislative History of the Water Pollution Control Act Amendments of 1972*, Cong. Res. Serv., at 792-793 (1973) [hereinafter cited as *1972 Legis. Hist.*]; H.R. Conf. Rep. No. 830, 95th Cong. 1st Sess. 70-71 (1977), *reprinted in A Legislative History of the Clean Water Act of 1977*, Cong. Res. Serv., at 254-255 (1978) [hereafter *1977 Legis. Hist.*]; *id.* at 545-546 (Senate debate on 1977 amendments, December 15, 1977; remarks of Sen. Culver). Apparently, these warnings were not heeded to Congress' satisfaction. Nevertheless, in CWA § 319(a)(2), Congress expressly recognized existing requirements, and encouraged states not to abandon previous efforts:

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In developing the report required by this section, the State (A) may rely upon information developed pursuant to sections 208, 303(e), 304(f), 305(b), and 314, and other information as appropriate, and (B) may utilize appropriate elements of the waste treatment management plans developed pursuant to sections 208(b) and 303, to the extent such elements are consistent with and fulfill the requirements of this section.

53. This language became new section 101(a)(7) of the CWA.

54. The grant programs added or modified in 1987 do not actually modify the *regulatory* requirements governing NPS control.

55. CWA § 319(a)(1)(A), 33 U.S.C. § 1329(a)(1)(A). The Senate Report explains that the reference to both water quality standards and to the goals and requirements of the CWA reflects the fact that not all waters meet the Act's goals and requirements (*i.e.*, do not meet fishable/swimmable uses), and a desire that additional NPS controls be used to improve water quality and to upgrade these waters. S. Rep. No. 50, 99th Cong. 1st Sess. 35 (1985), *reprinted in 1987 Legislative History, supra* note 51, at 1456.

56. CWA § 319(a)(1)(B), 33 U.S.C. § 1329(a)(1)(B).

57. CWA §§ 208(b) and 305(b)(1), 33 U.S.C. §§ 1288(b) and 1315(b)(1).

58. CWA § 319(a)(1)(C) requires states to identify the *process* by which BMPs and other control methods are identified. The *control strategies themselves* are required by CWA § 319(b)(2).

59. This tool also has parallels in the existing statute.
See CWA §§ 103 (interstate compacts), 401(a)(2) (procedure for resolving interstate water quality disputes) and 402(b)(5) (permits affecting downstream states).

60. CWA § 319(d), 33 U.S.C. § 1329(d).

61. CWA § 319(d)(3), 33 U.S.C. § 1329(d)(3).

62. Also by contrast, EPA is authorized to promulgate substitute water quality standards and wasteload allocations where state submissions are lacking. CWA §§ 303(c)-(d), 33 U.S.C. §§ 1313(c)-(d).

63. CWA § 319(d)(2), 33 U.S.C. § 1329(d)(2).

64. CWA § 319(h), 33 U.S.C. § 1329(H). In addition, where
state plans are inadequate, local governments, with state approval, may submit their own plans to EPA, and may receive EPA technical assistance and a portion of the state's grant funds. CWA § 319(e), 33 U.S.C. § 1329(e).

65. U.S. EPA, *Nonpoint Source Guidance*, December, 1987.

66. *See, e.g.*, U.S. EPA, *Guide to Nonpoint Source Pollution Control*, July, 1987; U.S. EPA, *Creating Successful Nonpoint Source Programs: The Innovative Touch*, August 1988.

67. *See* Memorandum from Lawrence J. Jensen, Assistant Administrator for Water to All [EPA] Regional Water Management Directors (subject - Nonpoint Source Controls and Water Quality Managers), August 19, 1987.

68. CWA § 319(d); 33 U.S.C. § 1329(d).

69. *See generally* U.S. EPA, December, 1987, *supra* note 65.

70. CWA §§ 208(b)(2)(F)-(K), 33 U.S.C. § 1288(b)(2)(F)-(K).

71. 40 CFR §§ 131.10, 131.12.

72. Strictly, this language appears in the subsection dealing with the state's nonpoint source assessment. Subsection (b), which applies to the management plan, requires simply an identification of BMPs that will be used to control pollution from each source category. It is inconceivable, however, that Congress intended states to identify *different* sets of BMPs, subject to different substantive standards, in their NPS assessment reports and management plans, respectively.

73. *See* CWA §§ 102(a) (Administrator to develop comprehensive plans for groundwater protection); 104(a)(5) (Administrator to develop a water quality monitoring program for surface and groundwater); 104(l) (EPA study of pesticides in water, and alternatives to pesticides); 104(p) (cooperative study with Agriculture Department on reducing agricultural pollution); 105(grants to study reductions in pollution migration and agricultural pollution); 106(e) (no State grants to any State that has not provided for a program to monitor, to the extent practicable, surface and ground waters); 208 (areawide waste treatment management plans to be developed for areas having substantial water quality control programs, and to include controls to protect ground and subsurface water quality); 304(a) (Administrator to develop water quality criteria for effects of pollution on groundwater); 516(a)(Administrator to report to Congress on measures taken to develop comprehensive sec. 102 plans and sec. 208 programs).

74. S. Rep. No. 50, 99th Cong. 1st Sess. 36 (1985), *reprinted in 1987 Legis. Hist., supra* note 51, at 1457.

75. *See* CWA §§ 303 and 208, 33 U.S.C. §§ 1313 and 1288.

76. CWA § 319(c)(2), 33 U.S.C. § 1329(c)(2).

77. CWA § 319(b)(2)(C), 33 U.S.C. § 1329(b)(2)(C) (emphasis added).

78. 33 U.S.C. § 1329(b)(4). This requirement was emphasized in the Legislative History. *See* H.R. Conf. Rep. No. 1004, 99th Cong. 2d Sess. 144 (October 1986), *reprinted in 1987 Legis. Hist., supra* note 51, at 833.

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PART TWO

Components of an Effective Poison Runoff Control Program

Developing effective strategies to control poison runoff requires looking at the "big picture," and choosing among many alternatives. Because nonpoint source control is an area where certain traditional approaches predominate, government agencies often do not undertake a serious search for alternatives.[1]

> ... the consideration of alternatives to particular policies is generally superficial at best. The typical reaction is to decide on a course of action....and then to justify it. A serious search for alternatives is seldom undertaken.[2]

All government officials involved in controlling poison runoff need to bring an open mind to the full range of technical and

[1] *See* Eads, George C., and Eric Van De Verg, "Alternative Policies For Cleaning Up The Chesapeake Bay: A Framework for Choice," *Second Annual Conference on the Economics of Chesapeake Bay Management,* Maryland Department of Economic and Community Development, Annapolis, Maryland, May 28-29, 1986, at 3.

[2] *Id.*

non-technical problems and solutions to poison runoff. Part Two of this report is designed to help overcome the temptation to get stuck in the rut of traditional–and ineffectual–approaches.

Control programs must incorporate a diverse set of legal, policy and program tools all of which can be combined in any number of ways. However, each tool has certain advantages and disadvantages. These pros and cons must be understood before informed decisions can be made.

Part Two presents information to assist decisionmakers in evaluating and choosing the best basic program components or "building blocks" that are at the foundation of any comprehensive effort to control poison runoff. Part Two consists of six chapters, each of which considers a fundamental component of poison runoff control and offers recommendations for improving its effectiveness as part of an overall management strategy. Many examples are given to demonstrate that states can improve the value of their control programs in order to meet the requirements of the Clean Water Act.

Chapter Three addresses effective programs to control agricultural water pollution. Chapter Four considers land use control and other factors contributing to poison runoff in urban settings. Silvicultural, rangeland and mining programs are the subject in Chapter Five. The effective collection and use of data in poison runoff control is analyzed in Chapter Six, and important funding considerations are covered in Chapter Seven. Finally, the legal issues that are germane to effectively controlling poison runoff, including state water quality laws, local land use powers and common law, are addressed in Chapter Eight.

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Poison runoff generated from agriculture is the single largest source of several important water pollutants in the United States.

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Chapter Three

Agricultural Pollution Control Programs: A Time For Innovation

Introduction

What types of programs are most effective in reducing water pollution from cropland, livestock agriculture and irrigation return flows? There are wide differences in the *types* of pollution caused by agriculture and in the responsible transport mechanisms. The severity of the problem also varies significantly. Therefore, generalizations about the kinds of programs that are the most effective in reducing agricultural pollution are dangerous. Nevertheless, certain types of programs have distinct advantages over others.

Traditionally, programs to control poison runoff from agricultural lands have relied heavily, in fact, almost exclusively, on voluntary government cost sharing programs. Due to this historical trend, this chapter begins with an extensive discussion of the pros and cons of these programs. Following this evaluation is a discussion of programs to control agricultural poison runoff that rely on approaches other than voluntary cost sharing, such as regulatory-based design standards and incentive-based design taxes.

Voluntary Cost Sharing versus Mandatory Programs

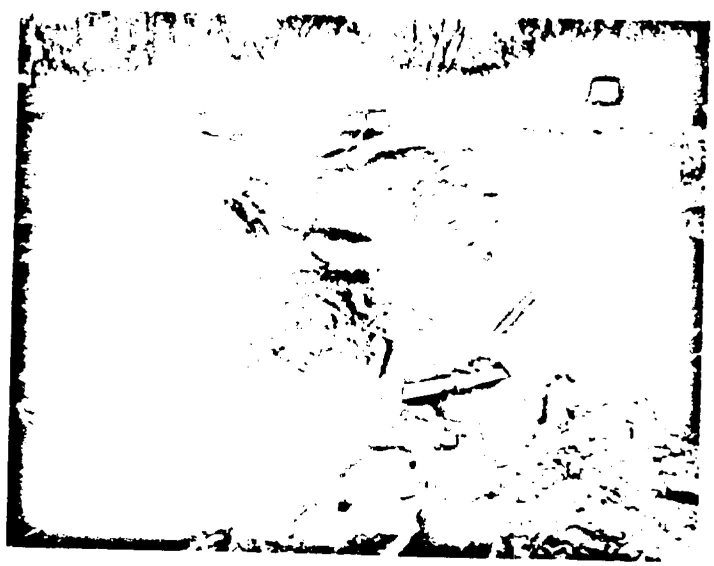
Current efforts to control polluted agricultural runoff rely heavily on voluntary cost sharing programs. Under these programs, government funds, education and technical assistance are provided to farmers to motivate them to implement structural or management prescriptions called Best Management Practices designed to reduce soil erosion or water quality degradation. The programs are voluntary, but government benefits are not available unless program requirements are met.

One of the most fundamental and most controversial issues in controlling the poison runoff and leachable contaminants caused by agriculture is whether a program based exclusively or predominantly on voluntary cost sharing, education and technical assistance is adequate to reduce agricultural pollution to the degree necessary, or whether mandatory controls are needed to supplement these efforts. A related question is whether such mandatory programs are rational, feasible and more effective than voluntary programs.

Past experience with voluntary programs to control agricultural pollution is not a perfect gauge to measure future voluntary efforts. In the past, many voluntary programs concentrated on reducing soil erosion rather than preventing water pollution, and only recently has water quality become a focus of some of these programs. Also, funding and state oversight of soil conservation (and in some cases agricultural pollution control) programs have improved somewhat over previous efforts.

Nevertheless, past experience tells us that certain fundamental aspects of voluntary cost sharing programs tend to limit their usefulness even with increased funding and oversight, and regardless of whether they are targeted to water quality problems. Conversely, even the limited experience with regulatory programs suggests that they have untapped promise, and should be reexamined seriously for controlling agricultural pollution.

Decades of voluntary cost share programs aimed at soil conservation and farm productivity have created expectations, on the part of farmers and policymakers alike, that voluntary approaches are preferable to mandatory ones for addressing



Streambank erosion can be attributed to cultivating to the edge of a stream or allowing unlimited livestock access to riparian areas.

water quality problems caused by agriculture.[1] As a consequence, little consideration has been given at the federal, state and local level to the use of mandatory approaches to control erosion, much less water pollution.[2]

But at least from a water quality perspective, an objective analysis of cost sharing demonstrates that the conventional wisdom may be wrong. In the words of one analyst, the voluntary approach has proven to be a "slow boat on waters that remain polluted with sediment, nutrients, and pesticides."[3]

In fact, many efforts to control poison runoff and prevent groundwater contamination under CWA § 208 were comprised largely of voluntary programs. Yet, the failure of CWA § 208 planning to improve water quality has been attributed in part to the voluntary nature of most state CWA § 208 plans.[4]

This does not mean that cost sharing has no place in an overall program to control agricultural pollution. Given the severity of contaminated agricultural runoff and the high cost of

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many controls, cost sharing in one form or another may be useful if not essential in many cases. A successful agricultural pollution control program should employ a range of management approaches. However, cost sharing should not be used to pay for controls that the farmer can afford without public assistance.

Therefore, the problem that must be faced is the *exclusive* (or primary) dependence on cost sharing (and the attendant education and technical assistance programs) to address water pollution from agricultural activities. This problem is magnified manyfold when cost sharing programs are not tied directly to pollutant load reduction goals as part of comprehensive watershed-wide water quality protection plans. Moreover, state officials often justify cost sharing based on the premise that mandatory programs are impossible or are not authorized under the CWA. As indicated in the preceding chapter as well as the remainder of this one, neither contention is true. Neither cost sharing nor regulatory approaches need be "chosen" over the other; most important, cost sharing should not be offered as a basis for rejecting the use of mandatory programs as well.

Below, we examine in greater detail the relative merits and drawbacks of voluntary and mandatory programs to control agricultural water pollution. We begin with an explanation of the historic roots of voluntary cost sharing programs and the effects of this long history on current strategies. Next, we evaluate economic, practical, public policy and other factors related to the use of voluntary and mandatory programs to control agricultural water pollution.

Historical Factors

The most significant influences on state programs to control agricultural water pollution have come from the U.S. Department of Agriculture's (USDA) federal assistance and land management programs, rather than from EPA's water quality protection programs. As a result, for the most part state programs to protect water quality from agricultural contaminants resemble the farmer assistance *USDA* model intitiated in the 1930s far more than they do the water quality-based *EPA* model contained in the 1972 Clean Water Act.

The USDA is the agency with primary responsibility for federal efforts to reduce soil erosion from the nation's 530 million acres of cropland.[5] USDA programs with soil conservation and pollution control potential are administered through a complex network involving primarily three federal agencies: the Soil Conservation Service (SCS), the Agricultural Stabilization and Conservation Service (ASCS) and the Cooperative Extension Service (CES).[6]

The SCS mainly provides technical assistance to farmers who participate in both state and federal soil conservation and agricultural pollution control programs.[7] The ASCS provides administrative support for both federal and state programs, and provides the cost share funds available through certain federal programs, such as the Agricultural Conservation Program (ACP).[8] The CES conducts research and furnishes educational services directly to farmers to help them improve crop productivity, control pests and reduce soil erosion and water pollution.[9]

These USDA agencies are part of an elaborate voluntary agricultural assistance network established in the 1930s primarily to enhance agricultural production and to improve the lot of the farmer and farmer families.[10] Through the years, the role of this assistance network has expanded to include soil conservation and, more recently, water quality considerations. Some USDA agencies maintain offices at the federal, state and county levels.[11] Federal employees work at the local level with local units of state government called Soil and Water Conservation Districts (SWCDs).[12]

SWCDs, managed by locally elected and unsalaried citizens (often farmers), were established (based on a legislative model prepared and actively promoted by the USDA) during in the 1930s and 1940s to improve the delivery of USDA program benefits to individual farmers.[13] Enabling legislation that states passed in order to establish these districts was similar to the federal model, except that most state laws did not include regulatory land use powers and created districts based on political, rather than watershed, boundaries.[14] Thus, as state programs with agricultural pollution control objectives were integrated into the USDA/SWCD soil conservation and farmer assistance model, most remained voluntary in nature—providing

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education, technical assistance and cost sharing to promote the adoption of BMPs designed to address soil erosion and water quality.[15]

Traditionally, "Technical Guides" and other planning tools used by USDA and associated SWCDs to design specific BMPs addressed primarily farm productivity and soil erosion concerns.[16] Addressing on-farm soil erosion concerns, however, is not the most effective means to address the *deposition of sediment* or pollutants dissolved in runoff or infiltration water, such as nutrients and pesticides.[17] Obviously, to the extent that soil erosion, as opposed to water quality, remains the primary focus of SWCDs' activities, the effectiveness of their programs to reduce water pollution from agricultural sources will be severely limited.[18] Recently, however, USDA has begun taking important steps towards addressing water quality concerns directly.

In its 1988-97 update of "A National Program for Soil and Water Conservation," USDA states that it will "elevate protection of water quality to second priority within existing USDA programs of research, education, and technical and financial assistance."[19] Among the activities planned to promote water quality protection are revisions to the "Technical Guides" to reflect groundwater protection, the development of an evaluation system to determine the impacts of BMPs on water quality, and improved training of SCS personnel in water quality protection techniques.[20]

While this new focus is necessary (and commendable), it does not ensure that required reductions of the poison runoff generated by agriculture will be achieved through a voluntary program approach. For instance, since the Guides are interpreted and implemented within the context of a locally managed and operated program and *only with the voluntary support of the landowner*, changing BMP specifications does not guarantee that the Guides will be followed faithfully or that enough BMPs will be implemented in a given watershed to attain compliance with water quality standards.

At the federal level, it is not clear how long it will be before activities to control nutrient, bacteria, pesticide *and* soil inputs into public waters are treated with equal importance compared to preventing soil erosion and improving farm productivity. This

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continuing uncertainty is evidenced by a recent statement by Peter Myers, Deputy Secretary of the Department of Agriculture, that the "principal objective" of the Soil Conservation Services is "to reduce soil erosion and the consequent adverse effects of sedimentation and depletion of the soil resource base."[21]

In summary, soil conservation and pollution control in the agricultural sector historically has relied on a "bottom-up approach based on voluntary participation and incentives."[22] The predominance of this approach can be traced to the long history of USDA agricultural and soil conservation programs, and the strong localized support for such programs.[23] Furthermore, USDA programs have been relatively successful in improving farm productivity—the primary goal for which they were created.[24] However, whether or not these programs (along with their state counterparts) are sufficient to comply with the critically important requirements of the CWA is another matter.

Participation in Voluntary Programs

In an approach dominated by voluntary programs, success in protecting water quality depends on individual farmers voluntarily accepting cost-share funds from local SWCDs and USDA to finance the installation of BMPs. Overall success depends on program-wide participation rates. More precisely, enough farmers in a given watershed must choose to employ BMPs that, in combination, will reduce pollution sufficiently to achieve water quality standards.

Unfortunately, there is little conclusive information on whether participation in voluntary agricultural cost sharing programs occurs at a rate adequate to achieve the load reductions needed to meet watershed-specific water quality goals. Participation in previous and current cost sharing programs targeted to soil erosion and productivity enhancement can be considered high, in that farmers may apply for all available program funds. However, this does not mean that adequate funds were available to achieve compliance with water quality standards, or that participation in a water quality-based program would be sufficient if high levels of farmer particpation were needed.

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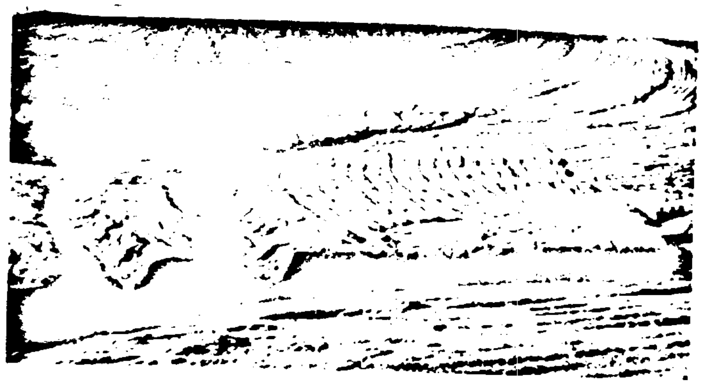
In fact, available information suggests that participation in voluntary water quality-based cost sharing programs may be too low to ensure program success. For example, a 1985 study of several voluntary Rural Clean Water Program (RCWP)[25] comprehensive monitoring and evaluation projects (in which adequate farmer participation was essential for program success) reported that five years after the RCWP was enacted, only two of the five projects had reached needed levels of participation.[26] RCWP is a federal program with over $70 million provided for intensive watershed planning, monitoring and cost sharing in just 21 watersheds scattered across the entire country.[27] With some notable exceptions, most state cost sharing programs provide no more than $1-2 million/year in cost-share funds. The limited participation in these RCWP projects—despite relatively large infusions of federal dollars—suggests that far smaller state programs would have even lower participation rates.

Logically, participation rates in programs designed specifically to address water quality may be expected to be lower than those designed specifically to address soil erosion and/or productivity. Soil erosion (and to a greater degree, productivity improvement) programs often have (or are perceived to have) on-farm as well as off-farm benefits. Thus they offer a "self-interest" incentive for farmer participation. In contrast, programs to protect water quality—often considered an off-farm benefit—present less (or no) inherent incentive for farmer participation.

From a micro-economic perspective, the voluntary approach to agricultural water pollution control may not be adequate because (as explained below) the profit motive of the farmer and general economic trends in agriculture often will prevent the voluntary adoption of soil conservation BMPs if they are perceived as having a negative impact on farm income. And to the extent that programs that are designed to reduce surface water and groundwater contamination from agriculture offer only BMPs designed to achieve "off-farm" water quality benefits (and these BMPs are perceived by farmers as reducing profits more than those that provide "on-farm" productivity and soil conservation benefits), the popularity of voluntary BMP programs will be even lower.



Severe sheet erosion can result from improper tillage and crop rotation decisions.

The success of a voluntary BMP cost sharing program in reducing agricultural pollution is largely a function of farm income: it works (*i.e.*, has a high participation rate) only when the farmer's return on the BMP investment exceeds BMP costs.[28] As with other business pursuits, profits drive the farmer's decisionmaking. Therefore, many analysts view economics as the primary factor influencing a farmer's decisions about how to farm his or her land.[29]

Reliance on the provision of information to farmers and on the development of positive attitudes towards soil conservation and land stewardship, long the management philosophy of USDA conservation efforts, are "necessary but not sufficient conditions to bring about the adoption of soil erosion control practices."[30] Thus it is even more unlikely that positive attitudes would be sufficient to motivate farmers to implement and maintain measures that are designed primarily to provide "off-farm" water quality benefits through reductions in sediment, nutrient, bacteria and pesticide runoff. "[M]ost farmers, because of economic and market constraints, place high priority on productivity and efficiency criteria when making decisions about what farming

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practices to use."[31] The importance of short-term survival leads to the general use of whatever farming techniques are perceived as maximizing short-term profits.[32] Unfortunately, some of these techniques incidentally degrade land and water resources.[33] Farmers under economic stress will:

> attempt to survive by ignoring soil erosion control practices or discontinuing practices that do not contribute to maximizing short-run output. Marginal land will be pressed into production; land devoted to such conservation practices as filter strips and crop rotation will be farmed; and existing land under cultivation will be farmed more intensively.[34]

Given the tenuous economic conditions in today's agricultural sector, it is not surprising that most farmers do not treat soil conservation and pollution control as a high priority. For example, studies have shown that farmers shun pollution-reducing "no-till" cultivation because they perceive it as risky.[35] They oppose practices that reduce nitrogen applications because excess nitrogen is often viewed as "insurance."[36] In fact, research has shown that farmers will continue to use land- and water-degrading practices even when they know they have an erosion problem, believe in soil conservation and are knowledgeable about conservation practices.[37]

Today it is popular to describe the on-farm economic benefits of soil conservation and pollution control BMPs.[38] However, while farmers need to be aware of potential economic gains (particularly long-term gains) from controlling poison runoff, they should not be given the false expectation that pollution control always translates into immediate profits. And where direct economic benefits to the farmer cannot be shown, participation in voluntary cost share programs is likely to drop. As explained above, voluntary cost share programs are often not effective as primary delivery mechanisms for state-wide agricultural pollution control programs because the implementation of many conservation practices (BMPs) may lower farm income.[39] With the possible exception of conservation tillage, "most research on the cost of soil erosion control in agriculture concludes that, for most farmers, the private costs of soil conservation exceed the private benefits...."[40] While controls designed to reduce the impacts of other pollutants such as nutrients and pesticides may have long term economic benefits to the farmer, initial reductions in profits to the farmer often are inevitable.

Moreover, farmers often do not make the connection between water pollution and any specific farm activities, particularly their own farm activities.[41] In one survey of farmers in the Great Lakes States, most said they "believed no relationship exists between farm fertilizers and pesticides, manure, or eroded soil and water quality."[42] Thus, when farmers *do* decide to employ innovative production measures, they often base their decision on profitability rather than conservation potential. And as mentioned previously, maintenance can also be a problem since farmers often neglect BMPs when economic conditions deteriorate.[43]

Finally, when farmers utilize BMPs to protect land or water resources, they often exaggerate the extent to which conservation practices are implemented.[44] All of these facts indicate that leaving conservation and water quality protection choices up to the farmer is not the optimal management approach, especially since, as indicated above, many controls often are *not* profitable to the farmer.[45]

These same factors would seem to indicate that farmers also will oppose regulatory controls. Curiously, however, this is not necessarily the case. Some farmers view increased regulatory control of agriculture as a legitimate exercise of government authority. Although research has not provided a model fully explaining farmers' attitudes towards regulation, some have speculated that farmers recognize that their past, relatively privileged immunity from environmental controls may be waning due to increasing public and governmental concerns over agricultural surface and groundwater pollution.[46] This reasoning was used to explain the results of recent polls indicating that 65% of the farmers in Iowa supported tighter regulations on the use of agricultural pesticides (over half favored tighter restrictions on fertilizer).[47]

Since farmers and their families often are the major victims of agricultural pollution, particularly groundwater impacts from agricultural chemicals,[48] the results of this study are not surprising. For example, unexplained headaches and chest pains, and foul-smelling drinking water were responsible for the decision of

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a farmer in Olmstead County, Minnesota to stop using pesticides and significantly limit his fertilizer use.[49]

On the other hand, some impacts of poison runoff are only felt miles away from the source, and controls often benefit some farmers at the expense of others.[50] This suggests that the agricultural community is unlikely to reach overall consensus concerning how pollution generated by agricultural activities should be controlled and that voluntary cost sharing will not be sufficient to bring about desired levels of BMP implementation.

Macro-economic Forces in Agriculture Discourage Voluntary Water Quality Protection

Certain enduring characteristics of U.S. agricultural production and the factors that influence decisions made by farmers will continue to limit voluntary acceptance of soil conservation measures and pollution controls. Agriculture depends on land as its basic capital input.[51] Unlike computer chips, steel or sulfuric acid, land is a resource that is fixed in a geographic space; its value cannot be altered by manufacturing it into a product or transporting it to another location.[52] In short, land cannot be centralized. Also, agricultural commodities generally have low prices based on highly elastic demand (*i.e.*, relatively small price increases by an individual farmer can greatly decrease his or her sales).[53] This tends to lead to overproduction and price instability.[54] Moreover, agriculture is a risky business because of uncontrollable and unpredictable climatic and other environmental conditions.[55] Finally, some of the economies of scale characteristic of many centralized industries are harder to achieve in agriculture (particularly row crop agriculture) because of the inevitable need for large quantities of land to produce a given amount of agricultural goods regardless of the overall size of the farm or the production inputs.[56]

These factors mean that agriculture generally produces low returns from investment, making large scale investment less likely than in more traditional industries.[57] Unfortunately, these structural and agronomic characteristics (price instability, low prices and high risk) that discourage centralization in agriculture also lead farmers to have short-term planning horizons and to engage in other "risk averse" behavior that results in environmental degradation.[58]

In addition to the implications of these economic factors, trends in farm management since World War II also:

> will tend to overwhelm approaches to soil conservation that rely on influencing farmer decision-making through cost-sharing, technical assistance and education.[59]

These trends include increased scale, mechanization, capital intensity and use of hired labor:[60]

> The result has been long-term trends toward row-crop and small grain monocultures; a reduced prevalence of crop rotation, particularly those involving legumes; separation of crop from livestock production;[61] and the intensification of crop production based on purchased petrochemical inputs.[62]

Implications for Poison Runoff Control Programs

These macro-economic changes in agriculture and the management trends discussed above are very important elements of the pollution control equation. The agricultural economy is *cyclical,*[63] whereas the need to protect water quality is *continuous*. Therefore, the cyclical downward trends in the agricultural economy can neither be combated by nor used to justify adhering to traditional, voluntary soil conservation and water pollution controls.[64] In other words, soil conservation and pollution reduction programs should be deliberately designed to remain in place regardless of short-term fluctuations in the agricultural economy.[65] Since poison runoff controls that are adopted and maintained voluntarily are likely to be abandoned under adverse economic conditions, state officials need to develop more permanent approaches (discussed in the following section) to ensure that the BMPs necessary for water quality protection are implemented.[66]

On the other hand, agricultural trends *should* be considered for their potential to increase or decrease water pollution. Understanding macro-economic trends in agriculture enables local, state, regional and national governments to develop taxation, marketing and economic development policies that better address water pollution needs.[67] In order to make use of these macro-economic trends, state and local poison runoff control officials first need to acknowledge the important relationship between state and regional changes in agriculture and programs to protect water quality. Tax incentives to convert cropland to timber stands could be created or increased.[68] Tax credits, venture capital, and technical assistance could be used to attract investors for the development of a regional animal waste processing and distribution industry.[69] Part-time production of specialty crops could be encouraged through state promotional campaigns, local land use management and tax incentives designed to create a favorable market climate for regional produce grown without farm chemicals. Besides state agencies, regional and local government entities also have important roles to play in promoting trends in agriculture that can have positive environmental benefits.

The Need to Apportion Costs Among Polluters and Taxpayers

While it is probably impossible to know all of the winners and losers in any particular pollution control program in agriculture, it is clear that a fair *distribution* of costs and impacts is important to successful program development.[70] Huge government expenditures would be necessary to provide enough cost sharing funds to accomplish pollution reduction goals.[71] The level of public funding needed just to cost share adequately the necessary *soil conservation* (not to mention *water quality protection*) BMPs could well be unacceptably high.[72]

For example, it has been estimated that at least 90 million dollars would be needed to address only soil erosion and animal-waste needs in Maryland.[73] Of course, government *can* decide to address agricultural runoff pollution by appropriating these huge sums. However, it cannot be claimed that voluntary cost sharing programs alone will suffice *unless* these expenditures are made and unless high participation rates are shown.

Moreover, such a massive infusion of government funding to pay for agricultural pollution control raises serious questions of equity. The general taxpayer is asked to subsidize pollution controls for an entire sector of the economy, without any analysis of whether these subsidies are needed. Arguably, cost sharing should be saved for situations where it is essential for maintaining the economic viability of the industry.

In fact, collecting taxes in order to provide cost sharing funds actually rewards farmers for correcting their polluting activities (at least to the extent that farmers will not accept payments unless the payments make them financially better off in the short term).[74] Rational farmers might choose to delay conservation activities in order to wait for higher levels of funding.[75]

Changes on the Nonpoint Source Management Horizon

Title 12 of the Food Security Act of 1985 (P.L. 99-198)[76] is an indication that the federal government is beginning to recognize the limitations of purely voluntary soil conservation and water quality protection programs. Four conservation provisions, implemented largely by the SCS and ASCS, were included in this new law to make the goals of USDA farm and conservation programs more consistent.

The Conservation Reserve (Subchapter IV) gives ASCS the authority to enter into ten-year contracts and to make annual rental payments to farmers who retire highly erodible land and land bordering water bodies from farming and plant it with a permanent cover crop, such as grasses, legumes or trees.[77] Under "conservation compliance" provisions (Subchapter II), farmers who plant annually tilled crops on highly erodible lands must implement locally developed and approved conservation plans by 1995 in order to remain eligible for price support, crop insurance and other USDA program benefits.[78] The "Sodbuster" provision (Subchapter II) also uses USDA programs to gain soil conservation benefits. To retain USDA benefits, farmers must follow a conservation system approved by the local soil and water conservation district when plowing fields that were not used for crop production between 1981 and 1985.[79] "Swampbuster" (Subtitle III) requires that USDA program benefits be withdrawn from all farmers who convert any naturally occurring wetlands to cropland after 1985.[80]

While these programs are targeted primarily at reducing soil erosion rather than at improving water quality, it is encouraging that agricultural programs that penalize poor land stewardship are being designed. The high visibility of these federal programs could stimulate the implementation of cross-compliance and other non-traditional programs at the state level. However, it remains an open question whether USDA is committed to moving away from primarily voluntary soil conservation approaches, much less towards water quality protection. After passage of the Farm Bill, the USDA Assistant Secretary for Natural Resources and the Environment stated that:

> [f]rom the outset I must emphasize that USDA is skeptical about the regulatory approach to correcting nonpoint-source pollution problems.[81]

In the summer of 1988, after a great deal of time and effort had been expended in USDA to begin implementing the "cross-compliance" provisions of the Farm Bill, this same official testified before a House Subcommittee that:

> USDA's primary strategy for dealing with nonpoint sources of water pollution is to encourage the *voluntary* development and application of Best Management Practices (BMPs) which restore and maintain productive uses of soil and water resources (emphasis added).[82]

Summary

Voluntary agricultural programs to control poison runoff are politically popular, and are a mainstay of the traditional soil conservation community.[83] However, voluntary cost-share programs usually have not been effective in improving water quality[84] because of many of the reasons illustrated above. More fundamentally, there have been and will continue to be many basic problems with using voluntary programs even for soil conservation purposes. Therefore, if even the broader goal of soil loss prevention is not promoted effectively through voluntary programs, it is axiomatic that such programs will not achieve water quality goals. And, as is discussed in detail later in the report, it is essential that water quality concerns drive programs designed to reduce the impacts of diffuse sources of pollution to suface water and groundwater.[85]

One of the important functions that USDA and associated state soil conservation agencies perform is to change behavior through "moral suasion" and informal information exchanges. It could be argued that any but voluntary programs could jeopar-

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dize this role by ruining the relationship between the farmer and the federal or state employee. However, non-voluntary controls are not mutually exclusive of these functions and could co-exist as part of a comprehensive water quality protection program. This is particularly the case if water quality agencies are responsible for the development and enforcement of such programs. SWCDs could maintain their relationship with the farmer while providing the state with technical assistance in evaluating problems, designing specifications and standards to protect water quality, and even assisting in inspection and enforcement activities.

Promising Alternatives to Voluntary Cost Sharing

Certain aspects of the agricultural sector lend themselves to mandatory pollution control programs. Some of these aspects are longstanding, while others result from recent trends in the structure of the modern farm.

Agricultural policies (including pollution control policies) often have been based on a vision of the small-to-medium size family farmer "working the land to provide a living for himself and his family, against almost insurmountable odds."[86] Although small "family farms" still exist and agriculture will never become as centralized as some industries, the vision of the "family farmer" is no longer accurate, either in terms of farm size or in terms of the environmentally benign picture it paints of agriculture.

Fewer, larger farms are producing a greater proportion of the nation's agricultural goods.[87] In 1984, 12% of the farms in the United States produced 68% of the agricultural cash receipts.[88] Today, family farms constitute less than 11% of moderate-size farms, compared to 21% in 1975.[89] Similarly, animal feedlots have decreased in number and increased in size.[90] There is a trend towards an agricultural sector split between very small, often part-time, farms and very large industrial operations.[91] One reviewer has remarked:

> Today's agricultural operations, especially those that produce the greatest share of the nation's food and fiber, are more accurately characterized

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Conservation tillage is one of the most effective means of reducing erosion rates on farmland.

as industrial activities requiring sophisticated management and producing significant amounts of environmental pollutants.[92]

These changes in agricultural production can cause "regionalized" agricultural production patterns. For instance, one region may shift towards part-time "hobby" farming and the production of specialized vegetable crops, while another shifts into vertically-organized poultry and/or livestock production.[93]

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This shift provides opportunities for improved water pollution control. For example, one result of the trend towards vertically-organized animal production has been the concentration of potential pollutants (especially urine, manure and organic matter) into relatively fewer, smaller geographic areas,[94] creating conditions similar to those usually associated with point sources. Concentration makes these pollution sources easier to identify, manage and control.

The growth of "corporate" farming also affects the cost considerations of controlling poison runoff. Because large-scale agribusiness corporations have relatively easier access to capital, pollution controls can be undertaken with less of an impact on farmers' personal income and financial stability. Thus, pollution control costs can be measured against the profitability of a complete vertical production and distribution system—not the production aspect alone. Moreover, the traditional hesitancy to interfere with the family farm has influenced the differences in the way point and nonpoint sources of water pollution were controlled.[95] Thus, to the extent that trends towards agribusiness concentration continue, the political willingness to develop more direct, regulatory water quality protection requirements might increase.[96]

Other Approaches to Agricultural Pollution Control

While it is easy to identify the weaknesses of voluntary cost share programs as well as any trends towards making more prescriptive approaches both desirable and feasible, it is not quite so easy to identify what particular kinds of programs might work better. Fortunately, promising options are available. These options are summarized in Table 3-1.

For instance, in situations where foregone short-term net returns to the farmer initially are so high that some public financing is needed, *investment tax credits* have been proposed as a potential income transfer to help offset the losses incurred through shifting away from the use of chemical fertilizers.[97] The use of "cross compliance" measures such as those found in the Food Security Act of 1985 have been mentioned previously. Other generic program approaches that do not involve cost sharing are discussed below.

Table 3-1
Possible Options for Agricultural Pollution Control

Option	Summary Description
1. Investment Tax Credits	Tax credit for expenditures needed to implement BMPs
2. Cross-Compliance Measures	Eligibility for financial and other government benefits contingent on implementation of BMPs
3. Performance Taxes	Differential tax based on amount of pollution caused by practices on a particular farm
4. Performance standards	Minimum runoff or water quality requirements prescribed
5. Design standards	Specific structural or management controls prescribed
6. Design Taxes	Differential tax based on specific farm management practices
7. Pricing mechanisms	Modify prices of inputs such as irrigation water, fertilizers, or pesticides, to discourage overuse

Technically, cost sharing is a form of economic incentive, and incentives are praised by economists as more "cost-effective" than other management approaches. But cost sharing is a subsidy and, hence, not the "type of economic incentive... favored by economists" since they "may result in higher costs than necessary."[98]

Control of poison runoff and groundwater contamination is most efficiently achieved through a combination of management and structural changes in the farm and not "simple additions of BMPs."[99] Keeping this in mind, generally the most *practical* program approaches are probably a combination of *general design standards* and *design taxes* to bring about the level of control needed to achieve state water quality objectives.[100]

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Strip cropping, or varying the tillage practices and crops grown in alternating "strips", can significantly reduce erosion rates on many farms.

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Design standards are imposed to prohibit or modify activities deemed to be environmentally unacceptable.[101] For instance, local governments could be required to develop and enforce ordinances that prohibit the application of pesticides near streams and lakes, the destruction of riparian vegetation, or the application of fertilizers or manure at rates that would threaten groundwater resources. In addition to design controls, performance criteria that prohibit any significant addition of pollutants from either point or nonpoint sources to state waters should be used when minimum design requirements are not adequate to control pollution from particular farms.

Design taxes consist of a variable tax, in which general polluting practices are taxed at different rates based on the relative environmental harm caused by the practices in a given area (*e.g.*, in areas with a particular soil erosion rate located within 200 feet of a stream).[102] With our present level of knowledge, it is not feasible to impose design taxes based on the water quality impacts of agricultural practices on individual farms.[103] However, *general* design taxes, under which farmers could be charged the same tax rates based on the predicted environmental impacts of various farm practices according to local topographical, soils, climatic and water quality conditions, can be developed and implemented.[104] For instance, farmers who choose to use conventional tillage, along with heavy fertilizer and pesticide applications, could be assessed a higher charge than a farmer who can verify the use of some beneficial form of conservation tillage in conjunction with an approved nutrient management and alternative pest control plan.[105]

While this type of design tax certainly holds promise, there is far less experience with its use than with design standards. The completely "rational" behavior of the farmer on which the success of design taxes depends has not been established conclusively.

Performance incentives and standards are a generic pollution control policy that also could be applied to agriculture. Unlike the farm-specific design incentives mentioned above, performance incentives would be directed at the individual farm's pollution flows and not its management practices, providing the farmer with the flexibility to adopt whatever BMPs were desired, so long as certain pollution flow criteria were met. Performance standards would consist of a requirement that certain minimum runoff or water quality criteria be maintained. Unfortunately, performance-based approaches are limited by a number of factors, including the effect of climatic variability on nonpoint source pollution flows and the difficulties of monitoring and enforcing such approaches. However, as improvements are made in our knowledge of the relationship between land use and water quality and the technology to detect certain changes in water quality, performance-based agricultural pollution controls hold some promise.

A useful analogy can be drawn from the approach EPA has developed to address the problems of hazardous waste treatment, storage and disposal facilities under the Resource Conservation and Recovery Act. As with farms, it is difficult to predict the precise level of environmental impact that will be caused by a given site. So, EPA has developed general *design standards* applicable to all such sites in an effort to provide an acceptable

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minimum level of protection.[106] The same principle can be applied to design standards for agriculture.

To date, few, if any, states have developed significant pollution reduction programs applicable to agriculture based on *general*, much less *farm-specifc*, design taxes. However, one example is given below. By contrast, many states and localities have adopted some form of design standards for agricultural water pollution control. We provide many examples in the pages that follow. Along with the standards themselves, the implementation and enforcement of these programs are described where possible.

In addition to examples of these programs, the use of other *pricing mechansisms* to improve the efficiency with which irrigation water is used (and thereby reduce the transport of poison runoff) is also addressed. Finally, *farmland protection programs* are described because maintaining properly managed prime farmland is an important component to a successful pollution control effort.

Promising New Approaches to Agricultural Erosion and Sediment Control

Erosion Control Through Zoning: Olmsted County, Minnesota

Some states and localities have developed mandatory programs[107] to require certain conservation practices to be implemented under a given set of circumstances. Olmsted County, Minnesota developed such a regulatory program[108] in response to surface water contamination due to excessive erosion. Because urbanization had pushed farms onto marginal, hilly land, data from 1974-1978 indicated that erosion rates in the county were at an unacceptable level of 10 tons per acre even with the increasing popularity of conservation tillage.[109]

Based in part on experience in another county showing that zoning could help reduce agricultural erosion problems, Olmsted County used model zoning ordinances, provided by the Minnesota Department of Agriculture and the Association of Minnesota Counties, to control its farmland soil erosion problems.[110] Use of a county ordinance to control farmland activities rather than

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urban activities was an important innovation that grew out of the County Board of Commissioners' recognition that local governments were being given more responsibility for resource management.[111]

Olmsted County adopted an ordinance that requires all farmers to implement those BMPs needed to reduce soil erosion to "tolerable" levels by developing and adopting an SCS-approved "conservation plan." This ordinance requires farmers to develop and implement a conservation plan, effectively prohibiting agricultural practices that cause excess erosion in fields and on stream banks.

The Olmstead plan is designed to address two major concerns. The first was that typical conservation ordinances are based on private complaints. Olmstead was concerned that this approach might unnecessarily harm farmers and cause resources to be spent on solving relatively minor erosion problems.[112] The second was that erosion control regulations might have unacceptable economic impacts on some farmers.[113]

In order to assure that enforcement focused first on the most serious erosion problems, a ranking system was developed. Using models and digitized soils and land cover data Olmsted County developed a system that assigns points to the land parcels not complying with the soil loss tolerances established in the ordinance itself, based on a variety of weighted factors including total erosion rates, ratio of erosion to "T" standards,[114] quality of pastureland, hydrologic characteristics and location within a flood control project watershed.[115] The total score for a particular parcel of land determines its enforcement priority (determining when particular farms should develop conservation plans or other erosion controls) and how violations should be treated.[116]

Potential adverse economic impacts were addressed by allowing the County Board four options to address violations of the ordinance:

1. to grant an extension of up to 120 days in the preparation of a conservation plan;

2. to grant an extension of up to two years in the implementation of conservation practices required in a plan;

3. to direct the Zoning Administrator to proceed with a civil suit seeking an injunction compelling compliance with the ordinances; or

4. to direct the Zoning Administrator to proceed with normal criminal enforcement proceedings.[117]

The extensive modelling that is necessary to estimate erosion rates and develop the priority ranking system is conducted with the Minnesota Planning Information Center's computer software and the county's digitized soils and land cover files, which are summarized to the level of one-tenth of an acre.[118] These data, along with models, were used to estimate sheet and rill erosion, wind erosion, the ratio of erosion to tolerable soil loss, poorly managed pastureland and the volume of runoff expected from particular land parcels.[119]

Because the information is in a variety of formats, it can be used to evaluate erosion on specific sites, and for broader planning purposes.[120] Ultimately, the county should be able to evaluate, as part of the site planning process (not as a set of constraints after site planning is completed), the land and water impacts of alternative subdivision designs to determine the most desirable sites for septic systems, buildings, roads, and drainage control systems.[121]

The Farmland Soil Erosion Ordinance allows a host of individuals and public officials to register complaints against landowners who are not complying with the standards established in the ordinance and developed through the computerized modelling efforts.[122] County enforcement of the standards is based on the priority ranking system also described above. The County Zoning Administrator is required to prepare an annual enforcement priority listing (which also takes into account complaints of excessive erosion). This list must be submitted to the SWCD and the County Conservation Committee, who then must investigate the areas on the priority listing and determine the level of compliance with the standards in the ordinance.[123]

Landowners found to be in noncompliance with the standards in the ordinance are required to develop Conservation Plans meeting the requirements of Technical Guides of the Soil and Water Conservation Districts.[124] Schedules are supplied for the completion of the plans and procedures are in place for the annual inspection of work carried out on the plan, for plan approval, and for appeals, variances and exemptions.[125] Enforcement is expedited because this ordinance provides for administrative proceedings to be used in considering cases of economic hardship, rather than automatically requiring the involvement of courts to consider such issues.[126] Also, since it was thought that judicial enforcement of criminal violations would be unlikely, the ordinance gives the Zoning Administrator authority to file a civil suit seeking an injunction against a violator.[127]

Besides those designed to reduce soil erosion, other mandatory programs have been proposed and developed to reduce surface and groundwater contamination from agricultural chemicals and bacteria. Examples of these programs are described in the following two sections.

Erosion Control Through Design Taxes: Pepin County, Wisconsin

Pepin County, Wisconsin is experimenting with the use of design taxes to address both soil erosion and agricultural runoff pollution. The goal is to provide positive rather than negative incentives to farmers. A five-year pilot program has been established in three Wisconsin townships by the Soil Conservation Service and the Pepin County Land Conservation Committee.[128] Using funds provided by SCS, a $3.00/acre property tax rebate[129] was offered to landowners who regularly tilled their soil if the land was treated (with the farmer assuming all treatment costs and responsibility) to reduce erosion to tolerable levels (T).[130] Ten percent of the program participants are randomly inspected for compliance each year.[131]

The program is based on the idea that tax relief should be offered to farmers who implement conservation practices with the *resulting tax burden* falling on the remaining operators not implementing conservation practices.[132] As more landowners enrolled in the program the tax differential would be set at a lower level and, with all landowners participating, the differential eventually would disappear.[133] However, because the Wisconsin state constitution requires uniform taxation of landowners, funds for the tax rebates had to be provided by outside sources (in this case, SCS).[134]

Compared to cost sharing programs, the results of the program seem promising. Acreage in the pilot townships coming under conservation practices more than doubled (12,598 acres to 30,126 acres) while increases in the township without the program were negligible (a 308 acre increase over an existing 23,204 acres already under conservation measures).[135] Adequately protected cropland in the pilot areas increased from 49.8% to 85.6% of total cropland acres, with 73.4% of all landowners with farms over 40 acres participating.[136] In contrast, only 22.6 percent of the farmers had participated in a cost sharing program in the last five years.[137] The costs of the program were: administrative - $12,000; technical assistance - $55,000; conservation practice planning, installation and inspection - $53,000; and tax credits - approximately $400,000.[138] An assessment of the tax credit project indicated that the hours needed for program administration and technical assistance were low compared to other types of financial incentive programs, such as cost sharing.[139]

Most participating farmers supported funding the conservation credit program through money used for current cost sharing programs.[140] The Pepin County Board, with support from all eight townships in the county, recently decided to support this program even after SCS funds are no longer available by having each township increase property taxes on all land in the county.[141] The state is transferring part of its cost sharing funds to the county for the development and implementation of the program.[142] To improve the disparity between the benefits received by farm and non-farm residents, part of the money will be used exclusively for nonagricultural water quality improvement projects.[143]

The major obstacle remaining in the development of this program is the requirement in the state constitution for uniform tax treatment, which prevents the application of higher property taxes to those landowners not implementing conservation plans.[144] In addition, the County Board, as well as others, recognize that "bad actors" are essentially rewarded under this kind of program relative to other farmers who implemented sound conservation practices before the program began. Finally, landowners who implement conservation practices may be financially affected in absolute terms because the value of their land will increase as a result of their good land stewardship practices,[145] leading to higher overall tax assessments.

There are two key reasons why the Pepin County program has been such a success. First, it was locally developed and implemented.[146] Second, it had high visibility in terms of reducing property taxes.[147] For instance, the percentage of farms participating in the pilot conservation credit program at the *local* level is much higher than the percentage participating in the *state* Farmland Protection Program (the state farmland protection program provides similar tax incentives for implementing conservation plans).[148] This is probably because the state program is administered in the state capital, is somewhat complex, and is based on income tax, rather than property tax.[149] Although obstacles remain, the high rate of participation, the involvement of local governments and the enthusiasm of program officials all indicate that taxes can be a significant tool to address pollution from agricultural lands.

Reducing Chemical Pollution from Agriculture

Measured by volume, sediment is the most prevalent pollutant from agricultural runoff. But it is agricultural chemicals that represent a major water quality threat. Fertilizers are a known cause of nutrient enrichment and groundwater contamination in many parts of the country, while concern over pesticide contamination continues to grow. Agricultural chemicals can contaminate surface water by attaching to soil particles or dissolving into surface runoff.[150] Contaminants also can enter groundwater or be transported to surface water through leaching.[151]

Some researchers feel that the most difficult pollution problem associated with nitrogen is nitrate contamination of groundwater.[152] Ironically, soil conservation practices that control surface runoff of nitrogen can increase nitrate leaching, which in turn can pollute groundwater or surface water (through the interaction of surface and shallow subsurface waters).[153] Therefore, control of nitrogen (and also phosphorus)[154] often should focus on "chemical management" to ensure that the "timing and

Applying chemical fertilizers to farmland can lead to water with an over-abundance of algae while depleting oxygen and aquatic life.

amount of nutrient are matched to crop needs" to minimize the nutrients available for leaching and surface runoff.[155] Because of the strong relationship between groundwater and surface water quality, any programs designed to address one will have to be coordinated effectively with the other.

Given the research estimate that 50 percent of applied nitrogen is not taken up by crops,[156] it is not surprising that the contribution of fertilizer to nutrient pollution is large. As mentioned above, efforts to control nitrogen must focus on the use of nitrogen fertilizer.[157] Over-application of nitrogen occurs because farmers set overly high yield goals for their acreage and do not take into account the nitrogen provided by crop rotations and manure.[158]

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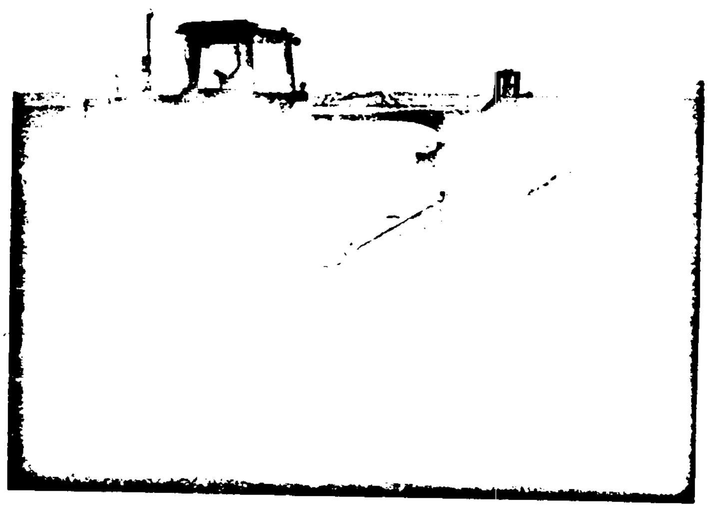
Fertilizer nitrogen is both the largest and the most controllable nitrogen input into the farm system (although livestock are a significant source of nitrate, especially in areas with high livestock densities).[159] In addition, farmers often could save money by reducing their use of nitrogen.[160] This is an important factor because the low profit margins associated with agriculture mean that reduced input costs (such as those associated with commercial fertilizers) can be even more important to a farmer's financial situation than increased yields.

In addition to improving the timing and amount of chemical fertilizers applied, substituting organic nitrogen from cover crops and manure while concurrently reducing the emphasis placed on implementing soil conservation BMPs have been suggested as part of an overall plan to reduce the chemical addition of nitrogen and the water pollution it causes.[161] Organic nitrogen has advantages over inorganic nitrogen in chemical fertilizers because nitrogen bound to organic matter leaches at a much lower rate, can improve soil fertility and is available for additional plant uptake.[162]

Another important method to reduce nutrient (especially nitrate) inputs into surface water is the use of forested riparian "buffer zones." By trapping sediment, assimilating nutrients and promoting the conversion of nitrate nitrogen to nitrogen gas, forested buffer strips as narrow as 50 feet can "remove the majority of nitrogen and phosphorus from surface and subsurface runoff."[163] The importance of subsurface flow as a pathway of nutrients into surface waters and soluble nitrate as a fraction of total nitrogen makes forested riparian areas preferable as a nutrient reduction "structural" BMP to those that reduce primarily particulate-associated nutrients.[164]

The lack of controls on pesticide applications to protect groundwater also has been well documented.[165] Reducing pesticide contamination often involves simply not using persistent substances (or using them in smaller quantities) where they can migrate to surface water and groundwater resources, without first testing for the presence of the target pest (prophylactic use).[166] Reducing pesticide use also can be accomplished through:



Many farmers continue to use heavy applications of pesticides even though the long-term health and environmental impacts may be severe.

1. using alternative crop production patterns and techniques—for example, crop rotation can eliminate or limit infestation by certain pests, or improve soil conditions, resulting in heartier crops and more pest predators;

2. modifying agricultural practices, application equipment and use patterns—for example, by applying chemicals only at rates and times indicated by field testing and monitoring to determine pest levels, or by using cultivation practices that limit weed growth; and

3. replacing leachable pesticides with materials that are less mobile, persistent and toxic—for example, by substituting the use of natural predators for a dangerous pesticide or using another chemical that degrades into safer compounds more quickly.[167]

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Other possible program components to control pesticide use include:

1. taxes on the sale and/or manufacture of pesticides to fund monitoring studies and to build a statewide data base;

2. requirements for pesticide users to report when, where, and how much a particular chemical is applied;

3. registration of pesticides at the state level, including information requirements (chemical data and monitoring results) designed to determine their potential to leach into groundwater;

4. authority for states and localities to cancel pesticide registration in local areas if soil conditions and other factors indicate a serious leaching problem; and

5. encouragement of pesticide substitution, changes in irrigation practices, prevention of chemical applications near drinking water wells and integrated pest management.[168]

Thus, there is no shortage of possible mechanisms for controlling water pollution from agricultural chemicals. The question remains, however, how to develop programs to ensure that these techniques are applied in the field. Below, we describe existing regulatory programs to control surface and groundwater contamination from both fertilizer and pesticides.

Regional Design Standards for Fertilizer Use: Central Platte Natural Resources District, Nebraska

Nebraska is beginning to incorporate design standards into its agricultural pollution control programs in order to address the contamination of groundwater by nitrates from commercial fertilizers.[169] By statute, Nebraska created Natural Resource Districts (NRDs) that have taken over the responsibilities of SWCDs as well as all local and regional water-quality and resource protection agencies.[170] NRDs have broad powers that

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include taxation and eminent domain and are required to implement a regulatory program designed to reduce water contamination.[171]

In response to increased awareness of groundwater contamination, the Nebraska Ground Water Management and Protection Act was passed to create a procedure by which Natural Resources Districts can designate groundwater control areas and subsequently adopt at least one of the controls stated in the Act.[172] These include: "reasonable rules and regulations as are necessary to carry out the purpose for which a control area was designated."[173] Groundwater management plans must be prepared for those areas not previously listed as control areas.[174]

One Natural Resource District, the Central Platte NRD (CPNRD), has developed a vigorous regulatory program in response to the high levels of nitrates found in many of the drinking-water wells in the area.[175] This program is designed to accomplish the following objectives:

1. extract the nitrates in the groundwater by utilizing them for the nitrogen needs of the crop;

2. fully utilize the residual nitrates in the soil profile for the nitrogen needs of the crop;

3. reduce fertilizer applications to account for nitrogen available in the soil and in irrigation water;

4. reduce the "opportunity time" for fertilizer to leach below the root zone;

5. encourage (and require) farm practices, techniques and the installation of equipment that have proven to be helpful in reducing groundwater nitrate levels and nitrate leaching; and

6. research new equipment and techniques that have potential for reducing groundwater nitrates.[176]

Areas within the NRD with groundwater quality problems are categorized based on the level of contamination; increasing degrees of regulation are applied as the level of contamination increases.[177] Land is classified as a Phase I management area if the average nitrate/nitrogen level (measured by the district's network of monitoring wells) is between 0 and 12.5 ppm.[178] Phase II areas contain average nitrate levels between 12.6 and 20.0 ppm, while Phase III areas have average nitrate levels exceeding 20.0 ppm.[179] Monitoring to determine average nitrate levels takes place periodically to determine if an area should be reclassified.[180]

In Phase I areas, the fall and winter application (before May 1) of commercial fertilizer is prohibited on sandy soils (defined as soils with a permeability rate of two inches per hour or greater for at least 30 of the upper 36 inches).[181] In addition, water and soil testing and other nitrogen management BMPs are encouraged.[182] Farmers in the District's Phase II area, which covers 440,000 acres, are required, in addition to Phase I requirements, to attend irrigation and fertilizer management classes to become certified in nitrogen management.[183]

Generally, an annual water analysis for each irrigation well (there are 4,500 in the Phase II area) and an annual deep soil analysis on each field are also required.[184] Fall application of fertilizer is banned under most circumstances but is permitted on heavier soils after November 1 if an approved inhibitor is used to improve the efficiency of nitrogen use.[185] Farmers are required to submit an annual report to the district indicating:

1. results of the water nitrate analysis for each well;

2. results of the soils analysis on each field or 40 acre tract;

3. the crop planned to be grown and the yield goal;

4. nitrogen fertilizer recommendations;

5. actual nitrogen fertilizer rate applied; and

6. the actual yield achieved by each field, with irrigation well locations indicated.[186]

While there are no Phase III areas in the Central Platte NRD at this time, Phase III regulations which would be triggered if any are identified have been written. Under Phase III regulations, fall and winter applications of commercial nitrogen are banned while use of fertilizer in the spring requires split applications (or the use of an inhibitor if 50% or more of the fertilizer is applied before the planting).[187] In addition, Phase III controls can include such "other reasonable regulations as the Board feels are necessary to resolve the problem."[188]

The CPNRD, as well as local fertilizer dealers, are assisting farmers in meeting these regulatory requirements by working with testing laboratories to develop a standard form that will contain the necessary sampling information; providing a tagging service to identify each well; and considering arrangements with fertilizer dealers to offer soil and/or water sampling as a service to farmers.[189] The Board of Directors of the CPNRD believes this regulatory program will have a positive economic impact because of the savings to individual farmers from better use of the nitrogen available in irrigation water and in the soil.[190] Although the program began in late 1987 and no comprehensive data is available to judge its success, those participating in the meetings and hearings that led to the adoption of the regulations "showed a strong interest in improving and protecting ... groundwater quality and support for the type of program the [CPNRD] proposed."[191]

Statewide Groundwater Protection Regulations: Wisconsin

Wisconsin has a groundwater management law that provides a simple yet effective regulatory framework for addressing agricultural (as well as any other) groundwater pollution.[192] By extension, the law could be modified to apply to surface water protection as well. The Wisconsin law provides for the development of groundwater standards in the form of "preventive action limits" and "enforcement standards."[193] These two standards must be developed and implemented for substances detected in, or with the potential to enter, groundwater.[194] Some substances are listed in the Act itself. Additional substances must be identified by a number of state agencies that regulate activities, facilities or practices related to the regulated substances. The Department of Natural Resources (DNR) must set the actual standards through regulation,[195] addressing the most important contaminants first.[196] Each substance to be regulated must be included in one of the following three categories:

1. Category 1 - highest priority substances and detected in levels exceeding available federal criteria;

2. Category 2 - those detected in groundwater but not in excess of available federal criteria; and

3. Category 3 - lowest priority substances that have a "reasonable probability" of being detected in groundwater.[197]

"Enforcement standards" define when a violation has occurred and require the activity, practice or facility that is the source of the violation to be subject to immediate enforcement action.[198] Preventive action limits are considered "warning levels" to determine the need for regulatory measures.[199] When a preventive action limit is met or exceeded, the regulatory agency with authority over the substance must evaluate the situation and take whatever action is necessary to maintain the concentration of the substance at the preventive action limit or, if it has been exceeded, at the lowest feasible concentration.[200]

After enforcement standards have been promulgated, regulatory agencies must review relevant rules regarding the activities, practices and facilities that are related to each substance and, if necessary, revise their rules to comply with the requirement to prevent violations of the standards.[201] Each agency must adopt a rule indicating the responses the agency may require of itself or responsible parties when standards are exceeded.[202] Rules regarding design and management practices must ensure compliance with preventive action limits and enforcement standards, if feasible.[203] Whenever a pollutant reaches or exceeds the preventive action limit or enforcement standard, relevant agencies must again review and, if necessary, revise their rules to ensure future compliance with these standards.[204]

When a violation of a preventive action limit occurs, involved regulatory agencies must evaluate the situation and implement activities that will:

1. where technically and economically feasible, minimize the concentration of the substance at the point where measurements are taken to determine standards violations (the point of standards application);

2. regain and maintain compliance with the preventive action limit, or if this is not technically or economically feasible, the lowest possible concentration; and

3. ensure that enforcement standards are not violated.[205]

If an enforcement standard is violated, however, the activity or practice using or producing the substance *must* be prohibited unless it can be demonstrated to the regulatory agency that an alternative control mechanism will achieve compliance with the standard.[206] Once compliance is achieved, the regulatory agency is responsible for ensuring compliance with the preventive action limit in the same location.[207]

The DNR, in cooperation with other regulatory agencies, must develop and maintain a groundwater monitoring and sampling system. DNR must notify the relevant regulatory agency when information indicates that a substance has been detected, a concentration of a substance is changing, or a standard has been violated.[208] DNR also must notify owners and users of potable wells of the testing results of any samples obtained from the well.[209]

The Wisconsin program has not been fully implemented, but the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) already has used it to help curb the use of the pesticide aldicarb. Current activities include increased groundwater monitoring requirements and a ban on certain aldicarb applications in areas where measured groundwater concentrations exceed 10 parts per billion (ppb).[210] Permitted uses of aldicarb have also been restricted. The pesticide cannot be applied more than once every two years, and is limited to an application of 2 pounds of the active ingredient per acre (down from 3 pounds).[211] In addition, it can only be applied by, or under the supervision of, a state-certified pesticide applicator.[212]

On the Horizon: A Proposal for Comprehensive Groundwater Quality Protection

Few comprehensive programs have been developed to address systematically the groundwater contamination caused by both fertilizers and pesticides. However, a generic management proposal has been made by a group of environmental organizations for a federal groundwater protection program that also can be translated into recommendations for state programs designed to prevent groundwater contamination.[213] This program calls for the development of a general goal to protect groundwater quality along with waste reduction and source reduction goals to reduce total loadings of various groundwater contaminants (including pesticides and nitrates)[214] by specified percentages.

Over a period of time, the proposal suggests the development best practical methods (BPMs) and best available alternative method standards (BAAMs) to be applied to various activities responsible for groundwater contamination.[215] The standards would be required immediately for new and substantially modified sources, and would be phased in gradually for existing sources.[216]

Groundwater standards and monitoring strategies are proposed as a means of determining "special protection" and "special correction" areas where protection requirements would be more stringent.[217] Other program components, such as groundwater mapping, source identification and well monitoring and replacement would help to ensure that the program would function effectively.[218]

Agricultural officials in Massachusetts have proposed to control pesticide contamination of groundwater through a process similar to the one described above. First, pesticides that pose a risk to groundwater would be targeted by identifying:

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1. pesticides that are susceptible to leaching because of physical and chemical properties;

2. application factors that may contribute to leaching;

3. priority pesticide use areas and the amount of pesticides used in these areas; and

4. the land areas susceptible to leaching because of geologic conditions.[219]

Each pesticide that may pose a risk to groundwater then would be ranked according to the health risk based on toxicological reviews, environmental fate studies and drinking water monitoring.[220] A variety of actions could be taken to ensure that pesticide residues do not approach the "health based standard as determined through the toxicological review."[221]

The action undertaken would depend on whether concern is focused on the control of a single pesticide (*e.g.*, product registration) or on the protection of the groundwater resource in general (*e.g.*, statewide regulations).[222] Since the groundwater protection program would function primarily on a pesticide-by-pesticide basis, many regulatory responses would involve changes in the registration conditions of individual pesticides.[223] Potential controls include restricted pesticide registrations that would allow their use only under specified conditions to protect groundwater resources.[224] Registrations also could be revoked, suspended or limited in a specific geographic area.[225]

Although this particular proposal has not been adopted, the Massachusetts Department of Food and Agriculture recently proposed regulations to "prevent contamination of public drinking wells by pesticides that pose a significant toxicological concern and meet or exceed significant leaching potential criteria."[226] The regulations would prohibit the use, handling, mixing, loading or storage of any pesticide posing a significant toxicological concern that has a significant leaching potential or is incorporated below the soil surface in sensitive groundwater areas.[227]

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Other Promising Agricultural Runoff Control Programs

Florida has a state regulatory program addressing the water quality impacts of *new* farms in the state. The Department of Environmental Regulation (DER) requires that new farming operations in the state comply with its requirements for stormwater permits[228] unless the farm is operated under the requirements of an approved conservation plan.[229] Many agricultural operations, such as "muck farms" that are periodically flooded and drained, must obtain Management and Storage of Surface Water (MSSW) permits based on computer modelling and a review of the operation by a water management district official.[230] These permits contain site-specific requirements for the maintenance of certain BMPs and the abatement of pollution problems for the purpose of complying with state water quality standards.[231]

In other states, programs are being considered or are under development that address farm chemical contamination. A bill was introduced in the Pennsylvania General Assembly in 1988 that would "establish requirements and an implementation schedule for the application of nutrient management control measures on agricultural operations."[232] The bill would establish a program requiring all farmers to submit and implement a "best management plan for nutrient control" in conformity with requirements and regulations adopted by the state Department of Environmental Resources (DER).[233] Although not in agreement with the specific details of the proposal, DER supports the concepts of the bill.[234]

In Arizona, legislation has been enacted that requires the Department of Environmental Quality (DEQ) to adopt General Permit rules that require the implementation of Best Management Practices for nitrogen fertilizer application.[235] By statute, the application of nitrogen fertilizer is a regulated activity which requires site-specific BMPs to be developed and used such that Aquifer Water Quality Standards are not violated.[236] Although permit requirements have not been developed at this time, the simple, straightforward nature of these program requirements indicates that the adoption of BMPs to manage fertilizers does not, by nature, have to be left completely to the discretion of the farmer. The program also shows that state environmental protection agencies can play an important role in the development and application of agricultural BMPs.

DEQ will propose rules requiring the implementation of a BMP plan that consists of an "on-site operational plan" and "appropriately implemented site-specific BMPs."[237] One of the purposes of the BMPs that will be developed will be to minimize the "movement of soluble nutrients to depths below the root zone."[238] While this program is still in the formative stage, it demonstrates the state authority that can be exercised when water resources are threatened.

Using Regulatory Controls in Livestock Agriculture

Livestock, including dairy and beef cattle, hogs, sheep and chickens, can contaminate surface and groundwater with nitrate, ammonia and fecal bacteria and also can increase drastically streambank erosion if the animals are allowed access to riparian areas.[239] Half of the 120 million tons of animal manure produced each year in the United States is generated by herds of *less than 100 cows* owned by hundreds of thousands of individuals.[240] These sources currently are not regulated under the CWA because, under EPA regulations, point source controls generally do not apply to herds of less than 1000 head.[241] Because water quality problems can result from small and medium-sized herds of cattle and other livestock, as well as from larger herds,[242] pollution control programs need to address all sizes of livestock operations.[243]

One hundred million cattle are raised unconfined on 40 percent of the U.S. land area (including both pastures and rangeland.[244] But the remaining 12 million head raised in confined feeding operations also can cause severe water quality impacts.[245] This section discusses pollution control programs for confined livestock feeding operations and the associated (unconfined) grazing of such livestock in limited pasture areas as distinct from rangeland settings.[246]

In general, few states have developed significant regulatory programs for controlling animal wastes from small, confined animal feedlots or from unconfined cattle production.[247] Howev-

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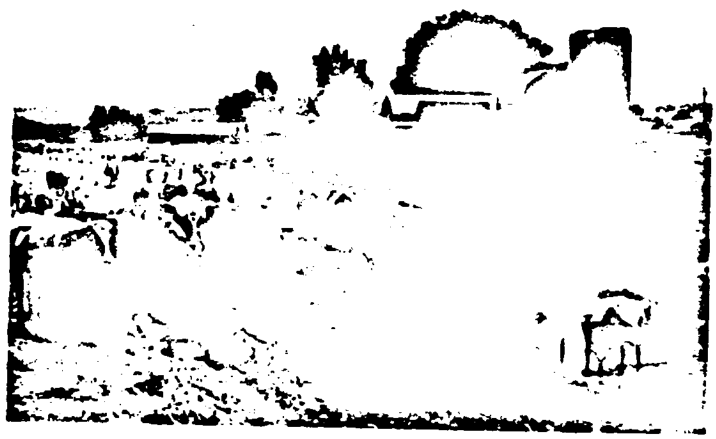

Livestock agriculture accounts for widespread water pollution problems.

er, some activity is underway, and the potential for more progress is good given recent research concerning methods for reducing the water quality impacts of livestock production.

Generally, control of contaminated runoff from unconfined cattle production (in both range and pasture settings) can be accomplished by:

1. using an effective erosion control program (discussed previously);

2. tailoring grazing programs and stocking densities to localized climate, soil, vegetation, topography and geology;

3. locating high density grazing and holding pens away from streams and associated riparian areas;

4. dispersing feeding, watering and shelter facilities to reduce manure accumulation, soil compaction, and erodible pathways;

The use of animal waste as fertilizer can be an effective disposal method only so long as the application rate matches crop needs.

5. maintaining grass/vegetative cover downslope from animal congregation sites and along stream banks; and

6. maintaining good forage and ground cover.[248]

Pollution from small confined cattle feedlots can be reduced by:

1. locating the facility away from streams or drainage channels;

2. using diversion terraces and roof gutters to divert runoff away from the feedlot surface;

3. collecting solids carried off the feedlot and settling them out in channels or grass waterways where they can be

collected and land disposed in an environmentally sound manner;

4. installing a large filter strip to intercept runoff before it enters a waterway;

5. installing a holding pond to trap runoff where it can be collected and disposed of by irrigation; and

6. using manure nutrients as a fertilizer to improve soils.[249]

Examples of programs that implement this type of requirement are given below.

Regional and Local Regulatory Programs: California

In California, one of the state's Regional Water Quality Control Boards (Santa Ana) has established individual waste discharge requirements for *all* dairy or confined animal facilities.[250] Under this program, facility operators must obtain a discharge permit to ensure that the facility is designed according to the standards established by the Regional Water Quality Control Board.[251] Basic requirements include:

1. an inventory of the population of animals in relation to the design capacity of the facility;

2. collection of all water runoff from manured areas that results from up to a 25-year frequency storm;

3. zero runoff when irrigating with barn water or runoff water;

4. a limit of 3 dry tons of manure per year per acre of disposal land (disposal land is defined as land used exclusively to percolate barn and runoff water);[252]

5. manure applications to cropland must be based on the crop's requirements for nitrogen;[253] and

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6. an annual report signed by the owner (under penalty of perjury) revealing the volume of manure produced and the location and method of disposal.[254]

These types of requirements are becoming more popular in the rest of California.[255] In addition, several counties in California (including Tulare, Kern and Kings) have been working with Regional Water Quality Control Boards to develop zoning ordinances that would establish minimum acreage requirements for unconfined livestock production in order to reduce the density of manure in pastureland,[256] as well as ordinances requiring runoff generated in the dairy area to be kept onsite.

A State Approach to Regulating Livestock Agriculture: Iowa

Iowa also has developed requirements for all confined feedlots. These apply (regardless of size) to open feedlots exposed to rainfall, total confinement systems where precipitation is not a factor, and to facilities with a mixture of these two kinds of systems.[257] At a minimum, all open facilities must remove settleable solids runoff.[258] This is accomplished by requiring that the velocity of the feedlot runoff be reduced to certain levels through design standards for certain types and sizes of operations.[259]

In addition, operations permits must be obtained for open facilities with over 700 head of livestock and for closed facilities (or open facilities with natural streams running through them) with over 300 head.[260] Operations permits are patterned after federal requirements for large, confined animal feedlots (*i.e.*, retention of all waste flows from a 25-year frequency, 24-hour duration storm).[261] Iowa regulations recognize, however, that most problems do not result from single, large storm events, but from repeated rains that create small discharges or that discourage the farmer from removing manure, and from manure accumulation over the winter. Therefore, Iowa regulations provide options allowing the farmer to dispose of manure less frequently if larger storage structures and other means are used to address these problems.[262]

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Total confinement systems of any size must meet a minimum standard of zero discharge into Iowa state surface waters. This usually is accomplished using storage pits located under or outside the containment structure.[243] Finally, manure collected through these requirements must be land disposed in a way that prevents contamination of surface and groundwaters.[244] Unlike the California program, disposal methods are not mandated. Guidelines are provided, however, to assist farmers in complying with the general prohibition against water pollution from land disposal.[245]

Creative Application of Sewage Disposal Regulations: Pennsylvania

The water quality impacts of livestock agriculture also can be regulated under sewage treatment programs. Pennsylvania's Clean Streams Law defines animal manure as sewage and thus prohibits its discharge into state waters unless that discharge is pursuant to a permit issued by the state Department of Environmental Resources.[246] Under state regulations, permits for the storage of animal manure are required unless the storage facilities are designed and operated according to state approved manure management practices. Permits for the land application of animal manure also are required unless application is in accordance with approved manure management practices.[247]

Summary

A significant problem with many of these feedlot and land application programs is that, even if mandatory and applicable to all sizes of operations, enforcement often relies on citizen complaints of acute water quality problems from feedlot discharges. More structural and automatic enforcement mechanisms are needed to enforce these standards.

Iowa, for instance, still bases the enforcement of its program on complaints. But in Iowa, water quality problems do not have to be identified to enforce design standards; only a violation of the standards themselves is needed to trigger enforcement.[248] California's program is based on requirements in state law for controlling runoff from confinement and manure application areas; some regions implement this objective through permit and reporting procedures to ensure compliance with standards and guidelines.[269]

Besides programs that reduce sediment and chemical contamination from non-irrigated crops and livestock agriculture, innovative approaches also have been developed to address pollution from irrigated cropland. These programs are described in the following section.

Improving Irrigation Efficiency to Protect Water Quality

Irrigated agriculture can affect ground and surface water quality through the addition of sediments, nutrients, pesticides, salts and other minerals.[270] In addition, fluctuations in the natural flows of rivers from irrigation reservoirs and diversions have caused damage to local populations of anadromous fish, wildlife habitat and recreation.[271] Most scientific studies on irrigation have focused on increasing crop yields and improving distribution systems, while relatively little attention has been given to controlling the water quality impacts of irrigation.[272] Problems are most severe in the arid and semiarid portion of the west where higher evaporation rates cause salts to accumulate near the surface of the soil.[273]

Natural water bodies receive irrigation water through open drains and ditches and underground tile drainage channels that collect return flows.[274] Irrigation water also can leach into groundwater.[275] Once this water leaves the farm, it can be used for other purposes, including wildlife habitat, reuse for irrigation, and drinking water.[276] Fundamentally, drainage is the disposal of unwanted or excess water to prevent plant injury, to minimize salt accumulation in agricultural soil and to allow early planting.

In some cases, reducing water volumes can greatly lower the quantities of trace elements transported by irrigation flows into receiving waters. This is so because the more irrigation water that comes in contact with the soil, the more pollutants potentially become available for transport. Thus, the efficiency of irrigation systems is an important consideration in preventing water pollution.[277] As with nitrogen, in some cases farmers simply may be using *too much* irrigation water. Correcting overuse could

Many important wetlands and wildlife habitat areas are affected by irrigation waters that have drained from surrounding agricultural areas.

save money as well as reduce pollution.[278] In other instances soil conditions are such that water quality can be impaired by relatively modest amounts of irrigation water. In such situations more severe solutions, such as purchase, transfer or modification of water rights, may be necessary to reduce drastically or to eliminate the use of irrigation water in a given area.

Concerns over efficiency and water quality arise from all aspects of irrigation, including river and reservoir operation; conveyance and distribution; on-farm application; cropping patterns; and return flow management.[279] Estimates of the need for irrigation water often do not consider fully changes in technology that could reduce water losses from evaporation, or the decreased water needs of improved strains of plants; the need for less "non-degraded" irrigation water as opposed to irrigation water that is high in salt content; and the increase in efficiency that would result from pricing irrigation water in accordance with its actual cost.[280] Methods to address the water quality problems associated with irrigation include:

1. restricting irrigation development in areas where water quality degradation is likely;

2. regulating the use of fertilizer or other agricultural chemicals that contaminate return flows (*e.g.*, this approach is exemplified by the program in Nebraska, discussed previously, that restricts fertilizer applications on irrigated cropland);

3. regulating when and how much water can be used; and

4. treating the irrigation water at various geographic levels (*e.g.*, individual farmer or regional areas), using those responsible for its degradation as a partial source of finance.[281]

Water quality problems caused by irrigation share many common characteristics with dry land agriculture. Therefore, many of the programs used for dry land agriculture could be modified to apply to irrigated farmland as well, and vice versa. Recent attempts to address the water quality impacts of irrigation have focused largely on improving the efficiency with which water is used, thereby reducing the quantity of water draining into surface- and groundwater systems as well as the pollutant loads associated with this water.[282]

The San Joaquin Valley in California has suffered major water quality impacts from irrigation, which in turn has threatened the viability of the extensive agricultural economy in the region.[283] In response, the State Water Resources Control Board, the San Joaquin Valley Drainage Program[284] and others are conducting research to assist the Central Valley Regional Water Quality Control Board in the development of a basin plan to restore the region's water quality.[285] Water quality "objectives" (*i.e.*, water quality standards) for selenium, boron, salts, and molybdenum, and dates for compliance with these objectives, have been recommended by the San Joaquin River Basin

Tile drainage can be contaminated with toxic substances that accumulate in agricultural soils.

Technical Committee (made up of staff from the State Water Resources Control Board and its regional Central Valley Water Quality Control Board).[286]

The Committee has recommended reducing drainage volumes, and consequently reducing pollution loads, through improving water management practices and implementing improved irrigation technology.[287] The Committee also has recommended the formation of a regional drainage district to improve coordination of irrigation activities in the area; provide flexibility in meeting water quality objectives; and reduce the costs associated with managing the area's water table and issuing individual permits.[288] Finally, the Committee has recommended the establishment of waste discharge requirements through permits, and requiring the adoption of BMPs to reduce pollutant loads.[289]

Institutional changes also are necessary to achieve significant reductions in the use of irrigation water in the San Joaquin

Valley. The high irrigation water subsidies provided by the federal government make the prices paid by farmers abnormally low, which in turn encourages inefficiency and overconsumption.[290] Substantial price increases would have to occur in order for the costs of water to be an effective incentive to reduce water use.[291] Other suggested institutional changes to promote water conservation include:

1. water transfers, which offer incentives for conservation by allowing the sale of conserved water for profit;[292]

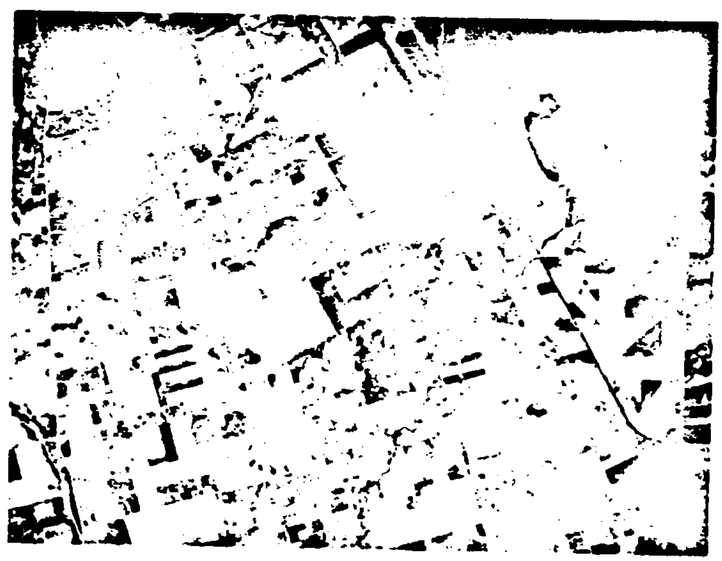
2. tiered water pricing whereby local irrigation districts charge higher prices for successive units of water; and

3. the expansion of water authorities to include drainage districts, groundwater control districts, or comprehensive water management districts, thus providing: (1) management, treatment and/or disposal of drainage water; (2) management of groundwater conditions through planned and controlled pumping; and (3) comprehensive management of surface-, ground-, and drainage water.[293]

Another way to improve the efficiency with which irrigation water is used is to provide tax incentives to operators who install equipment designed to use irrigation water more effectively. For instance, the tax code for South Carolina allows taxpayers to claim as a deduction the cost of purchasing and installing drip/trickle irrigation equipment (up to $2,500).[294]

Farmland Protection Programs, Conservation Easements and Leasing Arrangements

The destruction of prime farmland is an important (if indirect) contributor to water pollution because it forces the cultivation of more marginal land not well-suited for farming.[295] For this reason, farmland protection programs have great potential as an indirect means to reduce water quality impacts while at the same time controlling urban sprawl and generally increasing the effective application of land use controls. This



Farmland protection programs are useful only if landowners that benefit from the program are required to control adverse water quality impacts. These two photos show development of the same area over a 28 year period.

kind of program brings in farmers as *proactive* participants in solving pollution problems as well as other land use problems rather than just as subjects of regulation.

Comprehensive farmland protection programs encourage farmers to continue farming rather than sell their land to developers; discourage developers from obtaining prime farmland; and statutorily define land areas where the intrusion of conflicting land uses is discouraged or prohibited.[296] Collectively, these actions protect agricultural areas against encroachment of conflicting land use.

While a comprehensive discussion of farmland protection programs is beyond the scope of this study,[297] it is useful to describe briefly some of the innovations that have occurred in this area. A broad array of activities is being undertaken to protect prime farmland, but certain techniques have been more effective than others in preserving farmland and in reducing

The citrus farming area in the photo at left has been transformed into a dense suburban development.

agricultural water pollution. Successful farmland protection programs have three notable characteristics: incentives to encourage participation in the program; severe penalties assessed for withdrawal from the program; and effective enforcement.[298]

Farmland protection activities can range from simple tax incentives to complex "farmland districting" systems. Differential assessment mechanisms (called "use value" taxation) can tax farmland according to its value for agricultural use rather than for potential development use, thereby reducing the farmer's taxes—a technique used by nearly every state.[299] More complex and comprehensive programs can involve varying degrees of mandatory participation, zoning, or other land use controls designed to create agricultural districts where development is discouraged or barred altogether.[300]

Agricultural zoning can be used to preserve prime farmland through a state regulatory program mandating that localities zone certain types of lands for agricultural uses.[301] The zoning program can be carried out within agricultural districts that are defined to ensure that agricultural production in a given area is high enough to support the local service economy, which in turn supports the agricultural economy.[302]

Some county governments have begun Transfer of Development Rights (TDR) programs, which preserve certain agricultural land in exchange for allowing increased development in already urbanized areas.[303] Twelve states and some localities have established Purchase of Development Rights (PDR) programs, under which the right to develop agricultural land is purchased outright from the farmer or potential developer and is retained by the state or locality to preserve the land in its agricultural or natural state.[304]

One of the most widespread farmland protection activities, the "use value" tax assessment mentioned above, has proven not to be highly effective in protecting prime farmland, because the tax breaks to the farmers often are outweighed by the price that the developers offer for the land.[305] Other protection programs are needed to supplement the differential tax assessment approach. These programs might include the PDR and TDR programs mentioned above, as well as agricultural districting and comprehensive growth management programs, such as those in place in Oregon, California and Hawaii.[306] Penalties for withdrawal from programs should be substantial, and states should ensure that programs apply only to prime farmland.[307] For instance, Maryland and California use land productivity measures to determine the eligibility of farmland for differential use value assessment.[308] Finally, since agriculture itself is a source of water pollution, it is vital that any farmland protection program include provisions requiring that eligible lands be managed so as not to produce significant off-site damages.[309] Such a provision exists in the Wisconsin protection program, which requires participating farmers to implement approved soil conservation techniques that meet "T" standards for erosion control.[310]

In North Carolina, farmers can band together to form agricultural districts to protect their land from annexation or special tax assessments. But they must manage their lands "in accordance with the SCS-defined erosion control practices applicable to highly erodible land."[311] Keene (1984) has proposed a set of recommendations for the development of effective farmland protection programs. The recommendations are:

1. A state land planning agency with authority:
   a. to establish a comprehensive plan for the development and protection of the state's resources, including agricultural land, and
   b. to create urban growth boundaries around all major cities and towns located in or near agricultural reserves, within which fifteen to twenty years' anticipated growth can be accommodated.

2. A state agricultural land agency with authority:
   a. to regulate land use in agricultural reserves;
   b. to delegate the authority to regulate land use in agricultural reserves to local governments that enact regulations meeting state criteria, and
   c. to exercise a right of first refusal with respect to farmland that comes on the market and to buy it at publicly appraised fair market value and then to resell it to farmers at below market value.

3. Appropriate combinations of tax reduction and other economic compensation to owners of land that has a reduced market value because it has been placed in an agricultural reserve.[312]

On a more comprehensive scale, a regional system of open space preservation is being considered seriously by localities in the San Francisco Bay area to preserve up to 3.5 million acres of land (and related water resources) from the impacts associated with the region's high growth rates.[313] This approach calls for the development of a Bay Area Greenbelt to preserve farms and ranches, watersheds, parks and other recreation areas, and buffers between communities.[314] The plan for the Greenbelt incorporates expected housing, industrial and commercial land requirements for the next 50 years.[315] The plan may designate open spaces where development will not be permitted, while identifying "infill" spaces where future development will be

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allowed.[316] This regional approach to comprehensive planning provides many opportunities to address existing and potential pollution problems through sound land use management. Such comprehensive land use management approaches are discussed further in Chapter Four.

Conservation easements that preserve farmland also have been proposed as a way to improve indirectly the control of pollution while achieving other goals, such as production control and farm debt reduction.[317] Through the use of conservation easements, state and local governments, as well as conservation groups, can purchase certain rights on agricultural land, permanently barring water pollution-generating activities by incorporating easement provisions into the title of the land.[318] In exchange for certain rights to farm or develop land, outright payment could be made or a farmer's debt could be restructured and guaranteed by the state, according to the value of the rights conveyed in the easement.[319] Easement provisions could be tailored to suit the conservation needs in the area. These include:

1. limiting general or particular types of residential, commercial, or industrial development on prime farmland;
2. specifying the agricultural management of marginal land;
3. protecting natural habitat and wildlife on land not suited to certain kinds of agriculture;
4. reducing or barring irrigation in areas experiencing water shortages;
5. prohibiting grazing in forests and woodlands;
6. limiting tillage and crop production in natural waterways, floodlands and wetlands;
7. requiring filter strips in strategic areas; and
8. allowing public access for open-space recreation.[320]

Given advances made in BMP development and application, many other practices such as fertilizer, manure, and pesticide application controls also could be implemented to provide water quality protection to meet specific needs. USDA already recognizes the protection of surface and groundwater quality as legitimate purposes that conservation easements can be used to promote.[321] The use of easements is very promising, and becomes increasingly so as agricultural land values rise.[322] New Hampshire recently introduced legislation authorizing $10 million per year for five years to be spent to purchase easements in order to protect open space.[323] Massachusetts has restricted 18,674 acres of farmland to permanent agricultural use.[324]

Finally, leasing arrangements provide a method to improve water quality by creating an agreement between the farm operator and the landlord concerning the conservation practices on a particular farm.[325] Leasing arrangements that consist of written, multiyear agreements are preferred over oral, indefinite or year-to-year leases, and should allow the incorporation of a significant conservation and cost-sharing clause.[326] Longer leases are preferable because they provide more security to farmers and lengthen their planning horizons.[327] These clauses could be required when land is leased for agricultural purposes to specify the type of crop rotation and the BMPs to be used, as well as the division of the costs associated with the conservation practices.[328]

Of course, the landlord must have some incentive to include such provisions in a lease. A graduated lease premium has been suggested, whereby increasing payments would be made by a county or state to the landlord in exchange for increasing the length of the lease or having the lessee implement certain conservation practices with financial assistance from the landlord.[329] An important component of such a program is bringing an often uninformed and uninterested landlord into the long-term arrangement.[330]

Conclusions and Recommendations

Agriculture, including crop and livestock production, obviously can have many adverse effects on water quality, including sediment- and phosphorous-related surface water impacts from crop production; nitrate and bacterial surface and groundwater impacts from livestock production; and pesticide and nitrate impacts on both surface and groundwater. Therefore, effective programs to reduce the agricultural impacts of poison runoff and leachable contaminants must be able to implement a broad array of BMPs.

Voluntary programs based on cost-share incentives often will be less cost-effective and provide less overall protection than regulatory programs. Participation rates in current voluntary programs are often low. Even if effective, voluntary cost share programs require a massive infusion of government funds to tackle the widespread problem of pollution from agricultural runoff. And even if the necessary funds are available, serious questions of equity arise. The general taxpayer is asked to subsidize pollution control by the agricultural sector. Cost sharing rewards farmers for poor land stewardship, and punishes those with existing good stewardship practices. It places water quality protection goals at the mercy of an uncertain and unstable agricultural economy and often does not promote the best ways to control agricultural pollution.

A sound regulatory basis for design standards and taxes has been established in some states, regions and localities. These programs address pollution from cropland, livestock, and other agricultural operations. They have been effective in addressing a wide range of pollutants, including sediment, nutrients, bacteria and pesticides.

The programs described in this chapter give examples of how states and localities can implement the particular kinds of controls they need to address specific water quality problems. Here are the key recommendations drawn from these exemplary programs:

1. Unless states can demonstrate that voluntary controls (including cost-sharing, technical assistance and education) alone will result in the pollutant load reductions needed to achieve beneficial water uses in individual watersheds, and unless sufficient funds are available to achieve this result,

regulatory programs in the form of design standards and taxes should be developed, implemented and enforced.

2. Regulatory programs require one or more mechanisms to require or to induce farmers to implement adequate BMPs. These include:
   a. Design standards that require or prohibit certain practices;
   b. Design taxes based on farm management practices; and
   c. Performance standards that prohibit any significant off-site transfer of pollutants.

   The most effective programs may involve a combination of these approaches.

3. Technical assistance and education programs from the state (to regional and local program officials) as well as from sub-state officials (to the actual regulated parties) are important components of pollution control plans, but should not be used in lieu of regulations if serious pollution problems must be addressed.

4. Regulatory programs must require consistent and effective enforcement activities including: inspections; response to complaints; issuance of notices of violations; issuance of fines and other enforcement tools; an appeals process; and procedures for corrective action.

5. State and local officials should enforce agricultural water pollution control programs on a priority basis using all available information (*e.g.*, groundwater studies, geologic maps, cropping and farm management information, soil erosion estimates, etc.).

6. Nutrient and fecal bacterial contamination of surface and groundwater should be controlled through programs that:
   a. restrict the amount of fertilizer or manure applied to the ground;
   b. control the timing of these applications;

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c. require the development of forested buffer strips along streams; and
d. reduce the net amount of nutrients available for transport after crop needs have been met.

7. Programs to address water pollution from pesticides should include Integrated Pest Management (IMP) techniques. IPM components include:
   a. eliminating the prophylactic use of pesticides, *i.e.*, requiring testing for the presence of a target pest before a pesticide is used;
   b. replacing toxic, leachable pesticides with materials that are less toxic, mobile and persistent;
   c. using alternative crop patterns and techniques, such as crop rotation and crop species that are more resistant to pests; and
   d. controlling the amount and timing of pesticide use.

   States also should control pesticide pollution through taxes on pesticide sale and manufacture, and comprehensive regulatory programs that include area-specific problem assessments and restrictions on use and application along with pesticide registration and reporting requirements.

8. Livestock pollution control programs should require the control of runoff and leaching from confined feeding and storage areas regardless of herd size. Such programs should also require:
   a. control of livestock densities and locations;
   b. prevention of livestock access to riparian areas;
   c. regulation of the disposal of collected manure through land application;
   d. adequate dispersal of livestock facilities and location; and
   e. maintenance of adequate ground cover and forage.

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9. Water quality impacts from irrigation return flows should be reduced by requiring more efficient use of irrigation water and through regulations that control irrigation scheduling and the use of farm chemicals within the control of a comprehensive, multi-purpose regional drainage district. Irrigation subsidies should be eliminated or substantially reduced.

10. Farmland protection programs should go beyond traditional use value tax assessment programs and include a comprehensive state-level preservation plan (with local implementation) that preserves prime farmland using Transfer of Development Rights and Purchase of Development Rights programs, agricultural zoning and districting, and other land use controls.

11. Farmland protection programs should require that all lands receiving benefits from state and local programs participate in state programs to control poison runoff by requiring that off-site agricultural impacts be addressed adequately.

12. Conservation easements should be purchased from farmers for sensitive riparian land that cannot be managed feasibly through the use of the regulatory or tax-based programs described above. Easement provisions should be tailored so that the title to the farm requires the effective control of off-site water quality damages.

Notes - Chapter Three

1. Most states with programs designed to address agricultural NPS pollution rely primarily on voluntary cost share programs, along with education and technical assistance. U.S. EPA, *Report to Congress: Nonpoint Source Pollution in the U.S.*, Washington, D.C., January, 1984, at 3-7.

2. Crosson, Pierre, "Implementing Policies and Strategies for Agricultural Non-Point Pollution," 4 *Southwestern Review of Management and Economics* 31-33 (Spring 1985). At the federal level, one significant exception to this statement is the "cross-compliance" provision of the Food Security Act of 1985, discussed below.

3. *See,* Cook, Ken, "Agricultural Nonpoint Pollution Control: A Time for Sticks," 40 *JSWC* 105 (1985). The author explains that regulations are a fact of life for corporations and individual entrepreneurs when the public welfare is at stake, regardless of whether the regulatory party is "family-owned, low profit, hard-working, large or small." *Id.* at 106.

4. Keene, John C., *Agricultural Pollution: The Problem and Its Remedies,* Research Report Series No. 6, University of Pennsylvania, Department of City and Regional Planning, June 1984, at 24.

5. Twitchell, Karen R., "Agriculture Stabilization and Conservation Service: History, Policy and Problems," *31 S.D.L.Rev.* 425 (1986); U.S. Department of Agriculture, *The Second RCA Appraisal–Soil, Water and Related Resources on Nonfederal Land in the United States* (review draft), July - August, 1987, at 15-2.

6. *See* U.S. EPA, *Final Report of the Federal/State/Local Nonpoint Source Task Force and Recommended National Nonpoint Source Policy,* January, 1985, at 21-27.

7. *Id.* at 21-23; *See* Hiatt, Robert T., "The SCS and Soil Erosion," 31 *S.D.L.Rev.* 438-441 (1986); U.S. EPA, *Final Report on the Federal/State/Local Nonpoint Source Task Force and Recommended National Nonpoint Source Policy - Appendix B: Agency Strategies,* January, 1985, at B-22 - B-31.

8. U.S. EPA (Appendix B), January, 1985, *supra* note 7, at B-32 - B-36; U.S. EPA, *Final Report on the Federal/State/Local Nonpoint Source Task Force and Recommended National Nonpoint Source Policy,* January, 1985, at 23-24; Twitchell, 1986, *supra* note 5, at 425-434.

9. *See* U.S. EPA (Appendix B), January, 1985, *supra* note 7, at B-45 - B-51.

10. *See generally* Twitchell, 1986, *supra* note 5, at 425-434; Hiatt, 1986, *supra* note 7, at 435-452; Poretti, Daniel Quentin, *The Federal Government and Soil Conservation: Historical Context, Present Policies, and Future Strategies,* Paper Submitted in Partial Fulfillment of Master of Arts in Public Affairs, April 1983, at 15-25; Schloesser, Lynn L., "Agricultural Non-Point Source Water Pollution

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Control Under Sections 208 and 303 of the Clean Water Act: Has Forty Years of Experience Taught Us Anything?," 54 *N.D.L.Rev.* 587-618 (1977-1978).

11. *See* Twitchell, 1986, *supra* note 5, at 426-430; Hiatt, 1986, *supra* note 7, at 436-441; Poretti, 1983, *supra* note 10, at 19-20; Pimentel, David and Susan Pimentel, "Ecological Aspects of Agricultural Policy," 20 *Ecological L.* 567 (1980); Schloesser, 1977-1978, *supra* note 10, at 598-599; Statement of Peter C. Myers - Deputy Secretary, United States Department of Agriculture - Before the Fisheries and Wildlife Conservation and Environment Subcommittee and the Oceanography Subcommittee of the Merchant Marine and Fisheries Committee, U.S. House of Representatives, July 13, 1988.

12. Poretti, 1983, *supra* note 10, at 17; *see* Hiatt, 1986, *supra*, note 7, at 37-41.

13. Poretti, 1983, *supra* note 10, at 17; *see* Hiatt, 1986, *supra* note 7, at 37-41; Schloesser, 1977-1978, *supra* note 10, at 599, 601-603.

14. Poretti, 1983, *supra* note 10, at 17; Schloesser, 1977-1978, *supra* note 10, at 604-609.

15. U.S. EPA, January, 1984, *supra* note 1, at 3-2 - 3-4, B-1 - B-4. Approximately 30 states provide financial incentives to encourage the adoption of soil conservation measures. *See generally* "Update to the Handbook of State and Local Cost Sharing and Other Financial Incentives Programs," *NACD RCA Notes* (No. 64), National Association of Conservation Districts, August 25, 1987.

16. *See* Poretti, 1983, *supra* note 10, at 24; U.S. EPA, January, 1984, *supra* note 1, at 3-6 - 3-7; Madariaga, Bruce, "Assessing Current Cost-Share Programs for Agricultural Best Management Practices Within the Chesapeake Bay Drainage Basin," paper prepared for the Second Annual Conference on the Economics of Chesapeake Bay Management, May 28-29, 1986, Annapolis, Maryland, at 4.

17. *See* Crosson, 1985, *supra* note 2, at 33-34.

18. *Id.*

19. USDA, *A National Program for Soil and Water Conservation: The 1988-97 Update*, (no date), at 8, 11-14. Reducing the damages caused by excessive soil erosion on rural lands remains the top priority of USDA conservation activities. *Id.* at 8. This document is developed pursuant to the Soil and Water Resources Conservation Act of 1977 (RCA), P.L. (95-192).

20. Zinn, Jeffrey A., *Groundwater Issues and the U.S. Department of Agriculture—An Institutional Perspective*, Congressional Research Service, April 21, 1988, at 19-20.

21. Myers, July 13, 1988, *supra* note 11.

22. Copeland, Claudia and Jeffrey A. Zinn, *Agricultural Nonpoint Pollution Policy: A Federal Perspective*, Congressional Research Service, December 1, 1986, at 38.

23. *Id.*

24. Sampson, Neil, American Forestry Association, January 11, 1987 (personal conversation).

25. *See* 7 CFR § 700.2. The RCWP was authorized in Title II of the Agriculture, Rural Development, and Related Agencies Appropriations Act of 1980, P.L. 96-108, 93 Stat. 835.

26. *Rural Clean Water Program, Status Report on the CM and E Projects,* National Water Quality Evaluation Project, Raleigh, N.C., 1985, at vii.(hereinafter cited as National Water Quality Evaluation Project).

27. *Id.* at 1; Copeland and Zinn, 1986, *supra* note 22, at 11.

28. Miranowski, John A., "Macro-economics of Soil Conservation," in *Conserving Soil- Insights from Socioeconomic Research,* ed., Lovejoy, S.B., and Napier, T. L., Soil Conservation Society of America, Ankeny, Iowa, 1986, at 23: "...cost-sharing is designed to reduce the installation or adoption cost for particular conservation practices... Cost-sharing subsidies only induce conservation investment if private returns exceed private costs." *Id.*

29. *See* Swanson, Louis E., Silvana M. Camboni and Ted L. Napier, "Barriers to Adoption of Soil Conservation Practices on Farms," in *Conserving Soil-Insights from Socioeconomic Research,* ed., Lovejoy, Stephen B. and Ted L. Napier, Soil Conservation Society of America, Ankeny, Iowa, 1986, at 111-112; Buttel, Frederick H. and Louis E. Swanson, "Soil and Water Conservation: A Farm Structural and Public Policy Context," in *Conserving Soil-Insights from Socioeconomic Research,* ed., Lovejoy, Stephen, B., and Ted L. Napier, Soil Conservation Society of America, Ankeny, Iowa, 1986, at 26-39.

30. Swanson, Camboni and Napier, 1986, *supra* note 29, at 111; Buttel and Swanson, 1986, *supra* note 29, at 33.

31. Swanson, Camboni and Napier, 1986, *supra* note 29, at 111. Other important factors that influence farmers' conservation behavior include perceptions of risk and noneconomic variables such as personal beliefs and values, social pressure and traditions. Christensen, Lee A. and John A. Miranowski, *Perceptions, Attitudes and Risk: Overlooked Variables in Formulating Public Policy on Soil Conservation and Water Quality* (An Organized Symposium), ERS Staff Report No. AGES820129, February, 1982, at 2.

32. Swanson, Camboni and Napier, 1986, *supra* note 29, at 111-112.

33. *Id.* at 112.

34. *Id.*

35. Christensen, Lee and Patricia E. Norris, "Soil Conservation and Water Quality Improvement: What Farmers Think," 38 *JSWC* 16 (1983).

36. *Id.*

37. Swanson, Camboni and Napier, 1986, *supra* note 29, at 110-111.

38. Virginia Division of Soil and Water Conservation, *Chesapeake Bay Nonpoint Source Pollution Control Program - Annual Report*, November 20, 1986, at 13. In fact, alternatives to the simple implementation of BMPs, such as managing farm pesticide and fertilizer inputs to limit polluting outputs, could be profitable to the farmer over the long run but current educational, research and cost sharing programs often do not reflect this alternative sufficiently. *See, e.g.*, Shabman, Leonard, "Reducing Nitrogen Pollution from Crop Production Systems" (draft), paper presented at the Conference on the Economics of Chesapeake Bay Management IV, Baltimore, Maryland, May 23-25, 1988, at 11-20.

39. Epp, Donald J. and James S. Shortle, "Agricultural Nonpoint Pollution Control: Voluntary or Mandatory?," 40 *JSWC* 112 (1985).

40. Harrington, Winston, Krupnick and Peskin, "Policies for Nonpoint-Source Pollution Control," 40 *JSWC* 28 (1985). This observation applied to *soil erosion control* BMPs, to say nothing of *water quality protection* needs that often are even more costly and have less direct benefit to the farmer.

41. Christensen and Norris, 1983, *supra* note 35, at 16.

42. *Id.*

43. Swanson, Camboni and Napier, 1986, *supra* note 29, at 112; Epp and Shortle, 1985, *supra* note 39, at 112; Richard Watt, Chesapeake Bay Foundation, April 5, 1988 (personal conversation).

44. Bultena, Gordon L. and Eric O. Hoiberg, "Sources of Information and Technical Assistance for Farmers in Controlling Soil Erosion," in *Conserving Soil: Insights From Socioeconomic Research*, ed., Stephen B. Lovejoy and Ted L. Napier, Soil Conservation Society of America, Ankeny, Iowa, 1986, at 72.

45. *See* Christensen and Norris, 1983, *supra* note 35, at 16; Epp and Shortle, 1985, *supra* note 39, at 111-112.

46. Waddell, Thomas E., Bower and Cox, *Managing Agricultural Chemicals in the Environment: The Case for a Multimedia Approach* (draft), The Conservation Foundation, July, 1987, at 112.

47. *Id.; see* Halberg, George R., "Agricultural Chemicals in Ground Water: Extent and Implication," 2 *American Journal of Alternative Agriculture* 12-13 (Winter 1987).

48. Hallberg, George R., "From Hoes to Herbicides," 41 *JSWC* 357, 362 (1986).

49. "Guarding Our Buried Treasure," Rochester Minnesota Post Bulletin, Special Reprint, January 23-30, 1988.

50. Babcock, Hope M., "Compelling On-The-Ground Implementation of Measures to Control Nonpoint Source Pollution," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, May, 1985, at 60.

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51. Buttel and Swanson, 1986, *supra* note 29, at 32.

52. *Id.*

53. *Id.*

54. *Id.*

55. *Id.* at 31-32.

56. *Id.* at 32.

57. *Id.* at 32-33.

58. *Id.* at 32.

59. *Id.* at 33.

60. *Id.*

61. Separating livestock and crop production activities can contribute to poison runoff by reducing the proper use of manure as a fertilizer source and by contributing to more intensive, petrochemical-dependent crop production practices.

62. Buttel and Swanson, 1986, *supra* note 29, at 34.

63. *Id.* at 35.

64. Babcock, 1985, *supra* note 50, at 61; Miranowski, 1986, *supra* note 28, at 23 - "Although macroeconomic variables are beyond the control of soil conservation policy, these forces may have a major impact on soil conservation decisions. Some conservation programs may not accomplish the desired change in conservation activities because of the overriding importance of macroeconomic forces." *Id.*

65. Miranowski, 1986, *supra* note 28, at 15, 24 "... to achieve a long-run soil conservation objective may require the selection of conservation programs less sensitive to macro-economic forces. ... The policy goal should be to achieve the socially desired level of conservation investment over time regardless of short-run economic fluctuations. Casual evidence suggests a cyclical response of conservation investment. Because soil conservation is a long-run issue, we must differentiate the long-run, socially optimal rate of investment from the short-run cyclical rates and pursue policies designed to achieve the long-run, socially optimal rate." *Id.*

66. The "farm crisis," whether it results from poor domestic or international policy (or factors beyond our control), affects our ability to combat agricultural water pollution, so that soil erosion control and agricultural pollution are much more at the mercy of agricultural economics and associated farm policy than the converse. *See* Buttel and Swanson, 1986, *supra* note 29, at 31-37; Babcock, 1985, *supra* note 50, at 61; Miranowski, 1986, *supra* note 28, at 23; *see also* Benbrook, Charles M., "The Science and Art of Conservation Policy," 41 *JSWC*

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286 (1986). The author notes that soil conservation "never has and never will drive farm policy." *Id.*

67. Norris, Patricia and Leonard Shabman, "Transition in Agriculture: Opportunities for Improved Water Quality for the Chesapeake Bay in Virginia," paper presented at the Conference on Economics of Chesapeake Bay Management, Annapolis, Maryland, May 27-29, 1987, at 6-9.

68. *Id.*

69. *Id.*

70. Batie, Sandra S., "Economics: Nonpoint Source Pollution Impacts," in *Perspectives on Nonpoint Source Pollution,* U.S. EPA, 1985, at 231.

71. *See,* Miranowski, 1986, *supra* note 28, at 23; Madariaga, 1986, *supra* note 16, at 6.

72. Miranowski, 1986, *supra* note 28, at 23: "To reduce private costs sufficiently may require unacceptably high cost-sharing levels in the 1980s. Generally, the macroeconomic impact can be expected to swamp the cost-sharing subsidies." *Id.*

73. Madariaga, 1986, *supra* note 16, at 6.

74. *See* Braden, John, "Financing Nonpoint Pollution Abatement: The Peculiar Case of Agriculture," paper presented at the Conference on Political Institutional and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987.

75. Harrington, Krupnick and Peskin, 1985, *supra* note 40, at 31.

76. The Conservation Title of the Food Security Act of 1985 is contained in 16 U.S.C. §§3801-3845.

77. 16 U.S.C. §§3831-3836.

78. 16 U.S.C. §§3811-3813.

79. *Id.*

80. 16 U.S.C. §§3821-3823.

81. Myers, Peter, "Nonpoint-Source Pollution Control: The USDA Position," 41 *JSWC* 157 (1986).

82. Myers, July 13, 1988, *supra* note 11.

83. Political popularity is described as the "one important advantage over the other [NPS control] policies ...." Harrington, Krupnick, Peskin, 1985, *supra* note 40, at 31. Approximately 30 states provide financial incentives to encourage the adoption of soil conservation measures. *See generally, NAC RCA Notes,* August 25, 1987, *supra* note 15.

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84. Cook, 1985, *supra* note 3, at 105. The author explains that regulations are a fact of life for corporations and individual entrepreneurs when the public welfare is at stake, regardless of whether the regulatory party is "family-owned, low-profit, hard-working, large or small." *Id.* at 106.

85. See Chapter Two. See Chapter Nine for a description of how programs to control poison runoff and groundwater contamination should incorporate water quality considerations.

86. Norris and Shabman, 1987, *supra* note 67, at 2.

87. Keene, June, 1984, *supra* note 4, at 1.

88. *Id.*

89. *See* Babcock, 1985, *supra* note 50, at 81.

90. Keene, 1984, *supra* note 4, at 9.

91. Babcock, 1985, *supra* note 50, at 61.

92. Keene, 1984, *supra* note 4, at 1.

93. Norris and Shabman, 1987, *supra* note 67, at 2-4.

94. Keene, 1984, *supra* note 4, at 1, 11.

95. Babcock, 1985, *supra* note 50, at 61.

96. *Id.*; Norris and Shabman, 1987, *supra* note 67, at 6; Buttel and Swanson, *supra* note 29, at 33: "...society would likely be far less tolerant of soil erosion and runoff problems in a farm sector consisting largely of industrial-type farms. It would probably be far easier to implement mandatory regulation of agricultural practices if there were not a countervailing symbolic restraint: the struggling, financially strapped family farmer who should not be regulated into bankruptcy." *Id.*

97. *See generally* Shabman, 1988, *supra* note 38, at 18.

98. Krupnick, Alan J., "Economic and Nutrient Reductions in the Chesapeake Bay," paper presented at the Conference on the Economics of Chesapeake Bay Management IV, Baltimore, Maryland, May 23-25, 1988, at 28.

99. McSweeny, William and James S. Shortle, "Probabilistic vs. Deterministic Targets for Designating Agricultural BMPs," paper presented at the Conference on the Economics of Chesapeake Bay Management IV, Baltimore, Maryland, May 23-25, 1988, at 8, 11.

100. Dunn, James W. and James S. Shortle, "Agricultural Nonpoint Source Pollution in Theory and Practice," paper presented at the Conference on the Economics of Chesapeake Bay Management III, Annapolis, Maryland, May 27-29, 1987, at 17; *see also* Shortle, James S. and James W. Dunn, "The Relative Efficiency of Agricultural Source Water Pollution Control Policies," 68 *AJAE* 676 (1986).

101. Dunn and Shortle, 1987, *supra* note 100, at 17.

102. *Id.*

103. Dunn and Shortle, 1987, *supra* note 100, at 10-14. Some analysts predict that theoretically the most *cost-effective* approaches are *design incentives* in the form of *farm- specific* taxes at rates appropriate to bring about the desired level of conservation and pollution control on the part of the farmer. *See generally* Dunn and Shortle, 1987, *supra* note 100, at 8-14; *see also* Shortle and Dunn, 1986, *supra* note 100, at 676. Under such a system, a farmer would be charged a particular tax for his or her set of management practices based on their site-specific effect on water quality. According to the *theoretical* analysis, for a particular practice on a particular farm, an individual tax would be set at a rate just high enough to reduce pollution to desired levels, based on some measure of the water quality damages caused by the farmer's management choices. Taxes would be different for each practice based on each farm's individual environmental circumstances and the farmer would be free to choose how much pollution (and tax) was in his best economic interest. Dunn and Shortle, 1987, *supra* note 100, at 9-12. However, because of various factors relating to the difficulty of identifying an optimal tax schedule for each farm, in the agricultural context the *farm specific* design tax approach can be "of little practical interest because of the cost and complexity of the procedure." *Id.* at 10-14. It is also inconsistent with the fundamental approach of the Clean Water Act, under which there is no inherent "right" to pollute the nation's waters. The Clean Water Act envisions that pollutant discharges will continue only to the extent that there are technological limitations on our ability to control pollution. *See* S. Rep. No. 414, 92d Cong. 1st Sess. 42 (1971) *reprinted in A Legislative History of the Federal Water Pollution Control Act Amendments of 1972*, Congressional Research Service, at 1460 (1973). Decision-makers should be careful to differentiate control policies that are *theoretically* optimal from those that worked best *in practice*, given the present level of knowledge concerning the effect of farm management practices on water quality and the costs of BMP applications on farms. *See*, Dunn and Shortle, 1987, *supra* note 100, at 14.

104. Dunn and Shortle, 1987, *supra* note 100, at 17.

105. *Id.*

106. *See generally* 40 CFR 264; 42 U.S.C. §6424.

107. One author has proposed a model state program for setting standards and compliance schedules for soil erosion controls on farmland, with SWCDs responsible for setting local standards, surveying soil erosion and advising local governments of violations. Localities would be responsible for enforcement. Mandatory enforcement based on soil loss from individual farms would replace inconsistent enforcement based on complaints from damaged property owners. *See* Coughlin, Robert E., "Regulation of Soil Loss on Farmland: How Effective?," 40 *JSWC* 338-339 (1985).

108. To operate effectively, a regulatory program must have several components in place.

1. inspections;
2. response to complaints;
3. issuance of notices of violations;
4. issuance of fines;
5. an appeals process; and
6. procedures for corrective actions (including injunctive relief).

109. Wheeler, Philip H., Assistant Planning Director, Rochester-Olmsted County Consolidated Planning Department, "Olmsted County's Farmland Soil Loss Control," (no date), at 2-3; Zoning Ordinance Amendments Addressing Farmland Soil Erosion, Olmsted County, at §10.21(A) (hereinafter cited as Olmsted County Zoning Ordinance.

110. *See* Wheeler, (no date), *supra* note 109, at 3; Olmstead County Zoning Ordinance, *supra* note 109, at §10.21; Minnesota Department of Health, *A Guide For Local Health Professionals Involved in County Comprehensive Water Management Plans,* June, 1987, Part III, at 14-15.

111. *See* Wheeler, (no date), *supra* note 109, at 2-3.

112. *Id.* at 4. Enforcing soil erosion ordinances through complaints is not a adequate means of ensuring that minimum soil erosion controls are implemented. *See generally* Coughlin, 1985, *supra* note 107.

113. *Id.*

114. "T" value (for soil loss tolerance) is a measure of "the maximum rate of erosion that can occur on a soil without reducing the soil's capacity to support sustained economic production." U. S. Department of Agriculture, 1987, *supra* note 5, at 4-9. As mentioned throughout this report, soil erosion is often an inadequate proxy for poison runoff—specifically in approximating sediment delivery and agrichemical contamination. Crosson, 1985, *supra* note 2, at 31-33. However, this type of program could be modified to apply to poison runoff as well.

115. *Id.* at 6-7. Other related factors were incorporated into this point system. Factors were scored and weighted in the ranking system as follows:

1. the ratio of total erosion to tolerable soil loss was given a multiplier of one in the above ranking;
2. the total erosion score was given a multiplier of six (total erosion was considered a more significant contributor to off-site damages than the ratios of total erosion to tolerable soil loss limits);
3. poorly managed pasture was given an additional score of three;
4. areas with hydrologic runoff curve numbers greater than 81 were given a score of three;
5. areas within a flood control project watershed were given a score of nine. *Id.* at 6-11.

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116. *Id;* Olmsted County Zoning Ordinance, *supra* note 109, at 10.21(E).

117. Wheeler, (no date), *supra* note 109, at 11; Olmsted County Zoning Ordinance, *supra* note 109, at 10.21(G).

118. Wheeler, (no date), *supra* note 109, at 2, 4-10. There are 119 mapping units in Olmsted County describing soil, water and non-soil features. There are also 46 land use/cover classes identified in the mapping system that are distinguished on the basis of land use, erosion and runoff characteristics. Twelve types of cropland have been identified that include all possible combinations of rotations, contouring, terracing, and residue management. *Id.*

119. *Id;* Olmsted County Zoning Ordinance, *supra* note 109, at Appendix D-G.

120. "Computerizing Soil and Land Cover Data—Olmsted County Uses," (enclosure in a letter from Philip H. Wheeler, Rochester-Olmsted Consolidated Planning Department to Paul Thompson, Natural Resources Defense Council, April 8, 1988).

121. *Id.*

122. Olmsted County Zoning Ordinance, *supra* note 109, at §10.20(E)(3). The parties that can register complaints include: affected land occupiers; any elected or appointed official of Olmsted County or municipalities within the county or the SWCD; and the staff of the SCS and the County Zoning Administrator. *Id.*

123. *Id.* at §10.21(E)(4).

124. *Id.* at §10.21(F). Most SCS Technical Guides currently address soil erosion without adequate consideration of water quality. However, revisions of these guides to require assessment and consideration of off-site impacts is possible and could be substituted for the land-based approach currently in use. For instance, the Guides could require the potential for nutrient effects on surface water and groundwater to be considered before conservation tillage practices are adopted.

125. *Id.* at §10.21(F) and §10.21(G).

126. Phil Wheeler, Assistant Director, Olmsted County Consolidated Planning, Rochester, Minnesota, March 29, 1988 (personal conversation); Olmsted County Zoning Ordinance, *supra* note 109, at 10.21(G)(3)(C).

127. Wheeler, March 29, 1988, *supra* note 126; Olmsted County Zoning Ordinance, *supra* note 109, at 10.21(G)(3).

128. *See generally* Griswold, Jerry R., "Conservation Credit: Motivating Landowners to Implement Soil Conservation Practices Through Property Tax Credit," 42 *JSWC* 41-45 (1987); Griswold, Jerry R., *Assessment Report of the Conservation Credit Pilot Project—Pepin County, Wisconsin* (draft), December, 1987.

129. Griswold, 1987, *supra* note 128, at 42.

130. *See* U.S. Department of Agriculture, 1987, *supra* note 5, at 4-9; Griswold, 1987, *supra* note 128, at 42; Soil Conservation Service (in cooperation with the Pepin County Land Conservation Committee), *Conservation Credit Program*, September, 1985, at 5.

131. Soil Conservation Service, September, 1983, *supra* note 130, at 9; Griswold, 1987, *supra* note 128, at 42.

132. Griswold, 1987, *supra* note 128, at 41.

133. *Id.*

134. *Id.* at 42.

135. *Id.* at 43.

136. *Id.*

137. Griswold, December, 1987, *supra* note 128, at 3.

138. Griswold, 1987, *supra* note 128, at 44-45. With differential tax assessment (rather than SCS subsidies) this cost could be offset through increased property taxes for those not participating in the program.

139. Griswold, December, 1987, *supra* note 128, at 2.

140. *Id.* at 3.

141. Jerry Griswold, U.S. Soil Conservation Service, Madison, Wisconsin, May 19, 1988 (personal conversation).

142. *Id.*

143. *Id.*

144. *Id.* Obviously, many states may not be limited in this way. One possible remedy to the constitutional prohibition against non-uniform property taxation could be the development of a new tax that applies to agricultural *activities* rather than *property*.

145. Griswold, May 19, 1988, *supra* note 141.

146. *Id; see* Griswold, December 1987, *supra* note 128, at 3.

147. Griswold, May 19, 1988, *supra* note 141; Griswold, December, 1987, *supra* note 128, at 3.

148. Griswold, May 19, 1988, *supra* note 141; Griswold, December, 1987, *supra* note 128, at 3.

149. Griswold, May 19, 1988, *supra* note 141; Griswold, December, 1987, *supra* note 128, at 3.

150. *See* Chesters, Gordon and Linda-Jo Schierow, "A Primer on Nonpoint Pollution," 40 *JSWC* 10 (1985).

151. Keeney, Dennis, "Nitrogen Cycle and Fate of Applied Nitrogen," paper presented at the Symposium of Plant Nutrient Use and the Environment, Kansas City, Missouri, October, 1985, at 16-18; *see generally* North Carolina Agricultural Extension Service, *Best Management Practices for Agricultural Nonpoint Source Control–IV. Pesticides*, September, 1984; North Carolina Agricultural Extension Service, *Best Management Practices for Agricultural Nonpoint Source Control–II. Commercial Fertilizer*, August, 1982.

152. Keeney, 1985, *supra* note 151, at 22.

153. Madariaga, 1986, *supra* note 16, at 4-6; Crowder, Bradley and C. Edwin Young, *Managing Farm Nutrients–Tradeoffs for Surface-and Ground-Water Quality*, U. S. Department of Agriculture, Economic Research Service, January, 1988, at 15. This relationship between surface water pollution and groundwater contamination is so important that CWA §319(b)(2)(A) requires that the BMPs identified in State Nonpoint Source Management Plans take "into account the impact of the practice on groundwater quality."

154. Although a good deal of phosphorus NPS pollution can consist of particles attached to sediment, there still are questions regarding the significance of dissolved phosphorus that can be controlled by typical erosion control techniques. North Carolina Agricultural Extension Service, 1982, *supra* note 151, at 37-39; Gianessi, Leonard P., *et al.*, "Nonpoint-Source Pollution: Are Cropland Controls the Answer?," 41 *JSWC* 216 (1986); U.S. Fish and Wildlife Service, *Nutrient Dynamics in the Choptank River Watershed–A Comparative Analysis of Subwatershed Exports*, Annapolis, Maryland, April 1988, at E-3 - E-4. Since phosphorus can often be controlled through the proper use of BMPs that control erosion, runoff and sediment deposition and/or controls similar to those that reduce surface water and groundwater contamination by nitrogen and pesticides, this section focuses on these latter two contaminants.

155. *See* Crowder and Young, 1988, *supra* note 153, at iv., 15-18.

156. *See* Keeney, Dennis R., "Nitrogen Management for Maximum Efficiency and Minimum Pollution," in *Nitrogen in Agricultural Soils*–Agronomy Monograph no. 22 ASA-CSSA-SSSA, Madison, Wisconsin, 1982, at 615, 617; Jackson, Gary and Bruce Webendorfer, *Nitrate, Groundwater and Livestock Health*, Wisconsin County Extension Office, G3217. Shabman, 1988, *supra* note 38, at 1, 3, 5; Hallberg, 1986, *supra* note 48, at 389.

157. *See generally* Keeney, 1982, *supra* note 156, at 632-633; Shabman, 1988, *supra* note 38, at 1, 3, 5; Hallberg, 1986, *supra* note 48, at 389.

158. *See*, Hallberg, 1986, *supra* note 48, at 363. Keeney, 1982, *supra* note 156, at 615-617.

159. *See* Keeney, 1982, *supra* note 156, at 615-633.

160. Central Platte Natural Resources District Newsletter, Vol. 2, No. 3-87, 1987, at 3; *see* Central Platte Natural Resources District, *Groundwater*

Management Plan, (Volume 1), December, 1985, at 15. (hereinafter cited as *CPNRD Groundwater Management Plan*).

161. *See generally*, Shabman, 1988, *supra* note 38, at 10-18. This nitrogen control plan is more involved than the steps described above. Other aspects include:

1. deemphasize cost sharing no-till BMPs (because of their inherent profitability to the farmer) and increase the use of cover crops along with changes in other farm management areas such as crop rotation, animal waste utilization, etc.;
2. improve the use of wooded buffer strips and regional manure storage and distribution facilities (to increase the availability of manure fertilizer to fields where it can be used);
3. channel research to address the development of total farm management systems that account for nutrient cycling over time instead of "isolated" research issues;
4. carefully develop economic incentives to decrease the initial economic impacts that can come with input substitution (including investment tax credits, accelerated depreciation and low interest loans).

In an input substitution strategy, if direct cash subsidies (cost sharing) are used they should: be for a limited time interval; take into account the value to the farmer of the reduced need for commercial fertilizer; and require that commercial applications of fertilizers be considered as organic sources of nitrogen increase. *Id.* at 14-18.

162. *Id.* at 2-8.

163. *See* University of Maryland Cooperative Extension Service and U.S. Fish and Wildlife Service, *Streamside Forests: The Vital, Beneficial Resource*, 1988; Hall, Tim, Claudia Jones and Pat Meckley, *A Proposal to Adopt Forest Buffers as an Agricultural Best Management Practice*, U.S. Fish and Wildlife Service and Maryland Forest, Park and Wildlife Service, (no date); U.S. Fish and Wildlife Service, "Woody Riparian Ecosystem Values as They Relate to Fish and Wildlife Resources," (no date); Lowrance, Richard, Ralph Leonard and Joseph Sheridan, "Managing Riparian Ecosystems to Control Nonpoint Pollution," 40 *JSWC* 87-91 (1985).

164. Letter from Glenn Kinser, U.S. Fish and Wildlife Service, Annapolis, Maryland, to Charles Spooner, U.S. EPA Chesapeake Bay Liaison Office, Annapolis, Maryland, October 16, 1987. In fact, maintaining viable riparian areas is vital in controlling many types of pollution generated by diffuse sources—as evidenced by the use of setbacks in urban land use controls; the maintenance of streamside buffers in silvicultural operations; and the preservation of riparian habitat to reduce the grazing impacts in rangeland environments.

165. *See* Holden, Patrick W., *Pesticides and Groundwater Quality: Issues and Problems in Four States*, National Acadamy Press, Washington, D.C., 1986; National Research Council, *Ground Water Quality Protection - State and Local Strategies*, National Academy Press, Washington, D.C., 1986.

166. National Research Council, 1986, *supra* note 165, at 133; *see generally Agricultural Chemicals and Groundwater Protection: Emerging Management and Policy,* Proceedings of a Conference, October 22-23, 1987, Freshwater Foundation, St. Paul, Minnesota,; Gips, Terry, *Breaking the Pesticide Habit–Alternatives to 12 Hazardous Pesticides,* International Alliance for Sustainable Agriculture, Minneapolis, Minnesota, 1987.

167. National Research Council, 1986, *supra* note 165, at 140. One method to reduce pesticide use is called Integrated Pest Management (IPM), which involves using several pest control techniques to develop more cost-effective management of pests through non-chemical means and through improved timing and placement of chemical application. *Id.* at 142. *See* California Assembly Office of Research, *The Leaching Fields–A Nonpoint Threat to Groundwater,* March, 1985, at 130-144; *see generally* Gips, Terry, *Breaking the Pesticide Habit–Alternatives to 12 Hazardous Pesticides,* International Alliance for Sustainable Agriculture, University of Minnesota, 1987; U.S. EPA, *Protecting Groundwater: Pesticides and Agricultural Practices,* February, 1988.

168. *National Research Council,* 1986, *supra* note 165, at 16-17.

169. There is no reason why this program could not be used to control surface water pollution as well.

170. Neb. Rev. Stat. §§ 2-3201 - 2-3203 (1986).

171. *See, e.g.,* Neb. Rev. Stat. §§ 2-3276 - 2-3277 (1986).

172. Neb. Rev. Stat. § 46-666 (1986).

173. Neb. Rev. Stat. § 46-666(c) (1986).

174. Neb. Rev. Stat. § 46-673.01 (1985); *see CPNRD Groundwater Management Plan,* December, 1985, *supra* note 160, at 2. This issue concerns the development of policies and programs designed to manage the allocation of groundwater within a given area. The regulatory programs developed under this law are part of a broader natural resources planning process required for each district.

175. Besides the adverse surface water impacts that can be caused by groundwater discharges of nitrates to surface water, nitrate contaminated groundwater can be unusable as a drinking water source, even for livestock. In Nebraska, nitrates in groundwater have been recognized as an important problem. *CPNRD Groundwater Management Plan* December, 1985, *supra* note 160, at 1.

176. *Id.* at 52 (quoted).

177. Central Platte Natural Resources District Newsletter, Vol. 3, No. 6-87, 1987, at 1-2; *see* Central Platte Natural Resources District, *Groundwater Supply Management Controls,* (no date), Attachment C (hereinafter cited as *Groundwater Supply Management Controls*).

178. Central Platte Natural Resources District Newsletter, 1987, *supra* note 177, at 2. Given that federal drinking water standards are 10 ppm, this might be a more appropriate cutoff for Phase I.

179. *Id.* at 2-3.

180. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C.

181. *Id; CPNRD Groundwater Management Plan,* December, 1985, *supra* note 160, at 52.

182. *CPNRD Groundwater Management Plan,* December, 1985, *supra* note 160, at 52.

183. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C; Central Platte Natural Resources District Newsletter, 1987, *supra* note 177, at 2-3.

184. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C; Central Platte Natural Resources District Newsletter, 1987, *supra* note 177, at 2-3.

185. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C. An inhibitor slows the release of nitrogen so that the nutrient is more available for plant uptake and, consequently decreases the opportunity for nitrogen runoff or leaching. *See* Keeney, 1982, *supra* note 156, at 637.

186. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C.

187. *Groundwater Supply Management Controls,* (no date), *supra* note 177, at Attachment C. Central Platte Natural Resources District Newsletter, 1987, *supra* note 177, at 3.

188. Central Platte Natural Resources District Newsletter, 1987 *supra* note 177, at 3.

189. *Id.,* at 3-5.

190. *Id.*

191. *Id.* at 5.

192. Wisconsin Act 410, 1983.

193. Patronsky, Mark C. and Anne Bogan-Rieck, *The New Law Relating to Groundwater Management [1983 Wisconsin Act 410],* Wisconsin Legislative Council Staff, July 10, 1984, at 1; Wisc. Stat. §§ 160.001 (1984).

194. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 7; Wisc. Stat. § 160.01 (1984).

195. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 7-8; Wisc. Stat. §§ 160.05-160.09 (1984).

196. Patronsky and Bogan-Reick, 1984, *supra* note 193, at 9; Wisc. Stat. § 160.05(3) (1984).

197. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 9; Wisc. Stat. § 160.05(3) (1984).

198. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 11; Wisc. Stat. § 160.25 (1984).

199. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 2, 10-11; Wisc. Stat. § 160.23 (1984).

200. Patronsky and Bogan-Reick, 1984, *supra* note 193, at 2, 10-11; Wisc. Stat. § 160.23 (1984).

201. Patronsky and Bogan-Reick, 1984, *supra* note 193, at 9; Wisc. Stat. § 160.19(1) (1984).

202. Patronsky and Bogan-Reick, 1984, *supra* note 193, at 10; Wisc. Stat. § 160.21 (1984).

203. Patronsky and Bogan-Reick, 1984, *supra* note 193, at 9-11; Wisc. Stat. § 160.19(2) (1984).

204. Patronsky and Bogan-Reich, 1984, *supra* note 193, at 10; Wisc. Stat. § 160.19(4) (1984).

205. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 10-11; Wisc. Stat. § 160.23(1) (1984).

206. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 11; Wisc. Stat. § 160.25 (1984).

207. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 10-11; Wisc. Stat. §§ 160.23-160.25 (1984).

208. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 12; Wisc. Stat. § 160.27(3) (1984).

209. Patronsky and Bogan-Rieck, 1984, *supra* note 193, at 12; Wisc. Stat. § 160.27(6) (1984).

210. State of Wisconsin Department of Agriculture, Trade and Consumer Protection, *Draft Environmental Impact Statement For Proposed Rules Relating to Special Restrictions on the Use of Pesticides Containing Aldicarb*, (no date), at 3; Wisc. Stat. §§ 94.69-94.70 (1982); Wisc. Admin. Code §§ Ag. 29.17(5)-(8) (1988).

211. State of Wisconsin Department of Agriculture, Trade and Consumer Protection, (no date), *supra* note 210, at 3-4; Wisc. Stat. § 94.70 (1982); Wisc. Admin. Code § Ag. 29.17(2) (1988).

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212. State of Wisconsin Department of Agriculture, Trade and Consumer Protection, (no date), *supra* note 210, at 3; Wisc. Stat. § 94.70 (1982); Wisc. Admin. Code § Ag. 29.17(2)(b) (1988). Besides Wisconsin, Florida has also restricted the timing, method, site and rate of aldicarb application. Suffolk and Nassau counties in New York State have completely banned the use of aldicarb. National Research Council, 1986, *supra* note 166, at 136.

213. Clean Water Action Project, *et al.*, *Protecting The Nation's Groundwater: A Proposal for Federal Legislation*, June, 1988. (NRDC is a signatory to this proposal.)

214. *Id.* at 27-32.

215. *Id.* at 40-44. BPMs include prohibitions of unacceptable practices as well as design, technology, design, citing, monitoring and maintenance standards for sources, while BAAMs focus on "techniques and methods to reduce substantially the amount of waste that must be disposed of or chemicals that must be used on the land surface. *Id.* at ix.

216. *Id.* at 40-50.

217. *Id.* at x, 55-65.

218. *Id.*

219. Massachusettes Department of Food and Agriculture, Pesticide Bureau, *Protection of Groundwater From Pesticides* (draft), September, 1988, at 7-12.

220. *Id.* at 12.

221. *Id.* at 14.

222. *Id.*

223. *Id.* at 15.

224. *Id.*

225. *Id.*

226. Massachusetts Department of Food and Agriculture, Public Hearing Notice – Pesticide Board (proposed regulations to 333 Code of Massachusetts Regulations), no date.

227. *Id.*

228. Fla. Admin. Code 17-25.035 (1987). Florida's stormwater permit system is described in Chapter Four.

229. Fla. Admin. Code 17-25.030(4)(e)(1987); Jeff Ellige, St. Johns River Water Management District, April 5, 1988 (personal conversation).

230. Hal Wilkening, St. Johns Water Management District,

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March 21, 1988 (personal conversation). *See generally* Fla. Admin. Code 40E-40 (1987).

231. Fla. Admin. Code 40E-40 (1987); Jurgens, J.A., "Agricultural Nonpoint Source Pollution: A Proposed Strategy to Regulate Adverse Impacts," 2 *J. Land Use and Envt'l. L.* 203 (1986).

232. General Assembly of Pennsylvania, H.B. 2616 (1988 Session), §2(2).

233. General Assembly of Pennsylvania, H.B. 2616 §3(a)-(b).

234. Victor Funk, Pennsylvania Bureau of Soil and Water Resources, October 24, 1988 (personal conversation).

235. Ariz. Rev. Stat. Ann. §49-247 (1987).

236. *See generally* Arizona Department of Environmental Quality, *DEQ Concept Paper—Agricultural General Permit Rules for Nitrogen Fertilizer Application*, April 27, 1988. Obviously, if surface water quality considerations are not also taken into account, this program could simply transfer the contamination to surface waters through runoff.

237. *Id.*

238. *Id.*

239. North Carolina Agricultural Extension Service, *Best Management Practices for Agricultural Nonpoint Source Control—Animal Waste*, Raleigh, North Carolina, August 1982, at 1-3; Elmore, Wayne and Robert L. Beschta, "Riparian Areas: Perceptions in Management," *Rangelands*, December 1987, at 260 - 265; Sweeten, John M. and Stewart W. Melvin, "Controlling Water Pollution from Nonpoint Source Livestock Operations," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, May, 1985, at 215.

240. Sweeten and Melvin, 1985 *supra* note 239, at 215.

241. 40 CFR §122.23 and pt.122, appendix B. NRDC does not necessarily agree that EPA has the authority to exempt small feedlots from point source controls. A major federal effort to control some of these water quality impacts is the development of a national point-source permit program for *confined* feedlots with *at least 1,000 animal units*. The permit requires that holding ponds be installed to collect all runoff from a 25-year frequency, 24-hour duration storm (or that a wastewater treatment process as well as land disposal by irrigation or evaporation be utilized). Sweeten and Melvin, 1985, *supra*, note 239, at 215.

242. Dave Knicely, Shenandoah Valley Sail end Water Conservation District, December 6, 1988 (personal conversation); Keene, 1984, *supra* note 4, at 5.

243. U.S. EPA, January, 1984, *supra* note 1, at 2-11.

244. Sweeten and Melvin, 1985, *supra* note 239, at 215.

245. *Id.*

246. The control of poison runoff from rangeland grazing is discussed in the following chapter.

247. Fred A. Douma, Milk Producers Council, May 16, 1988 (personal conversation); *see* Swetten and Melvin, 1985, *supra* note 239, at 216; U.S. EPA, January, 1984, *supra* note 1, at 2-11, 3-7 - 3-9.

248. Sweeten and Melvin, 1985, *supra* note 239, at 216.

249. *Id.* at 217.

250. Fred A. Douma, Testimony before U.S. House of Representatives, Subcommittee on Department Operation, Research, and Foreign Agriculture of the Committee on Agriculture, December 9, 1987, at 1; Cal. Admin. Code, tit. 23 R. §§ 2560-2565 (1984).

251. Douma, 1987, *supra* note 250, at 1; Cal. Admin. Code tit. 23 R. §§ 2560-2565 (1984).

252. Cal. Admin. Code tit. 23 R. §§ 2560-2565 (1984); Michael Adackopara, Santa Ana Regional Water Control Board, May 19, 1988 (personal conversation). This level was set using a computer model to establish a level with groundwater impacts comparable to those caused by properly managed septic systems or cropland agriculture, and providing protection from Total Dissolved Solids (TDS) and nitrate. Michael Adackopara, May 19, 1988, *supra*.

253. *See*, Douma, 1987, *supra* note 250, at 2; Cal. Admin. Code tit. 23 R. §§ 2560-2565 (1984).

254. Douma, 1987, *supra* note 250, at 2; Cal. Admin. Code tit. 23 R. §§ 2560-2565 (1984).

255. *See* Duoma, 1987, *supra* note 250, at 4-6; California Regional Water Quality Control Board, Central Valley Region, "Regulation of Confined Animal Facilities," correspondence with Kings, Kern, Tulare, Merced, Madera and Maripora counties, April, 1988.

256. *See* Douma, 1987, *supra* note 250, at 4; Adackopara, 1988, *supra*, note 252.

257. Ubbo Agena, Iowa Department of Water, Air, and Waste Management, May 17, 1988 (personal conversation); *see generally*, Iowa Admin. Code 567 § 65 (1987).

258. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(1) (1987).

259. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(1)(b), § 65 (Appendix A) (1987).

260. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.3(b) (1987).

261. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(2) (1987).

262. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(2), § 65 (Appendix A) (1987).

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263. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(3)(c), §65 (Appendix A) (1987).

264. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(7) (1987).

265. Agena, 1988, *supra* note 257; Iowa Admin. Code 567, § 65.2(7) (1987). For example, a limit of 250 lbs/acre of nitrogen has been suggested, although even this limit is probably too high. Requirements for land disposal were recently considered in Iowa but later were rejected, mainly because it was thought such requirements, in the absence of controls on fertilizer users, would not be equitable. Agena, 1988, *supra* note 257.

266. Pa. Stat. Ann., tit. 35, § 691.1, § 691.202; Pennsylvania Bureau of Water Quality Management, *Manure Management for Environmental Protection*, Publication No. 43, at 6; Pa. Admin. Code § 101.8(a), § 101.8(b). Waters of the Commonwealth include both surface and groundwaters. Pa. Stat. Ann., tit. 35, § 691.1.

267. Pa. Admin. Code § 101.8(a), § 101.8(b).

268. Agena, 1988, *supra* note 257; *see generally* Iowa Admin. Code 567, § 65 (1987).

269. Adackapara, 1988, *supra* note 252.

270. *See generally Environmental Aspects of Irrigation and Drainage*, Conference Proceedings, University of Ottawa, Ottawa, Ontario, July 21-23, 1976, American Society of Civil Engineers; Carter, David L., "The Impact of Irrigation on Groundwater Quality," in *Irrigation and Drainage: Today's Challenge*, American Society of Civil Engineers, 1980, at 13-20.

271. Willey, W.R.Z., *Irrigation and the Environment in the U.S.*, Proceedings of the American Society of Agricultural Engineers' Second National Irrigation Symposium, October 1980, at 42.

272. USDA Economic Research Service, *Irrigation in the United States*, NTIS Publication 85-195568, at 35-36.

273. *Id.* In more humid regions salts are often leached out of the soil.

274. *Id.* at 36; Council For Agricultural Science and Technology, *Agriculture and Groundwater Quality*, Report No. 103, May 1985, at 15-18.

275. Council for Agricultural Science and Technology, 1985, *supra* note 274, at 15-18.

276. *Id.*

277. California State Water Resources Control Board, *Regulation of Agricultural Drainage to the San Joaquin River - Executive Summary*, August, 1987, at 6 (hereinafter cited as State Water Resources Control Board).

278. Keeney, 1982, *supra* note 156, at 628-629; California State Water Resources Control Board, August, 1987, *supra* note 277, at 6-7.

279. Willey, 1980, *supra* note 271, at 43.

280. USDA Economic Research Service, *supra* note 272, at 36.

281. *Id.; see generally* J.M. Lord, Inc., *Study of Innovative Techniques to Reduce Subsurface Drainage Flows*, November, 1987.

282. State Water Resources Control Board, August, 1987, *supra* note 277, at 6-7; *see generally* University of California Committee of Consultants on Drainage Water Reduction, *Opportunities for Drainage Water Reduction*, The University of California Salinity/Drainage Task Force, January, 1988.

283. San Joaquin Valley Drainage Program, *Evaluation of On-Farm Agricultural Management Alternatives*, October, 1986, at 1-1 (hereinafter cited as San Joaquin Drainage Program).

284. The San Joaquin Valley Drainage Program, made up of representatives of the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, and the California Departments of Fish and Game and Water Resources, was convened to investigate methods of addressing the drainage problem in the San Joaquin Valley.

285. State Water Resources Control Board, August, 1987, *supra* note 277, at 1.

286. *Id.* at 4.

287. *Id.* at 6-7.

288. *Id.* at 8.

289. *Id.* at 8-9.

290. For a detailed evaluation of the problems associated with federal water subsidies and potential ways to address these problems, *see generally* King, Laura and Phillip Le Veen, *Turning Off the Tap on Federal Water Subsidies*, Natural Resources Defense Council and the California Rural Legal Assistance Foundation, 1985.

291. San Joaquin Valley Drainage Program, October, 1986, *supra* note 283, at 1-4.

292. This approach raises legal questions concerning the "appurtenancy" provision of Reclamation Law which may permanently attach water rights to particular pieces of land. San Joaquin Valley Drainage Program, *Developing Options - An Overview of Efforts to Solve Agricultural Drainage and Drainage-Related Problem in the San Joaquin Valley*, December, 1987, at 28.

293. San Joaquin Valley Drainage Program, December, 1987, *supra* note 292,

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at 28. San Joaquin Valley Drainage Program, October, 1986, *supra* note 283, at 9-7 - 9-8.

294. S.C. Code Ann., §12-7, §6-15.(A)(1) (Law. Co-op. 1986)

295. *See* Gaffney, Mason, "Nonpoint Pollution: Tractable Solutions to Intractable Problems," in paper presented at the Conference on Political, Institutional and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987; Wheeler, no date, *supra* note 109, at 2.

296. *See* Keene, 1984, *supra* note 4, at 49.

297. For a more comprehensive discussion of Farmland Protection Programs, *see* Ward, Justin R. *Taxing The Rural Landscape: Improving State and Federal Policies for Prime Farmland*, Natural Resources Defense Council, January, 1988; Keene, 1984, *supra* note 4.

298. *See* Keene, 1984, *supra* note 4, at 50-52.

299. Ward, 1988, *supra* note 297, at 9.

300. *See* Keene, 1984, *supra* note 4, at 50-52.

301. Geier, Karl E., "Agricultural Districts and Zoning: A State-Local Approach to a National Program," 8 *Ecology Law Quarterly* 670-671 (1980).

302. *Id.* at 675.

303. *See Farmland Notes*, "TDC Program in Montgomery County, MD, Upheld in Second Legal Battle," National Association of State Departments of Agriculture, August, 1985 at 1.

304. Ward, 1988, *supra* note 297, at 16; "North Carolina County Initiates PDR Program," 40 *JSWC* 288 (1985).

305. Ward, 1988, *supra* note 297, at 14.

306. *See* Keene, 1984, *supra* note 4, at 52; *Farmland Notes*, "Exploring The Use of Buffer Zones in Hawaii," National Association of State Departments of Agriculture, November, 1985, at 2; *see generally* Geier, 1980, *supra* note 301, at 655-696.

307. Ward, 1988, *supra* note 297, at 17-19.

308. *Id.*

309. *Id.* at 19.

310. Jerry Griswold, U.S. Soil Conservation Service, Madison, Wisconsin, May 18, 1988 (personal conversation); Wis. Stat. §92.025 (1985-86).

311. *Farmland Notes*, "Agricultural Districting Legislation Passes in North Carolina," National Association of State Departments of Agriculture, August 1986, at 1.

312. Keene, 1984, *supra* note 4, at 53.

313. *Farmland Notes*, "Groups Target Bay Area Open Space for Protection," National Association of State Departments of Agriculture, June 1985, at 1.

314. *Id.* at 3.

315. *Id.*

316. *Id.*

317. *See* Sand, Duane, "Conservation Easements: A Credit Crisis Compromise," 40 *JSWC* 217 (1985); Ward, Justin, *Conservation Easements: Prospects for Sustainable Agriculture*, Natural Resources Defense Council, June 1988.

318. Ward, June, 1988, *supra* note 317, at 1-7.

319. Sand, 1985, *supra* note 317, at 217.

320. *Id.*

321. *Farmland Notes*, "Conservation Easement Regulations Issued By Farmer's Home Administration," National Association of State Departments of Agriculture, June 1986, at 1; Food Security Act of 1985, 7 U.S.C.A. § 1997. USDA can establish conservation easements for "conservation, recreational, and wildlife purposes on farm property that is wetland, wildlife habitat, upland or highly erodible land." 53 Fed. Reg. 35,750 (September 14, 1988).

322. Sand, Duane, "Conservation Easements and the Conservation Movements," 40 *JSWC* 338 (1985).

323. *Farmland Notes*, "State Farmland Protection Updates," National Association of State Departments of Agriculture, June 1987, at 2.

324. *Id.*

325. Derr, Donn A., "Integrating Soil Conservation Practices Into Farmland Leasing Arrangements," 42 *JSWC* 356 (1987).

326. *Id.* at 357.

327. *Id.* at 358.

328. *Id.* at 357-358.

329. *Id.* at 358.

330. *Id.*

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Per unit area, water quality impacts from intensely developed urban lands often are greater than the impacts from agriculture.

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Chapter Four

Land Use and Contaminated Urban Runoff Controls

Introduction

Contaminated runoff from urban areas presents unique management requirements. For example, most urban water pollution runs off or through government-controlled streets or stormwater systems. Therefore, programs to control poison runoff may require even more involvement by local governments than agricultural controls. Additionally, water pollution in urban areas is caused by a diverse set of sources whose management requires a broad range of program activities.

Like controls for other categories of poison runoff, however, urban controls must address *aggregate* pollution sources that individually contribute relatively minor pollution loads, but that cumulatively may have large impacts. Fortunately, urban residents may be more willing than rural residents to pay for controls and to accept the need for regulation.[1] In fact, unlike agricultural pollution control programs, there is little debate over the "voluntary vs. regulatory" issue in controlling pollution from urban areas. Specific regulatory urban controls (such as erosion and sediment control and stormwater management requirements) already are common, although many *general* urban program to control poison runoff still have significant voluntary components.[2]

An array of controls is available to address poison runoff generated in urban areas. In this chapter, these controls are grouped into three general categories:

1. land use controls;
2. stormwater control programs; and
3. erosion and sediment control programs.

The necessary elements of each type of program are described below, drawing on examples from model programs around the country.

Two general principles, however, transcend each type of program. First, comprehensive urban runoff controls cannot and should not be divorced from the routine functions of local government—in particular, zoning and comprehensive planning. For example, some experts have labeled zoning the most effective local means to control groundwater contamination.[3] Urban runoff problems also are addressed most effectively by sound land use planning, rather than by focusing only on structural stormwater controls.[4]

Similarly, urban controls can be imposed either before or after development and associated water pollution problems occur. Pre-development controls take advantage of comprehensive, non-structural approaches that can guide growth in ways that *prevent* pollution problems. Trying to manage urban stormwater after pollution problems have developed often is more expensive and less efficient than pre-development controls. But in areas where development already has occurred, "retrofitting" urban runoff controls often is essential.

Therefore, capital-intensive structural controls to retrofit existing development must be integrated with ongoing land use management programs designed to address problems arising from new development. Table 4-1 gives examples of available land use management tools for both pre-development and post-development control of contaminated urban runoff. These controls can be applied to protect critical environmental resources such as erosion- and flood-prone lands, wetlands, aquifers, steep slopes and streams.

Table 4-1
Potential Tools for Urban Poison Runoff Control*

Pre-Development Controls	Development Controls	Post-Development Controls
1. amount, density, nature, location and timing of development	1. grading and other soil disturbance controls	1. volume and rate of discharges to stormwaters systems
2. natural drainage features and buffer zones	2. infiltration devices, detention ponds and other stormwater controls	2. erosion and sediment reductions in developed areas and on streambanks
3. infiltrative soils	3. permeable surfaces	3. site-specific BMPs for individual areas: golf courses, refuse sites, etc.
4. vegetative cover	4. site stabilzation	4. easement purchases

* Source: Adapted from Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, 1984, Hauppauge, New York, at Chapters 1, 2 and 9.

Land Use Controls

General Principles for Controlling Land Use to Protect Water Quality

Perhaps the broadest and most versatile category of programs to control poison runoff comes under the general heading of land use controls. When used effectively, land use controls can prevent pollution problems by establishing land use patterns that are consistent with water quality protection, open space preservation and other environmental objectives, while at the same time providing for orderly and rational economic development.[3] The

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Uncontrolled land use development can devastate an aquatic system.

controls discussed in this chapter are applied largely at the local level.[6]

Land use controls can reduce water pollution loads in two ways. First, the rate of growth and the location and type of development can be controlled through the use of a zoning ordinance and Comprehensive Plan. Second, pollution generated by a *given* type or level of growth can be reduced by such techniques as subdivision ordinances, special overlay districts, and site plan reviews.

The Northern Virginia Planning District Commission evaluated the impact of the land use controls, and developed the following general guidelines on how to employ land use planning to protect water resources:[7]

1. *Per Capita Loading*—Generally, the greater the density the lower the *per capita* and the greater the *per acre* pollution loadings, indicating the usefulness of open space or cluster

development requirements in zoning and subdivision ordinances.

2. *Soil Permeability*—Since runoff is influenced by soil permeability,[8] land use planning should encourage large lot and medium density single family homes in areas with relatively permeable soils while requiring land uses such as shopping centers and apartments in areas with impermeable soils.

3. *Cluster Development*—Cluster developments can further minimize impervious surfaces and provide open space by tailoring lot placement and road design to reduce pollution loads.

4. *Growth Policies*—Growth in certain areas should be limited through the zoning ordinance, thereby reducing the pollution loads associated with certain densities or kinds of development.

Land use controls also can be employed to control the level of land disturbing activities (*e.g.* construction) in an area at a given time; allowable activities in and around a riparian area; construction on steep slopes; the use of erosion control practices on developing land; and the level of vegetation left on a site. Other controls can restrict the location of buildings or storage areas in relation to streams or aquifers (setbacks and recharge zone restrictions, respectively), or require the use of specific BMPs or compliance with performance standards that will improve runoff quality and reduce its quantity.

Three major types of land use controls are useful in controlling poison runoff in urban areas:

1. Zoning and Comprehensive Planning;

2. Subdivision Review; and

3. Site Plan Review.[9]

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Zoning is a land use control that dictates the density and type of development within a given area. Typically, zoning is imposed by local ordinance. By limiting development density or restricting land uses to those that are compatible with protecting water quality, zoning can be an important tool to control poison runoff.[10]

Overall local development is controlled through a *Comprehensive Plan* that takes into account a wide range of factors, including water quality and other environmental goals. Certain land uses generally are reviewed through a special use permit process, and design regulations or performance standards for various uses can be included in the ordinance.[11] Zoning maps generally delineate districts where certain land uses are allowed if in conformity with minimum standards such as lot size, building setbacks, and lot coverage requirements (*i.e.*, what percentage of lot surface can be covered by structures and pavement).[12] For example, zoning ordinances can impose setback requirements from water bodies, and can require lower density for riparian lots.[13]

Subdivision review involves reviewing subdivision maps and plots for conformance with rules and development standards for adequate building lots, streets, sewers, grading, and relationship to other properties and with the Comprehensive Plan and zoning map.[14] Subdivision review can include drainage and grading requirements and provisions for parks, buffer areas, and open space. It also can include requirements for innovative cluster developments that concentrate development in suitable areas while preserving sensitive land as open space.[15]

Site plan review and authorization means the municipal review of plans for individual new developments or expansions of current uses to ensure compliance with zoning requirements and other factors related to public health and safety.[16] Site development standards and BMPs related to water quality protection also can be imposed through the site plan review.[17]

In addition, a number of other land use controls may be helpful in controlling urban water pollution. These include:

1. transfer of development rights (TDR) to bar development in certain areas, with the provision that the rights to

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development can be applied in other areas not normally subject to such development;

2. the use of county or city Sanitary Codes to control on-site sewage systems and drinking-water wells;

3. watershed rules and regulations designed specifically to protect water quality;

4. ownership/easements to prevent or restrict development;

5. building codes to improve control of potential pollutants; and

6. regulations to prevent unsuitable land uses in flood prone areas and on steep, erodible slopes.[18] (Regulations also can be developed at the local level to prevent the destruction of wetlands, riparian areas or other sensitive environmental resources).

Table 4-2 describes briefly some of the specific land use controls listed above.

Table 4-2
Land Use Controls Valuable in Reducing Water Pollution Impacts*

Type of Land Use Control	Description	Examples
1. zoning	identifies allowable land uses and restrictions in particular areas	areas are divided into residential, commercial and other development zones; parks, greenbelts and open space are provided; high intensity uses are zoned away from waterways
a. use restrictions	in a given area, only land uses compatible with planning goals and objectives are allowed	industrial and high density development near waterways or sensitive environmental areas is prohibited
b. density restrictions	in a given area, maximum development intensity, as measured by dwelling units per area, is controlled	high density development near waterways is prohibited
c. lot surface restrictions	coverage establishes maximum amount of impervious surface per unit area	impervious surface is limited to 25% of each parcel
d. setbacks	building within a certain distance of a stream or other sensitive resource is prohibited	construction activity within 200 feet of a stream or wetland is prohibited

* Source: Adopted from Schenectady County Planning Department, *Groundwater Supply Source Protection - A Guide for Localities in Upstate New York* (no date). Specific numeric values, such as 200 foot setbacks, are given only as examples. Appropriate requirements will vary depending on location.

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Type of Land Use Control	Description	Examples
e. special use permits	"special" land uses authorized only on a case-by-case determination to allow the imposition of special restrictions	industrial activity in a particular zone is classified as "special use," authorizing the zoning board to review and modify individual applications and to impose special conditions
f. design and performance standards	prohibits certain land uses unless a specified set of criteria and standards is followed	zoning ordinance references BMP manuals and state water quality standards as minimum requirements that must be met in order to site a commercial development
g. special protection areas	delineates special areas to protect specific natural resources; special restrictions (including preservation) apply in these areas	groundwater or surface water "protection districts" are established where a set of special environmental protections apply (such as prohibiting on-site septic systems or the use of certain pesticides)
h. special overlay districts	similar to special protection areas except special restrictions are superimposed on (not a substitute for) underlying zoning characteristics	areas are established in the zoning ordinance where special density restrictions are applied to protect groundwater or surface water, in addition to other restrictions
2. Site Plan Authorization	review of individual development plans for environmental impacts; applies restrictions and/or incentives as necessary	planning board refuses to authorize a site for a shopping mall unless additional infiltration devices are used to reduce contaminated runoff
3. Subdivision Maps and Plats	place restrictions on the subdivision of land to account for water quality protection needs	new subdivisions are conditioned on the use of natural drainage features, open space, and other water quality protection measures

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Type of Land Use Control	Description	Examples
4. Local Sanitary Codes	set minimum design, location, and operation and maintenance requirements for septic systems, drinking water wells and sewer systems	use of septic systems is conditioned on calculations of mass nitrogen loadings to underlying groundwater; sanitary sewers must be kept separate from storm sewers
5. Watershed Rules and Regulations	establish comprehensive requirements within a particular hydrologic unit in order to protect water resources	comprehensive county program sets uniform requirements such as setbacks and zones of protection throughout entire watershed
6. Building Code	establishes specifications for the design and construction of residential, commercial and industrial sites; enforced by local building inspectors	uniform state building code requires industrial chemicals and materials stored outside to be covered; prohibits outside storage of used motor parts; prohibits use of building materials that contaminate stormwater
7. Floodplain Regulations	impose land use and other restrictions to control development in flood-prone areas and areas with steep, erodible stream banks	county ordinance prohibits new construction in 20- year flood plain on slopes greater than 10 percent

Land and Easement Purchase. The most drastic but most effective land use control to protect water quality is the use of eminent domain to purchase sensitive riparian zones, wetlands, floodplains, or other areas. This public land also provides aesthetic, recreational, habitat and other benefits. A less drastic and less expensive alternative is to purchase conservation easements, for example to restrict development along a coastline; or development rights, to allow existing uses to continue while preventing more intensive future development.

Of course, these strategies require significant expenditures. One way to pay for land acquisition is to dedicate taxes from land development elsewhere in the jurisdiction. And private conservation groups can be authorized and encouraged, by state or local laws and tax incentives, to purchase lands and easements to supplement government efforts.

Nevertheless, the amount of land that can be protected through outright purchase, conservation easement, or development restrictions is finite. Therefore, this strategy should focus on areas that require the greatest degree of protection. Governments should identify, prioritize, and acquire these areas as soon as possible.

Moreover, given these limitations, acquisition must be viewed as a way to *supplement*, not to supplant, the other land use controls identified above. Pollution from developed areas easily can overwhelm gains achieved through land acquisition.

Wetlands Protection. Preserving any open space is desirable to control poison runoff. Open space and related natural vegetation preserves natural drainage, thus reducing the total runoff in an area. And obviously, any area that is kept open will not be a source, or at least a major source, of poison runoff.[19]

For purposes of water quality protection, however, one of the most important types of "open space" is the natural wetland. Wetlands play a major role in natural hydrological systems. They protect water quality by controlling flooding, reducing erosion, recharging groundwater, filtering sediment, and reducing (by uptake into biological systems) nutrients and other pollutants.[20] Of course, from a broader land use perspective, wetlands provide a wide range of other public benefits such as important fish and shellfish habitat (including spawning areas for commercial and recreational fisheries), habitat for waterfowl and other birds and wildlife, water supply, recreation, environmental education, and aesthetics.[21]

An existing federal regulatory program, under section 404 of the Clean Water Act, is designed in part to prevent the loss or destruction of wetlands from the discharge of dredge and fill material.[22] However, the 404 program has, at best, been extremely incomplete in its ability to preserve wetlands for water quality protection. Section 404 contains a number of exemptions, most notably an exemption for "normal farming, silviculture, and

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ranching activities."[23] The Corps of Engineers interprets section 404 as applicable only to discharges of dredge and fill material, and not to wetlands loss due to simple drainage.[24] And the program has been criticized widely due to inadequate implementation and enforcement, and a host of other problems.[25]

Because of these problems and limitations, wetlands in the United States continue to be lost at a frightening rate. Over the past two decades, wetlands losses averaged between 300,000 and 500,000 acres per year.[26] All told, since the mid-1950s, we have lost almost 15 million acres of freshwater wetlands and almost a half million acres of saltwater wetlands.[27] For freshwater wetlands the primary culprit has been agricultural drainage, while most saltwater wetlands losses have occurred as a result of development.[28]

Clearly, then, states cannot rely exclusively on the section 404 program to protect wetlands for water quality or other purposes. Other avenues are available, however, for state and local governments to protect wetlands.

For one, states could assume responsibility of the section 404 program from the Corps of Engineers. Under section 510 of the Clean Water Act,[29] states could implement this program more stringently and more expansively than the Corps. Alternatively, states could exercise their authority to deny water quality certifications for section 404 permits, under section 401 of the Clean Water Act, to protect wetlands when the Corps otherwise would have issued a permit.[30] However, given that these authorities have been available all along, but have been used sparingly, additional regulatory approaches at the state and local level may be appropriate.

Perhaps the most obvious way for states and localities to protect wetlands, consistent with the principles addressed in this chapter, is through comprehensive planning and zoning and other land use controls, including direct acquisition. Wetlands can be zoned for open space or watershed protection. Development can be restricted or prohibited in and within prescribed buffer zones around wetlands. Tax incentives can be provided to induce private landowners to preserve wetlands.

In addition, some states have enacted special legislation to protect wetlands. For example, currently most coastal states have land development elsewhere in the jurisdiction. And private conservation groups can be authorized and encouraged, by state or local laws and tax incentives, to purchase lands and easements to supplement government efforts.

Nevertheless, the amount of land that can be protected through outright purchase, conservation easement, or development restrictions is finite. Therefore, this strategy should focus on areas that require the greatest degree of protection. Governments should identify, prioritize, and acquire these areas as soon as possible.

Moreover, given these limitations, acquisition must be viewed as a way to *supplement*, not to supplant, the other land use controls identified above. Pollution from developed areas easily can overwhelm gains achieved through land acquisition.

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laws that protect coastal wetlands.[31] In contrast, fewer than 20 states have laws to protect inland wetlands.[32] Both coastal and inland wetlands protection programs often restrict only certain types of activities or apply to wetlands of a certain type or minimum size.[33]

State programs to protect inland wetlands are particularly underdeveloped. As mentioned above, many states do not have any programs to protect these natural areas. And existing state programs often exclude significant activities from their coverage. For example, a recent review by the Virginia Division of Soil and Water Conservation of state inland wetlands programs revealed that programs typically exclude agricultural activities from wetland conservation requirements, despite the fact that agriculture is a major cause of inland wetland destruction.[34] However, the fact that many diverse programs have been developed to reduce or eliminate the environmental impacts of dredge and fill, construction, excavation and other activities in these important areas demonstrates that significant protection of inland wetlands is possible.

For example, in Washington State, the *state* program to protect wetlands exempts small wetlands and minor developments from regulation.[35] The exemption can result in significant cumulative impacts on wetlands.[36] In the Puget Sound *region* of the state the Department of Ecology is responding, in part, by developing new standards for local regulatory programs to protect wetlands, including standards to improve the protection of certain types and sizes of wetlands.[37] The inclusion of wetlands protection in state water quality standards also is being considered.[38]

The protection of non-tidal wetlands was an important legislative issue in Virginia in 1988. A bill was introduced in the 1988 legislative session that called for the establishment of a regulatory program to reduce the destruction through development and agricultural activities of non-tidal wetlands in the eastern part of the state.[39] However, the bill, which included many exemptions,[40] was opposed both by environmental and development interests and is not being carried over into the 1989 legislative session.

Avoiding Potential Pitfalls of Land Use Management for Water Quality Protection

By managing development within a watershed to produce land use patterns that minimize water pollution, proper land use controls can reduce the need for public expenditures for structural BMPs such as regional detention basins and street sweeping.[41] At present, however, traditional land use controls implemented by local planning and zoning agencies usually focus on amenity values (*e.g.*, aesthetics) rather than on public health or physical measures of environmental quality.[42] Thus, land use controls designed exclusively by local zoning authorities often do not stress water quality considerations.[43]

One way to overcome this shortcoming is to involve a local health or environmental agency in preparing land use controls to reduce poison runoff. Olmsted County, Minnesota, for example, involved the County Health Department in the development of zoning controls by directing the Health Department to develop its own subdivision ordinance (apart from the zoning authority's subdivision ordinance).[44] This ordinance applies to water wells and septic systems throughout the county (not just in the unincorporated parts of the county where the ordinance developed by the zoning authority applies).[45]

Another major potential drawback to the use of land use controls to prevent poison runoff is that uneven land use controls can encourage developers to shift development away from a community with strict standards and towards a community with no controls, poor standards or lax enforcement.[46] For this reason, consistent (although not uniform) and coordinated programs are needed in neighboring (or competing) jurisdictions.[47] Accordingly, the state should be involved in making sure that land use controls in *all* localities address water quality problems related to local development and land use.[48]

States can develop guidelines for controlling nonpoint source pollution and require the incorporation of these guidelines into local land use controls as minimum standards.[49] Statewide standards should address such issues as: (1) How much open space generally is necessary to reduce surface runoff in an area? (2) What minimum construction setbacks are adequate to prevent streambank erosion and to protect riparian vegetation?

(3) What densities are appropriate for the use of on-site septic systems? and (4) What types of intensive uses require special conditions? To the extent feasible, such state guidelines should require that site-specific factors, such as soils, potential water uses, and existing development be taken into account when water quality protection standards are established. In the absence of local cooperation, state-developed land use controls can be used and state funds can be withheld for local decisions not in conformance with the guidelines.[50]

Examples of Land Use Control to Protect Water Quality

The exact mechanisms utilized to implement these types of controls differ from locality to locality. Areas known for pioneering the use of land use controls for surface water and groundwater quality protection include the state of Maryland; the counties of Nassau and Suffolk on New York State's[51] Long Island; Dade County, Florida and the counties and municipalities of Cape Cod, Massachusetts.[52] Some of these specific programs for protecting "special areas" and general land use planning activities are discussed below.

Maryland's Chesapeake Bay Critical Area program[53] provides an excellent example of a state program implemented by local land use planning and aimed at protecting water quality through the preservation of a "special area"–land bordering the Bay's tidal tributaries. A state Critical Area Commission established criteria for classifying and protecting lands in a 1000-foot strip of land surrounding the tidal portions of Maryland tributaries to the Chesapeake Bay.[54] In order to administer its own program, a locality must adopt a program including zoning, site plan and subdivision review and other activities. The program must comply with the state criteria and obtain formal approval from the Critical Areas Commission.[55] According to the results of a detailed planning and evaluation phase, land is classified generally into one of three categories based on existing land use–each of which requires a different set of land use controls. (Details are provided in the endnotes.)[56] These controls can be tailored by the community to site-specific environmental and

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economic conditions, while being scrutinized thoroughly by both state officials and the public.[57]

In Dade County, Florida, a Wellfield Protection Ordinance was developed, based on a mathematical groundwater flow model used to predict the travel times of groundwater in the recharge area of particular wellfields.[58] Since groundwater (and its potential contaminants) travels faster as it moves closer to drinking water wells, the ordinance provides for controls based on proximity to the wellheads.[59] These "zones of influence" are used as the basis for employing, with various degrees of stringency, zoning and other land use restrictions to prohibit underground storage tanks and other activities associated with water pollution from locating in the recharge zone of public wells.[60] This type of "impact zone" approach also could be used to protect surface waters.

In Massachusetts, the Cape Cod Planning and Economic Development Commission (CCPEDC) also defines zones of contribution for wellfields. Local governments use these zones in their zoning ordinances to limit the density and kind of development in critical recharge areas.[61] Performance standards of 5 parts per million (PPM) are set for nitrogen loading (to ensure that a health standard of 10 ppm is not exceeded). A site plan review process is used to consider the site-specific potential for water quality impacts from various development proposals, including those involving chemical storage and use activities.[62] Recently, the CCPEDC completed a comprehensive planning process to improve groundwater quality protection called the Cape Cod Aquifer Management Project (CCAMP).[63] It will begin implementing the study's recommendations shortly. In addition, CCPEDC is working to initiate a Geographic Information System so that local governments can input land use and other environmental information into a computerized database in order to improve their land use management capabilities.[64]

The Long Island Regional Planning Board (LIRPB) has provided perhaps the most valuable illustrations of localities attempting to develop and use both specific "special area" protection programs and general land use planning to reduce pollution. From the experiences (both successes and failures) of the LIRPB and its constituent local governments, a wealth of information is available both to guide officials to problem areas and to provide realistic solutions.

The LIRPB provides technical assistance to the counties and municipalities of Long Island in their activities to protect their sensitive sand and gravel glacial aquifers (particularly the areas that recharge the deep portions of the aquifer).[65] This groundwater resource supplies over 2.6 million residents with all of their fresh water needs.[66] LIRPB also advises localities on how to protect surface water resources.[67]

In 1978, the LIRPB established the concept of hydrogeologic zoning to allow counties and municipalities to use land use controls to protect water quality.[68] Through extensive research on the hydrology of the area's complex, interconnected aquifer system, zones have been identified that recharge either deep or shallow aquifers.[69]

The Nassau County Planning Commission reviews all proposed subdivisions within the unincorporated portions of the county and can require that 3% of a subdivision be dedicated as parkland (or that cash be paid to purchase lands for parkland).[70] The 3% requirement, of course, represents a fairly small portion of total developed land, and may not be sufficient to protect water quality. The concept of mandating minimum amounts of open space, however, is useful. The amount of land that needs to be set aside for watershed protection should be based on a more careful analysis of what is needed in the area in question to meet water quality standards.[71]

Suffolk County has purchased over 17,700 acres of environmentally sensitive land (including prime aquifer recharge areas, watershed management areas and wetlands) which are dedicated to open space. Additional lands being considered for acquisition were identified in a Bi-County Comprehensive Plan and in an Open-Space Policy Report.[72] To ensure that it remains undeveloped, much of the parkland is dedicated as "forever wild" under the County Charter.[73] The county also has prepared guidelines to be used by localities for managing land restricted by perpetual conservation easements.[74]

Six towns in Suffolk County have revised or are in the process of revising their comprehensive plans to reflect water quality concerns.[75] In Brookhaven, 13,000 acres of residentially zoned land within a recharge area have been reclassified successfully from a category requiring 1/2 to 1 acre lots to minimum lot sizes of two acres.[76] Southhampton has rezoned over 25,000 acres to require minimum lot sizes of five acres instead of two.[77] East Hampton and Islip have mandatory cluster ordinances for new residential development to protect groundwater and other environmental amenities.[78] The subdivision ordinances of several towns also require open space dedications to preserve sensitive areas.[79]

While communities on Long Island have fairly advanced site plan and subdivision review procedures,[80] evaluation by the regional planning entity (LIRPB) uncovered many problems that could apply to other localities. Generally, localities failed to consider water quality adequately in site plan and subdivision reviews.[81] Zoning and subdivision ordinances were not revised to account for potential water quality impacts and adequate authority to consider water quality was not delegated to responsible officials.[82] Procedures for granting variances to zoning ordinances and exemptions to the site plan review procedures were not developed with water quality protection in mind.[83] Many other problems were identified. Appendix A contains a detailed description of the findings of the evaluation.

Based on the problems identified in the study, the regional planning authority developed an extensive list of recommendations for localities to use in modifying their land use planning process. For instance, it was recommended that municipal codes *require* water quality to be considered as a reason for using local police power and that specific legal authority be provided for considering water quality in the site plan review process.[84] It was further recommended that zoning, site plan and subdivision ordinances be revised to reflect water quality concerns by altering land use densities to control nitrate loadings and by identifying critical areas where certain land uses would be prohibited or regulated through the required use of BMPs.[85]

Other recommendations included the development of Special Groundwater and Special Surface Water Protection Areas; concentrating development in existing high density areas; and establishing general development guidelines to control the exercise of the zoning and subdivision authorities and the site plan review process. (Details are given in the Endnotes.)[86] Many other recommendations (including those made to improve communication among relevant local agencies) were made. These also are provided in Appendix A.

Coastal Zone Management as a Water Quality Protection Tool

Although often categorized by states as separate from general local land use planning, coastal zone management is in many ways a type of zoning/land use control, with a special focus on protecting coastal water quality and other coastal resources. Perhaps this division has emerged because, while coastal zone management can be achieved by many kinds of local land use programs, it also is subject to a specific federal program. Although coastal management programs obviously focus on protecting *coastal* waters, good coastal management can set an example for general water quality protection through integrated resource management. Coastal zone programs can be used to apply all of the types of protections discussed above, such as setback and open space requirements, use restrictions, and special conditions on new development.

The Coastal Zone Management Act of 1972 (CZMA) was established in response to the very high rates of development in the nation's coastal areas, and out of concern about the environmental effects of this growth.[87] Before the CZMA was enacted, some states and localities (including Delaware, Maine, and the San Francisco Bay Conservation and Development Commission) had adopted laws and programs designed to prevent pollution from specific sources such as oil terminals, large scale developments, or landfills. Others (*e.g.*, California) had addressed the impacts of general coastal development.[88] States also had developed programs designed to reduce erosion rates on beaches and dunes.[89]

The CZMA, however, provided a national program to encourage environmentally responsible development through long-range planning and the establishment of clear, enforceable standards for growth and land use in specific areas.[90] While not all states have adopted programs under the CZMA (and while the CZMA is often interpreted not as an environmental

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protection program but as a program to *balance* development and environmental goals),[91] some state and local CZMA programs provide good examples of how to protect coastal water quality. In this sense, the CZMA is a tool that can (and must) be utilized to comply with the water quality standards provisions of the CWA.

With water pollution in coastal areas increasing,[92] adequate CZMA programs are essential to protect coastal water quality. It should be recognized, however, that the water quality goals of the CWA *are* the water quality goals of the CZMA, and that the tools developed as part of a CZMA program must be used to achieve the goals established in a state water quality management program under the CWA.[93]

The degree of control that should be exerted at the state level varies according to the particular state. But the CZMA requires federal oversight to ensure that State CZMA programs are implemented adequately.[94] Federal oversight should ensure reasonably uniform minimum stringency among state programs, so that development is not attracted to states with weak programs.

Similarly, giving a great deal of discretionary authority to local officials yields a system where the degree of protection often varies from jurisdiction to jurisdiction.[95] Control over such variability must be exercised at the state level. At the same time, the need for strong, uniform state standards must be balanced with the need for adequate program coverage. Thus, while a state coastal zone protection program must require the involvement of local governments, it must also ensure that localities comply with minimum standards and are not able to sacrifice coastal resources for political purposes.

In addition, coastal protection programs should not allow overly liberal exemptions for small developments or seemingly innocuous proposals for expansion in coastal areas. Recent information concerning the *cumulative* impacts of small-scale development on local and downstream waterbodies points to the need for controls applicable to a broad range of activities, including general residential and commercial development.[96] Due to inter-jurisdictional pollution impacts and the inherent limitations of state and local programs designed to improve water quality,[97] there is a clear need for federal, regional and state oversight and conflict resolution mechanisms[98] as well as adequate *minimum* standards for state and local programs and permits.[99]

Of course, compliance with water quality standards also needs to be incorporated into state and local decisionmaking. State officials should review development proposals and local programs with an eye to, among other things, achieving compliance with these standards. Habitat and biological parameters have to be utilized in situations involving contaminated sediments, the combined impacts of several pollutants, or impacts associated with damaged or threatened biological resources. Therefore, land use and water use plans and programs must be integrated into a state, regional and local comprehensive coastal planning process, not unlike the general planning process described in Chapters Nine and Ten and the land use planning and urban runoff controls discussed earlier in this section.

Tools used in coastal management programs include the following:

1. regulatory permit systems;
2. land use controls through zoning and subdivision ordinances;
3. land acquisition and restoration;
4. promoting desirable coastal development; and
5. negotiation.[100]

State programs can require special coastal permits that apply to all development in the coastal zone (used in California from 1972-1976), special use permits (*e.g.*, coastal protection provisions in building permit programs) for particular activities, or permits for certain uses within sensitive areas (used in North Carolina).[101] Through the use of information about the water quality impacts of particular land uses, permits can be used to restrict, modify or

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stop development in order to reduce cumulative water quality impacts.

North Carolina and California use such permits to prohibit or otherwise control large developments that might have an adverse impact on the environment.[102] An effective CZMA permit program provides a second line of defense against developers that might have "slipped" through a locality's land use review process. Permits can provide additional water quality protection through special conditions or through required mitigation measures.

Comprehensive planning and land use controls such as zoning and subdivision ordinances and land acquisition can be popular components of coastal protection programs (*e.g.*, California, Oregon, Florida).[103] Also, state and regional agencies can have major roles in reviewing and modifying local plans.[104] Planning aids developers and environmental interests alike by identifying important environmental impacts and potential conflicts, thereby saving time and money on project developments that would not be permitted, at least not without modification, mitigation or conflict resolution.[105] Coastal protection policies can be incorporated into local land use ordinances to meet water quality and special area protection objectives.[106] Studies of coastal areas and the establishment of land conservancies can be used to acquire important lands as state parks and preserves.[107]

State economic development policies can be used to guide low-impact growth into sensitive coastal areas and high-impact growth away from these areas.[108] Negotiations between state agencies with conflicting goals, as well as between private developers and environmental interests, also can be used to interject environmental concerns where they would normally not be present.[109] State and local governments can create permanent or *ad hoc* committees representing these different interests to review and evaluate specific proposals or ongoing program activities.

Two states that have developed coastal controls with specific application to the control of poison runoff are North and South Carolina. In North Carolina, state regulations require that the stormwater discharged from developments in coastal areas must be controlled using a variety of methods, to avoid violations of state water quality standards.[110] Potential stormwater control methods include specific impervious surface limitations, setback requirements, and stormwater treatment and disposal designs.[111]

The South Carolina Coastal Council uses a set of stormwater management guidelines when development proposals within the coastal zone are reviewed.[112] These guidelines represent the minimum acceptable level of stormwater management for developments that must be permitted or certified under the state's coastal zone management program. The guidelines specify the types of stormwater management systems that are required based on the location, lot coverage and land use associated with the development proposal.[113] Detailed design specifications are given for a variety of stormwater management (and other BMP) requirements that apply to particular types of development in certain areas of the coastal zone.[114]

Coastal protection in Florida provides a good example of the kinds of programs that can be used to protect sensitive areas, while at the same time pointing out the problems that can hamper effective coastal resources management at the state level. Recently, Florida's implementation of its Coastal Zone Management Program was criticized by the federal Office of Coastal Resources Management, which even suspended the state's 1988 grant under the CZMA until certain problems were addressed.[115] These problems, however, concerned the lack of emphasis placed on interagency coordination and state leadership, and not the range of programs available to address development impacts in coastal areas.[116]

Thus, the problems relate to *poor implementation* of existing program requirements—an important problem—but one that relates more to *site-specific organizational and political factors* than the actual content of various program requirements. The deficiencies associated with coastal zone management in Florida illustrate that even the most innovative and stringent programs can be crippled by poor leadership and enforcement.

Nevertheless, coastal management in Florida now embraces many significant programs and activities. State requirements for coastal protection must be addressed in local comprehensive plans.[117] Regional planning entities assist in evaluating and approving developments with significant regional impacts.[118] In

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addition, specific state programs have been created to acquire sensitive coastal land, prevent beach erosion and prohibit construction in erosion-prone areas. A more detailed description of coastal zone management activities in Florida is provided in Appendix A.

California's coastal zone management program is considered by some to be the premier program of its kind in the nation.[119] While it is beyond the scope of this report to describe or analyze the California program comprehensively,[120] a few observations are useful.

The California program has gone through separate phases leading to the establishment of certified local coastal programs. The state role includes oversight, technical assistance and an appeals process for those who disagree with local decisions.[121] At first, the California State Coastal Commission and its six regional commissions regulated all development in the coastal permit area (1000 yards from mean high tide line) and prepared a statewide coastal plan applicable "inland to the highest elevation of the nearest coastal mountain range."[122] Now the Commission assists many local governments in preparing and approving their own coastal plans; hears appeals concerning local permit decisions; provides technical assistance; monitors local permits to assure compliance; evaluates local programs (every 5 years); regulates state tidal lands and ensures consistency with federal CZMA requirements.[123]

Early in the program, it was observed that the state commission had not developed strong working relationships with local planning officials.[124] Later, the state legislature shifted regulatory control back to the localities and mandatory policies were established at the state level to be used in guiding localities in developing a Local Coastal Program (LCP) consisting of a land use plan and an implementation program (zoning, subdivision review, etc.).[125] The original 1000-yard permit area was abolished, and permits now are required within the whole coastal area (as defined by the state).[126]

The success of this state-local planning approach in the coastal area requires that ongoing, working relationships be established between state and local levels.[127] Success also requires that the state enforce its land use planning requirements consistent with

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land use goals and objectives; and that political pressure on local officials not be allowed to interfere with legitimate local coastal protection goals.[128]

The California State Coastal Conservancy complements the state commission and LCP officials by buying, selling, restoring, resubdividing, improving, developing or managing land in order to reduce the water quality impacts of development.[129] Funded through legislative appropriations, profits from state property transactions, grants from the Coastal Commission, statewide bond issues, payments required by the Commission as a precondition of development in lieu of mitigation measures and other sources, the Conservancy has undertaken several significant activities. These include:

1. *wetland restoration* - as a condition for filling wetlands, the Commission often requires a fee to be paid which is used by the conservancy to acquire off-site property, convert it into equivalent wetlands and hold the land until a permanent (often private) group can accept management responsibility for the land;[130]

2. *transfer of development credits* - as a condition for the right to develop certain appropriate sites in the Santa Monica Mountains, the Commission has established a transfer of development credits (TDC) requirement whereby developers must purchase the restricted development rights (many from those acquired by the conservancy) from land not suited for development; and

3. *lot consolidation* - land which is not desirable for park or recreation agencies or for development, is purchased by the Commission which alters or transfers the development rights associated with the land to another (more suitable) location before reselling the newly protected land.[131]

Summary

The link between land use and water quality has been recognized for years. However, bridging the management "gap" between these two concerns has been difficult because of

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political, institutional and technical obstacles. Current developments in state, regional and local land use management indicate that the goals and objectives of the CWA can, in fact, be integrated successfully into land management through the innovative and aggressive use of the government's authority (and responsibility) to regulate land use.

Stormwater Management

Discrete discharges of contaminated urban runoff (euphemistically known as "stormwater") are regulated as *point sources* under the Clean Water Act.[132] But some stormwater or urban runoff contaminates groundwater or enters surface waters directly without ever being channelized into a point source. This section addresses how to limit stormwater quantity and to improve stormwater quality *before* it enters discrete conveyances to become a point source, or enters surface or ground waters directly.[133]

Considerations in Establishing a Stormwater Management Program

Controlling urban runoff requires that decisionmakers consider: (1) which sources to control; (2) what level of government is appropriate for implementing controls on urban runoff and stormwater; and (3) the proper program approaches for establishing specific controls and facilities. For instance, one management approach may be appropriate for controlling sources of runoff from areas that *already* are developed, and another may be better suited to areas undergoing, or potentially undergoing, development. Likewise, one set of controls may be needed to address pollution from general urban areas and another may be needed to control pollution from highways, railroad facilities, landfills and other governmental land uses.

In general, past efforts to control urban runoff solely with engineering solutions designed at the local level to reduce flood damages have not been adequate.[134] As urbanization has increased, merely building more and more drainage and discharge facilities to channel runoff immediately into storm sewers has proven to be environmentally and economically unacceptable.[135]

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Effective control of the stormwater generated in urban areas is central to improving water quality.

From an environmental standpoint, relying solely on structural controls is not effective. It does little to prevent habitat destruction and downstream flooding, and it ignores impacts on aquatic life and aesthetics.[136] From an economic standpoint, channelization and other large capital projects are so expensive that improvements have not kept pace with increasingly large flow volumes.[137]

Urban runoff is better controlled by retaining it on-site (preferably through infiltration into the soil)[138] or by detaining it in various kinds of ponds and marshes designed to serve reasonably sized drainage areas.[139] In this way, storm flows can be released in a coordinated fashion over time, making both water quality and water quantity more manageable.

Good stormwater management programs require a number of components. Effluent standards should be developed for discharges of contaminated runoff, and design, operation and maintenance standards must be established to provide the basis for an effective performance standard.[140] In addition, enforcement of stormwater provisions and inspection and maintenance of stormwater facilities are important (and vulnerable) components of the stormwater management process.[141]

All of these management needs require significant technical expertise, human and financial resources, extra-local institutional capacity and water quality management objectives and tools (including water quality and effluent standards) that often are not available at the municipal level. In order to coordinate the individual management entities and facilities in specific drainage areas, stormwater programs require the development of master stormwater systems that provide for optimum location and BMP choices for both on-site and regional facilities, as well as improved land use planning that uses the ability of floodplains and other natural areas to manage urban runoff.[142]

Without a *comprehensive* approach to stormwater management many problems can ensue. These problems range from poor coordination between political jurisdictions within a given hydrologic boundary to high costs, wasted resources, and over-reliance on structural approaches.[143] Programs that are designed to promote individual on-site stormwater management facilities are inferior to multi-jurisdictional watershed-wide approaches for many other reasons. For example:

1. randomly located detention basins can increase downstream peak flows and degrade riparian habitat through channel scouring;

2. individual basins do not combine the water quality and quantity aspects of managing runoff;

3. operation, maintenance and enforcement are difficult;

4. point-nonpoint source trade-offs cannot be made objectively;

5. the costs of a piecemeal program will probably be much greater than those of an effective regional management program; and

6. stormwater problems from existing sources cannot be addressed adequately.[144]

Most fundamentally, reliance on localities as the sole stormwater management entities is undesirable since such approaches tend to address stormwater problems in isolation, making the management problems mentioned above much more likely. Local governments may be the logical choice for the general *implementation* of urban runoff programs.[145] As discussed above, localities usually are responsible for land use planning and regulation, and are able to address a "manageable" number of nonpoint sources. However, without strong oversight it is unlikely that local programs will be coordinated sufficiently to achieve compliance with state water quality goals.

Besides fragmentation and the attendant management problems, other aspects of autonomous local stormwater programs point to the need for regional or state controls. For instance, many local programs focus on preventing flood damage—the typical local concern—and not on preventing water quality degradation. Flood control is a legitimate concern. But urban stormwater programs also need to address the smaller, more frequent storms that are responsible for persistent, continuing water quality impacts, and they need to develop monitoring programs to measure the impacts of these storm events.[146]

Although many urban programs to control poison runoff rely on local initiatives to establish the controls necessary to comply with water quality standards, local governments often are reluctant to take action because of the potential impact on economic development.[147] Many localities fund specific capital improvements on a one-time basis and neglect the maintenance of the facility once constructed,[148] which means that proper operation is often jeopardized.[149] Conflicts between entities within the watershed require an outside party to negotiate (or mandate) some compromise so that water quality and flood protection are not sacrificed.

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These factors indicate that federal and state control is needed to *develop, evaluate and enforce* minimum requirements for local programs and to ensure that comprehensive, well-coordinated stormwater management is provided within watersheds.[150] Mechanisms also are needed to ensure that localities have the legal authority necessary to implement and enforce these minimum requirements, and to participate effectively in multiple jurisdiction programs.

Stormwater Utilities: An Institution Whose Time Has Come. Many stormwater management officials believe that one of the best and most equitable ways to develop a comprehensive local stormwater master plan is to establish a local stormwater management utility that charges rates for the financing of the stormwater program.[151] The stormwater utility addresses a number of important needs.[152]

Because adequate maintenance is so critical to successful stormwater management, one of the primary benefits of the utility is that it provides steady funds to develop, operate and maintain a stormwater management system.[153] Funding also is provided for retrofitting developed areas as well as for undertaking master watershed planning activities.[154]

Since a stormwater utility can be established according to hydrologic rather than political boundaries,[155] it can be used to develop and implement a comprehensive, rather than fragmented, stormwater management program.[156] Thus, the utility provides the basis for integrated, long-range planning and stable, adequate financing.[157]

Utilities can be financed by user fees calculated on the basis of area of impervious cover. In fact, a recent survey of stormwater utilities by the Maryland Department of the Environment indicated that most of the utilities investigated were basing fees charged to individual property owners on the total amount or percentage of impervious area associated with the property.[158] Monthly fees charged by the 25 utilities surveyed ranged from $1.25 to $4.40 for the equivalent of a single family residential parcel.[159]

This type of funding has the dual benefit of providing funds *and* encouraging developers to reduce the amount of impervious cover on a site.[160] The utility also can make the services it renders subject to an equitable charge to distribute costs to those using the system.[161]

The formation of a stormwater utility requires the collection and analysis of an adequate amount of water quality, land use and economic information and the establishment of an equitable billing system for all property served by the utility.[162] Establishing the utility may require considerable front-end expenditures for engineering, legal and financial studies, new staff and information management.[163] Public education and involvement is essential in establishing a stormwater utility, since public resistance to a new municipal charge is likely.[164] Education will also ensure that local officials participate in the development and implementation of the utility's activities.[165] Although not widespread, stormwater utilities have been successfully implemented in a number of areas, with service reaching populations that range from 20,000 to almost 700,000.[166]

In Florida, numerous stormwater utilities have been established or are being contemplated, and these institutions represent the framework for the implementation of future local master plans.[167] Other cities that have addressed stormwater management through some form of a stormwater utility include: Billings, Montana; Denver, Colorado; Aurora, Colorado; Tacoma, Washington; Corvallis, Oregon; Roseville, Minnesota; and Baltimore City and Baltimore County, Maryland.[168]

Boulder, Colorado established a utility in 1974 to guarantee annual revenues for purposes of master planning and capital improvements.[169] Fees are charged along with monthly water bills and are based on lot area, a computed runoff coefficient, site location and proximity to the floodplain.[170] Reduced rates are offered to commercial and industrial facilities using detention basins while rates are increased 40% for developments located in flood-plains.[171]

Bellevue, Washington was the first city in the nation to establish a stormwater utility for managing surface runoff and stormwater. Rates are charged according to the amount of runoff generated from a site, which in turn is determined by the percentage of the site that is covered by an impervious surface.[172]

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The Bellevue Storm and Surface Water Utility is shaped by the desire to use the city's natural surface water drainage system to convey and dispose of runoff. The utility contains an integrated system of pipes and stream channels to convey runoff, as well as lakes, wetlands, ponds and detention basins to control flows and to treat water.[173] Recognizing that structural drainage systems are incomplete solutions to stormwater management needs, Bellevue has begun to utilize BMPs as well as physical stormwater treatment.[174]

Toxic Poison Runoff: A Stormwater Management Challenge. The results of the Nationwide Urban Runoff Program (NURP) study, published in 1983, highlighted the significance of the toxic constituents of urban stormwater (including inorganic metals such as lead, copper, zinc and chromium and organic chemicals such as various pesticides and solvents).[175] Particulate metals represent the most prevalent toxic constituents in urban runoff. Although 60-95% removal efficiencies can be achieved for particulate metals,[176] removal of dissolved contaminants such as copper is lower (estimated at approximately 50% in the NURP study).[177]

Even this removal efficiency is only possible, however, if the stormwater management facility is selected, designed and maintained in order to address toxic pollutants.[178] Wet detention basins and detention (or infiltration) of runoff (where groundwater will not be threatened), are effective means to reduce toxics discharged to surface waters by stormwater runoff.[179] Detention basins must be designed to promote gradual reductions in flow velocity so that particulate matter settles adequately.[180] Long flow lengths must be provided and aquatic plants must be used in order to remove dissolved metals.[181] Finally, particulate metals must be kept bound to sediment, which requires that sediment pH be maintained near 7.0 in an oxygenated environment.[182] Therefore, the accumulation of sediment and decaying plants must be monitored and appropriate sediment-removal and other maintenance activities performed.[183] Contaminated sediment obviously must be disposed of in a manner that prevents pollution of surface or ground water.

Both the short-term and long-term effects of coastal development must be taken into account by poison runoff control officials.

Recharge devices to promote infiltration are useful in areas where groundwater contamination is not a threat.[184] In order to eliminate urban stormwater discharges completely, the "treatment" rate produced by the soil infiltration characteristics and surface area of the recharge device must be equal to or greater than the rate of the stormwater discharge.[185] If stormflows exceed this "treatment" rate, water quality improvements are needed in the stormwater that escapes infiltration.[186]

Obviously, the best way to prevent toxics in stormwater from contaminating surface water (and groundwater) is to prevent the toxic constituents from entering the stormflow in the first place. Evaluations of individual facilities can be performed to determine their potential for releasing toxics that could contaminate stormwater. Site-specific BMPs then can be incorporated as conditions in individual stormwater management permits. This is the case particularly with industrial facilities where proper materials storage, cleaning regimes, and manufacturing processes related to the industrial operation itself may be the only way to prevent discharges of some soluble organic pollutants to surface waters.

There are many Best Management Practices that can be used to prevent the contamination of stormwater from industrial and storage areas. In general, they are "the same traditional practices used by industry for pollution control, safety, industrial hygiene, fire protection, protection against loss of product, insurance company requirements, and public relations."[187]

Preventive BMPs include the development of a spill control committee and rules for effective reporting and cleanup of spills; a materials inventory system to track potential contaminants and investigate alternative materials or storage; routine visual inspections for leaks, spills or runoff associated with pipes, materials storage areas, tanks, etc.; containment facilities to prevent contaminated runoff from reaching waterways; and general good housekeeping so that all potential contaminants are transported, treated, stored and disposed with the prevention of poison runoff in mind.[188] These practices can be applied to industrial and commercial facilities whether or not they are "point" sources subject to permits under the CWA.

Model State and Local Programs

Some states have made significant advances in the development and implementation of stormwater controls. Two of these states, Maryland and Florida, are often considered "in front of the pack." Other useful lessons can be learned from programs in Puget Sound, Washington and Long Island, New York.

Maryland: A National Leader in Stormwater Management. Comprehensive stormwater management began in Maryland in 1982 with the passage of a state law[189] that requires each county and municipality in the state to adopt a stormwater management ordinance based on state criteria developed by regulation.[190] The purpose of these regulations is to establish state and local stormwater management programs:

> to maintain after development, as nearly as possible, the pre-development runoff characteristics and to reduce stream channel erosion, pollution, siltation and sedimentation, and local flooding.[191]

The Sediment and Stormwater Administration (SSA) is in charge of the overall program. The state reviews and approves local stormwater management ordinances as well as their implementation and develops stormwater management plans for state and federal construction projects.[192] SSA responsibilities also include inspection and enforcement (along with local authorities); development of guidelines and regulations; technical assistance and education, and research on stormwater control effectiveness.[193] Finally, the state is required to review the effectiveness of each initial local stormwater program and to conduct another review every three years thereafter.[194]

The required local stormwater management ordinance must address several areas in a fashion consistent with the regulations: submission and approval of a stormwater management plan; exemptions and waivers; criteria and procedures for stormwater management; proper implementation of an approved stormwater management plan; maintenance responsibilities and inspection procedures; and penalties for noncompliance.[195] Stormwater management plans are required for any land development not specifically exempted by regulation.[196] Allowable exemptions include additions and modifications to detached single family houses; developments of under 5,000 square feet; and residential developments of single family houses located on lots of 2 acres or larger.[197] Provisions for waivers of requirements for individual projects must be approved by the state and cannot adversely affect water quality.[198]

Depending on the particular county, local ordinances must require at a minimum that post-development peak discharge for a 2-year and/or 10-year frequency storm event "be maintained at a level equal to or less than the 2-year [or 10-year] pre-development peak discharge rate."[199] To accomplish this performance standard, a list of design criteria must be contained in each local stormwater ordinance.[200] In order to influence the stormwater management controls chosen by developers, state regulations require that preference be given to specific designs in the following order:

1. infiltration of runoff on-site;

2. flow attenuation by use of open vegetated swales and natural depressions;

3. stormwater retention structures (and no discharge to surface waters); and

4. stormwater detention structures (with discharge to surface waters only after treatment by settling).[201]

Use of a particular stormwater control by a developer requires that justification, based on site characteristics, be given as to why the preferable controls are not feasible.[202]

In addition to the local standards and specifications approved by the state, the regulations also provide minimum guidance for each of the acceptable stormwater management designs.[203] This guidance incorporates water quality concerns in various ways. For instance, off-site detention and retention structures generally cannot discharge into natural trout streams as identified by the state.[204] Also, the release rate from such structures cannot increase downstream channel erosion.[205]

Stormwater management officials must ensure that stormwater controls are inspected at regular, specified points during the construction process.[206] Municipal ordinances also are required to contain provisions for effective inspection, enforcement and maintenance.[207] Facilities must be inspected by local officials during their first year of operation and at least once every three years thereafter, while owners are responsible for preventive maintenance activities.[208]

Finally, officials are required to employ procedures to "ensure that deficiencies indicated by inspection are rectified" (including followup inspections and enforcement proceedings).[209] Penalties for noncompliance with minimum stormwater management requirements, including suspension of construction activities, must be included in all local ordinances.[210]

Florida: Statewide Stormwater Management. Florida's stormwater management program, which applies to all *new* development, is designed to ensure that the volume, rate, timing and pollutant load of runoff after development do not cause violations of state water quality standards.[211] The Florida Stormwater Rule is implemented by the state's regional water management districts so that the program can be coordinated with the district's surface water management permit programs,[212] which primarily affect water quantity.[213]

The Florida rule essentially is a performance standard driven by what is expected to achieve compliance with state water quality standards.[214] If permit applicants can meet the performance standard, it is generally assumed that state water quality standards will not be violated by stormwater discharges. However, more stringent controls can be imposed if it is determined that violations of water quality standards will result even after the performance standard is met.[215] Stricter treatment requirements are imposed on stormwater discharges to waters not in compliance with state water quality standards, and on discharges directly into waterbodies identified as Outstanding Florida Waters.[216] The standard was designed so that stormwater management systems would remove at least 80-95% of the annual pollutant load of sediments, nutrients and many heavy metals, similar to the minimum treatment level for point sources with secondary treatment.[217]

The actual general standard requires that, for development under 100 acres, the runoff from the first inch of rainfall or the first half-inch of runoff (whichever is greater) either be retained on-site (no discharge of the diverted water to surface waters) or detained (stored in treatment ponds and passed through a suitable filter).[218] Facilities draining areas over 100 acres must treat the first inch of rainfall (*i.e.*, there is no option to treat the first half-inch of runoff).[219] Larger developments are not allowed to treat the first half-inch of runoff because the "first flush" effect[220] usually decreases as the drainage area increases and as percent impervious areas decrease (because of unequal rainfall distribution and additive impacts of smaller drainages within the larger watershed).[221] Research is underway to verify the removal effectiveness of permitted systems.

Projects meeting this performance standard can obtain a general permit (over 90% of all facilities obtain the general permit), allowing work to begin if the district does not contact the developer to indicate that the proposal is inadequate.[222]

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Projects using other types of controls to provide equivalent treatment cannot obtain a general permit.[223] If stormwater controls are not being implemented in accordance with approved permits, the Department of Environmental Regulation may issue a stop work order to halt construction of the entire development.[224]

Recent changes to the rule allow general permitting for regional stormwater discharge facilities that are designed to treat runoff from multiple parcels.[225] In order to promote local stormwater utilities and comprehensive stormwater management throughout a watershed, individual discharges to such regional facilities are exempted from the permitting process.[226] These changes were designed to address some of the following problems that had been identified in the Florida Stormwater Rule:

1. difficulties with ensuring that property owners' associations have the administrative, legal, financial and technical means to operate and maintain facilities properly;

2. incomplete verification of the pollutant removal effectiveness of various systems permitted under the rules;

3. the grandfathering (exemption from regulations) of existing local government master systems built only for flood control purposes;

4. a fragmented approach to developing stormwater management capability; and

5. a lack of coordination among state, regional, and local governments, all with stormwater management authority.[227]

Perhaps the most significant problem with Florida's current program (as well as with many other states) is its general applicability only to *new* developments. The Florida DER, in cooperation with water management districts and local governments, is considering establishing priorities among watersheds based on ambient water quality and existing pollutant loadings, which then will be addressed by BMP implementation and other

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systems over a 25-year period.[228] Urban redevelopment projects would be required to retrofit old stormwater facilities with on-site treatment systems unless localities have established a master stormwater plan to provide regional treatment.[229]

Increased coordination between government levels and agencies also is being encouraged. Officials speculate that in the near future, local governments will be required to develop stormwater master plans that would be reviewed at the district level and integrated into regional master plans.[230]

Innovations in Stormwater Management

A Process for Initiating Comprehensive Stormwater Management: Washington State. The Puget Sound Water Quality Authority requires all cities and counties and all federal facilities and highway authorities in the Sound watershed to control stormwater to achieve water and sediment quality criteria.[231] Starting with the largest cities, each local government must develop programs for operating and maintaining existing stormwater systems, and must adopt ordinances for controlling stormwater from new developments. The Puget Sound program applies to all residential, commercial and industrial areas.[232] The program emphasizes controlling stormwater through source controls and BMPs before it is discharged into municipal storm sewers.[233] Each program must include, at a minimum, the following:

1. inventories of storm drains and land uses discharging to stormwater systems, and the identification of problem areas;

2. monitoring of problem storm drains identified in inventories;

3. programs for the operation and maintenance of storm drains, detention basins, ditches, and culverts;

4. investigations for illegal hookups and dumping, spill responses and remedial actions;

5. assurances of adequate local funding for the stormwater program through surface water utilities, sewer charges, fees or other revenue-generating sources;

6. agreements with neighboring jurisdictions that share watersheds;

7. ordinances requiring implementation of best management practices for new construction (*e.g.*, erosion/sedimentation controls, detention/retention basins, oil separators, housekeeping measures);

8. a public education program aimed at residents, businesses, and industries in the urban area;

9. provisions to require retrofitting of existing development or treatment of discharges from new and existing development if there are still discharges that cause significant environmental problems;

10. inspection, compliance, and enforcement measures; and

11. an implementation schedule.[234]

The State Department of Ecology (DOE) provides technical assistance and leadership in the form of design manuals and guidelines.[235] DOE approves, monitors for compliance and generally oversees the programs, and coordinates programs developed by localities with runoff impacts on another jurisdiction to ensure consistency.[236] Each program is "audited" every two years, and is a part of the priority watershed process described in Chapter Nine.[237]

Guidelines for urban stormwater programs have been prepared by DOE in cooperation with local governments to ensure that the requirements for local stormwater programs are satisfied in an effective manner. These minimum guidelines include:

1. procedures for conducting inventories of storm drains and combining this information with land use data;

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2. monitoring requirements and protocols, if necessary;

3. review of operation and maintenance programs;

4. procedures for investigations, implementation of spill control measures, enforcement, and remedial actions;

5. methods for assuring adequate local funding for the urban stormwater program;

6. guidelines for agreements with neighboring jurisdictions because stormwater and watersheds do not always follow jurisdictional boundaries;

7. model ordinances for new construction;

8. requirements for public education programs;

9. requirements for retrofitting or treatment measures, if necessary;

10. guidelines for inspection, compliance, and enforcement measures; and

11. requirements for implementation schedules.[238]

Guidelines for developing local ordinances also will be developed, including procedures for DOE review and approval of ordinances and minimum requirements for runoff control.[239]

Finally, DOE will require the State Department of Transportation (DOT) to develop a program to control runoff from highways in the Puget Sound area.[240] Existing and new highways must be included in the program, and the DOT must comply with the requirements of local stormwater programs.[241] DOT must also proportionally fund the construction, operation and maintenance of any publicly or privately owned stormwater control facilities receiving discharges from DOT-owned property.[242] All NPDES permits for federal facilities, including military bases, must contain stormwater controls at least as stringent as those required for industrial facilities, including limits on toxics and particulates and requirements for monitoring and spill control.[243] DOE will request that EPA review existing permits for federal facilities to ensure that they comply with the same controls as those for industrial facilities under the Municipal and Industrial Discharges Program.[244]

A Watershed-Wide Retrofitting Effort: Anacostia. Addressing the stormwater problems caused by existing development is difficult. This difficulty is magnified when the existing development crosses many political boundaries. The Metropolitan Washington Council of Governments (MWCOG) is attempting to deal with these complications by assisting in the establishment of a stormwater management system in the 170 square mile Anacostia River watershed, located in Maryland and Washington, D.C.

Guided by a multi-jurisdictional group called the Anacostia Watershed Restoration Committee (AWRC), MWCOG is administering the development of a strategy to "improve water quality and restore aquatic habitat within the free-flowing and tidal portions of the Anacostia River."[245] An important part of this strategy is a three-year effort to retrofit the entire watershed through the Coordinated Anacostia Retrofit Program (CARP).[246]

Under this program, MWCOG "will assist local governments in selecting, designing, constructing and monitoring urban retrofit projects within the Anacostia Basin."[247] Initial activities include: an inventory of possible facility sites leading to a priority list for each local jurisdiction; implementation of up to 12 projects in the first year of the program; and technical support and design workshops describing new and innovative retrofitting techniques.[248] The high level of coordination and involvement by all jurisdictions and the technical capabilities of MWCOG demonstrate that retrofitting stormwater controls in existing areas is possible.

Regional Recommendations for Local Controls: Long Island. The Long Island Regional Planning Board has developed

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fairly detailed stormwater management provisions for inclusion in zoning and subdivision ordinances. Existing requirements for managing stormwater developed by various Long Island communities include:

1. runoff from each plot in a development must be self-contained or all stormwater must be recharged into the ground;

2. no water can be diverted so as to exceed the design capacity of existing stormwater systems;

3. no stormwater systems are allowed that would create flooding or a need for additional drainage structures; and

4. the existing drainage systems of sites undergoing redevelopment must be upgraded to certain specifications.[249]

The recommendations for improvement of local stormwater management developed by the LIRPB are provided in Appendix A.[250]

Summary

Control of contaminated urban runoff involves more than a system of pipes and channels to collect and transport flood waters so that they can be deposited in the nearest convenient waterbody. Pollution from urban runoff now is recognized as such a significant source of water quality degradation that it is virtually impossible to protect water quality without adequate stormwater controls. One positive aspect of stormwater management is the diversity of available control strategies and programs, and the flexibility with which they can be applied.

Erosion and Sediment Controls For Construction Activities

This section addresses factors to consider when designing erosion and sediment control (ESC) programs applicable to construction activities.[251] The types of BMPs necessary to control pollution from construction runoff are so well documented that they need no detailed review here.[252] Fundamental principles include:

1. Using diversion structures to channel runoff away from disturbed surfaces during construction;

2. Collecting and retaining or treating (through settling) any water that does contact disturbed surfaces (*see* stormwater section above);

3. Stabilizing exposed surfaces as soon as possible after construction is complete, if possible in phases, and ensuring that permanent stabilization is successful; and

4. Using good materials storage, spill prevention and other "housekeeping" practices to prevent runoff contamination by toxic chemicals such as paints, solvents, pesticides, metals from building materials, or fuels.

These basic concepts apply whether the construction involved is a building, a highway, or a bridge.

The more difficult problem is how to develop and implement an effective program to ensure that these BMPs are used. Elements of effective ESC programs are described below. Examples of existing state programs also are presented. Because the effectiveness of local programs can vary significantly depending on (among other things) municipal growth and economic development polices, a strong state presence is necessary.[253]

The significant differences in state erosion and sediment control (ESC) programs have been explored,[254] and in-depth evaluations of individual programs have been conducted.[255] However, few detailed studies have sought to develop a general outline of an effective ESC program structure. One study[256] has described some of the necessary aspects of an erosion and sediment control program. That study concluded that a fundamental element of an effective ESC program is adequate

Construction activities generate far more sediment per unit area than any other land use.

program authority.[257] What level of program authority is adequate depends, in turn, on several factors, including:

1. the range of nonpoint sources covered;[258]

2. the number of exemptions;

3. the clarity of legislative authority;

4. the management attitudes of program administrators; and

5. the adequacy of technical standards.[259]

ESC enabling legislation should be drafted to grant adequate powers to the officials charged with implementation and enforcement. Specifically, legislation should contain provisions authorizing ESCs to protect water quality, as opposed to simply control erosion or flooding.[260] The enabling legislation for the ESC program should make clear the mandatory nature of program requirements (*i.e.*, regulations rather than guidelines).[261] Local program administrators should be fully trained to understand and exercise the full scope of their authority to implement and enforce the program.[262]

Adequate resources also must be provided to ensure ESC program success. Specifically, sufficient funding and personnel must be provided to review site plans, evaluate runoff controls and perform inspections.[263] One way to improve funding is to charge fees for ESC plan reviews or for ESC permits.[264] State legislators or ESC program officials should consider allowing localities with few funds to recover through permit fees the *full costs* of administering an effective program.[265]

Technical assistance should be offered by the state to train local ESC personnel and private interests (*e.g.*, contractors) who must develop and carry out ESC plans and controls.[266] Training courses at construction sites, video tapes, press releases and seminars all could be part of a required training process for plan reviewers, inspectors, contractors and developers.

A certification program should be developed for private parties involved in preparing and implementing ESC plans.[267] ESC plan review and approval should be performed only by individuals trained as engineers or by equivalent technicians.[268] Finally, state technical assistance should include data collection and analysis. Localities need adequate information on soil types, slopes and drainage characteristics of the various construction sites covered by the program so that proposed ESC plans can be thoroughly evaluated.[269]

Administrative activities also are important. ESC programs should include program components to ensure that:

1. construction sites covered under the program are identified before earth-moving has begun;

2. a clear, consistent set of procedures is followed in carrying out the ESC program;

3. variance requests are considered consistently and are based on clear, narrowly-drafted guidelines rather than on political factors; and

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4. programs are evaluated periodically and modified as necessary.[270]

Building or grading permit applications or site plan review procedures should trigger a process to determine if an ESC plan is required. If so, approval of these applications and procedures should be made contingent on the submittal and approval of an ESC plan.[271] ESC permits and plan approval should be required before any construction begins.[272]

Variance decisions and dispute resolution should be based on clear and objective factors. State government must retain the statutory authority to override local decisions and to implement a local ESC program in cases where local action is inadequate.[273]

Inspection and enforcement also is crucial to program success.[274] Effective inspection and enforcement requires an adequate staff; systematic inspection procedures; effective penalties and program intervention to correct violations. Initial installation and maintenance of adequate controls should be verified and monitored through an effective, mandatory inspection procedure that includes standardized schedules, documentation and checklists.[275] Enforcement actions also should be standardized in content and in their application to various kinds and degrees of noncompliance.[276]

Stop-work orders and administrative penalties are important for ensuring timely responses to non-compliance and to reduce the time, expense and uncertainty associated with judicial actions.[277] Citizen suits provide an added enforcement mechanism when municipal action proves ineffectual, and can supplement government enforcement resources.[278] When courts are used as part of an enforcement process, both civil and criminal penalties as well as injunctive relief should be available.[279]

Bonding requirements are needed to ensure that funds are available to correct problems when responsible parties fail to act.[280] Required bond amounts should be large enough to cover the full government costs of correcting ESC problems at the site.[281] Moreover, bond release should not occur until the site has been fully and permanently stabilized and the risk of erosion and sediment damage from construction activities has been eliminated.

Additional suggestions for effective inspection and enforcement of local ESCs are given below:

1. The number of site inspections should be based on the amount of activity at a site, the results of previous inspections and the experience of the responsible parties.[202]

2. A standardized inspection report should be presented to the project inspector while at the site to ensure that:
   a. the ESC plan is on-site;
   b. controls are in place and correctly installed and maintained;
   c. any monitoring or reporting requirements are followed; and
   d. off-site sediment transport is noted and corrective actions recommended.

3. Any violations should be noted in a report prepared on-site and made available to the contractor during the visit. A formal written report can follow later.

4. Major construction sites or sites in critical or sensitive areas should be visited after major storms to check ESC control effectiveness.

5. A final inspection should occur at all sites before bonds or other guarantees are released, utility service is authorized or occupancy permits are granted. Before funds are released the site should be stabilized, not just seeded.

6. Penalties should be large enough so that, if necessary, repairs to off-site damages can be successfully undertaken and proper ESCs installed; and each day of noncompliance should be treated as a separate violation.

7. Stop work orders should apply to the whole project, not just earth moving activities, to ensure that ESC problems

will be corrected even after earth moving activities have ceased but before the construction project is finished.

8. Damages and the size of performance bonds should be based not only on the amount of earth disturbed at a site, but also on the slope of the site, changes in grades, soil type, proximity to water, sensitivity of the surrounding area to damages well and other relevant factors.[283]

State Experiences With Erosion and Sediment Control

Several states have ESC programs containing many of the program aspects mentioned above.[284] Maryland has established a detailed set of regulations for state review and approval of various aspects of local erosion and sediment control programs and individual ESC plans.[285] For instance, regulations establish minimum requirements for an adequate inspection and enforcement component of an ESC program and under what circumstances the state must assume these responsibilities.[286]

By regulation, the state sediment and stormwater administration is required to consider specific aspects of each proposal for local assumption of the inspection and enforcement activities of an ESC program.[287] Local enforcement authorities are *required* to:

1. ensure that all approved ESC plans and permits are kept on-site;

2. ensure that all active sites are inspected for compliance an average of at least once every two weeks;

3. prepare written reports after each inspection providing specified information, including the type of enforcement actions taken in cases of violations;

4. notify a responsible party whenever violations are observed and describe the violation, any required corrective actions and the time period in which the violation must be corrected; and

5. investigate complaints of violations and, when confirmed, use enforcement procedures within 3 working days; and within 7 days, notify the complaining party of any actions taken.[288]

Local enforcement is supplemental and is overseen by the state. The state can investigate any complaints received by the local enforcement authority and may "initiate an on-site investigation in order to properly evaluate the complaint."[289] Also, the Sediment and Stormwater Administration "shall take enforcement action when appropriate ...." when its site investigation indicates that the complaint is valid.[290] Enforcement authority can be delegated to localities only for renewable 2-year periods.[291] Delegation can be suspended and assumed by the state when state officials determine that the standards established by the regulations have not been maintained by the locality.[292]

Localities also must have approved erosion and sediment control *ordinances*.[293] Here again, the state exerts considerable influence under the guidance of the regulations. The Sediment and Stormwater Administration must approve or disapprove such ordinances using a host of criteria that are based on compliance with the rest of the regulations as well as with the intent of the relevant state statute.[294] In addition to its initial approval of the local ordinance, the state also must review periodically the adequacy of local programs (including the ordinance and a field review of active construction sites) to determine if they meet to regulatory requirements.[295]

Enforcement actions *require* some combination of: cessation of *all* work on the site (except work necessary to correct the violation) if the violation persists after a specified date, and civil and criminal prosecution in cases where "reasonable efforts to correct the violation are not taken."[296] In addition, legislation recently enacted has authorized administrative penalties for violations of an ESC plan.[297] Maximum penalties are $1,000 per day up to $20,000 for each violation.[298]

In an important step, Maryland has made a strong commitment to move away from control only at the site perimeter. Instead, the Maryland regulations expressly require permanent or temporary stabilization[299] of the disturbed earth on the entire site. Under the regulations, virtually *all* land at a permitted site must be stabilized within 14 days of disturbance or redisturbance (perimeter controls, dikes, swales, ditches and steep slopes must be stabilized within 7 days).[300]

In addition, Maryland's regulations now require that an ESC plan be approved before any grading or building permits can be issued.[301] Federal and state land is subject to the program, as are single-family home sites unless they are built on lots two acres or larger.[302] Finally, applicants for ESC plans must certify that the personnel in charge of on-site clearing have attended a 4-hour ESC training program.[303]

Pennsylvania's program requires local agencies to inform the agency responsible for the ESC program of all requests for building permits, and requires that the permit be withheld until an ESC plan has been approved.[304] Violation of the ESC program are considered violations of the state Clean Streams Law and can be subject to fines of up to $10,000 per violation.[305] Each day of a continued violation is considered a separate violation under the law.[306] Changes under consideration in Pennsylvania's ESC program would give the State Department of Environmental Resources the exclusive right to administer an ESC plan for projects crossing political boundaries of conservation districts administering local ESC programs.[307] These changes also would prohibit most earth disturbing activities within 75 feet of a streambank in watersheds designated as either High Quality or Exceptional Value waters under state law.[308]

Other state programs provide for the identification of critical resource or erosion-prone areas; apply to federal land- disturbing activities and other commonly exempted land disturbances; allow state review, approval and (if necessary) implementation of local programs; require periodic inspections; provide for citizen actions to obtain injunctions; provide for administrative fines; and place damage awards in funds for program maintenance.[309]

The success of ESC programs depends heavily on local enforcement. State programs that incorporate the components described above will help to ensure that local ESC activities succeed in maintaining and improving water quality.

Summary

Erosion and sediment control (ESC) programs are perhaps the most established non-voluntary urban programs to control poison runoff. This probably stems from the relatively narrow activity to which such programs apply, as well as from the obvious nature of erosion problems at unprotected construction sites. But while there is a proliferation of ESC programs across the country, there is also wide diversity in the content—and the success—of such programs. State and local officials must recognize that merely instituting an ESC program does not guarantee that the targeted problem will be eliminated. Therefore, officials must ensure that the elements of successful programs which are spelled out in this section are incorporated into ESC activities.

Conclusions and Recommendations

Contaminated urban runoff must be controlled using a variety of management approaches. The control methods described in this chapter are already being implemented by states and localities across the country, using well-established regulatory tools and technical capabilities. Using the organizational and management approaches discussed in this chapter, as well as in Chapters Nine and Ten, states can exercise leadership and oversight that is effective in ensuring that localities undertake the area-specific controls that are necessary to reduce pollution impacts. Whether urban contaminants consist of sediment, BOD, bacteria, nutrients or toxics, programs are available today that effectively address threats to water quality.

Successful programs to control urban runoff must be based on the link between land use and water quality. Programs that prevent water quality degradation through good land use planning are preferable to post-development retrofitting that relies on expensive structural controls. But in many cases, pollution generated from existing development must be controlled. Fortunately, state and localities also can use tax incentives and other means to encourage private individuals and conservation groups to protect land and water resources through acquisition.

Urban program recommendations are summarized below:

1. Localities should use land use controls to achieve compliance with water quality standards. This should be accomplished through comprehensive and coordinated use of:
   a. zoning and comprehensive planning;
   b. site plan and subdivision review; and
   c. building codes.
   These tools should be used to control the location, rate and type of growth, and to minimize pollution where development occurs.

2. Localities should develop and use innovative and specialized land use tools, such as overlay zones, to protect riparian areas and ground- and surface water resources.

3. Local land use programs (and coastal resources protection programs) should address explicitly the water quality impacts of cumulative small (including residential) developments, not just large-scale or industrial development. As a supplement to land use controls, areas that are the most sensitive or contain the most valuable natural attributes should be protected through acquisition, either through outright ownership or conservation easements or development rights. States and localities also should use tax incentives and other means to encourage private individuals and conservation groups to protect land and water resources through acquisition.

4. Special programs designed to protect coastal resources, including coastal zone management plans, should be incorporated into local Comprehensive Plans.

5. State and regional oversight and review of local land use programs should be required to ensure compliance with state water quality standards and consistent levels of water quality protection, and to provide for conflict resolution and coordination within watersheds.

6. An effective stormwater management program that addresses both future and existing development should be

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required as a basic part of a local effort to control poison runoff.

7. Stormwater controls (as well as other urban controls) should be required at the local level but overseen by state and regional entities to ensure that state goals and extra-jurisdictional impacts are addressed and that regional solutions are developed.

8. Stormwater controls should include both design standards and a performance standard requiring the site-specific removal of identified pollutants, so that the discharge from a site or facility does not violate state water quality standards.

9. A master drainage plan should be developed for all of the watersheds in a given area and incorporated as part of the stormwater management plan.

10. Stormwater management utilities following watershed boundaries should be the primary stormwater management institutions and, as such, should be managed cooperatively by the involved localities with state leadership and oversight.

11. Stormwater utilities should be funded through user fees based on a measure of stormwater impacts by individual sites, such as percentage or total area of impervious surface. Design standards for retention and detention basins should reflect the control of toxic substances.

12. Individual stormwater management permits should include the implementation of site specific BMPs when needed to address problems of toxic runoff.

13. Erosion control ordinances should specifically authorize the use of erosion and sediment controls (ESCs) to protect water quality.
    a. ESCs should require:

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i. diversion structures to channel runoff away from disturbed surfaces;
ii. retention or treatment of any contaminated runoff;
iii. rapid and permanent stabilization of disturbed surfaces; and
iv. BMPs to prevent contamination of runoff by construction chemicals or other materials.

b. ESCs should include a performance standard to require additional controls in situations where minimum standards are not sufficient to meet water quality standards.

14. Clear and consistent ESC regulations should be adopted to ensure that:
    a. construction does not begin before an adequate ESC plan has been approved;
    b. inspections are carried out effectively at all construction sites; and
    c. variances are not granted or water quality compromised due to political pressure.

15. ESC programs should include:
    a. citizen suit provisions;
    b. stop work orders that can be issued after earth-moving operations have ceased;
    c. administrative penalties of sufficient size to finance any required corrective actions, as well as civil, criminal, and injunctive remedies;
    d. requirements for developers to submit performance bonds sufficient in size to perform necessary ESC work, with bond release only upon effective, permanent site stabilization; and
    e. adequate funding, training, and technical assistance.

Notes - Chapter Four

1. *See* National Association of State Departments of Agriculture, *Cooperating for Clean Water: Institutional Issues in Agricultural Nonpoint Source Pollution Control Policy - Briefing Paper 3,* March 1987, at 12.

2. For example, The Virginia Nonpoint Source Pollution Management Plan, prepared pursuant to CWA § 319, has an urban runoff program component with many voluntary aspects. One of the goals of the plan is to "promote the incorporation of BMP implementation strategies into the subdivision and land development regulation processes of localities in identified priority areas." Virginia Department of Conservation and Historic Resources, *Virginia Nonpoint Source Pollution Management Plan,* August 4, 1988, at 5-2. At least outside of the Chesapeake Bay drainage basin, a significant part of this promotion will consist of the (presumably voluntary) development and signing of Memoranda of Understanding (MOU) between the lead state agency and local governments. *Id.* at 5-24. However, the state Division of Soil and Water Conservation already has a mandatory ESC program. *Id.* at 4-3. Va. Code. § 10.1-560 et seq. (1986).

3. Spofford, W.O., B.T. Bower and T.E. Waddell, *Guide for Analysis for Integrated Residuals Management* (draft), report from Resources for the Future to the U.S. EPA, Athens, Georgia, 1987, at 110.

4. *See* Livingston, Eric *et al., The Florida Development Manual: A Guide to Sound Land and Water Management,* 1988 (in press), at 4-9.

5. *See* Blatt, David J. L., "From The Groundwater Up: Local Land Use Planning and Aquifer Protection," 2 *J. of Land Use and Envtl. L.* 126-130 (1986).

6. The need for state oversight over local land use decisionmaking is discussed in chapters Nine and Ten.

7. Northern Virginia Planning District Commission, *Guidebook for Screening Urban Nonpoint Pollution Management Strategies,* November, 1979, at 29. Per capita loadings from lower density development are higher than per capita loadings from greater densities for nutrients and biological oxygen demand, not heavy metals. *Id.* at 30.

8. Soil permeability refers to the ease of water transmission through soil. It depends on particle size, density and pore space of soil. Generally, the finer the soil particles, the slower the permeability. Draggan, Sidney, John J. Cohrssen and Richard E. Morrison, *Geochemical and Hydrologic Processes and Their Protection—The Agenda for Long-Term Research and Development,* Praeger Publishers, New York, 1987, at 81-82. Building heavily on permeable soils, therefore, both wastes the inherent capacity of the soil to reduce stormwater runoff and risks contaminating groundwater resources. There is an obvious trade-off between increasing pollution loadings to groundwater to protect surface water resources and diverting stormflows (that otherwise would infiltrate (and contaminate) groundwater) to surface waters.

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9. *See generally Guidebook for Screening Urban Nonpoint Pollution Management Strategies*, 1979, *supra* note 7; Schenectady County Planning Department, *Groundwater Supply Source Protection - A Guide for Localities in Upstate New York*,(no date); Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, 1984, Hauppauge, New York; National Research Council, *Groundwater Quality Protection - State and Local Strategies*, National Academy Press, 1986.

10. *See* Schenectady County planning Department, (no date), *supra* note 9, at 24.

11. *Id.*

12. *Id.* at 24-26; *see* National Research Council, 1986, *supra* note 9, at 154-161.

13. Special use or overlay districts may provide additional protection. *See* generally Schenectady County Planning Department, (no date), *supra* note 9, at 26. *See* Table 4-2.

14. Schenectady County Planning Department, (no date) *supra* note 9, at 27.

15. *Id.*

16. *Id.* at 26.

17. *Id.*

18. *Id.* at 27-30.

19. This general statement, of course, depends on the definition of "open space". The least impact will occur on lands that are preserved in their natural state, with no artificial development. Such land uses as urban parks or greenbelts, on the other hand, may include a mixture of natural areas with bike paths, golf courses, playgrounds, ballfields, and other uses of generally low intensity. But such uses may involve the use of fertilizers, pesticides, irrigation, and associated buildings and other structures. These land uses, therefore, are not free from contaminated runoff.

20. *See* Conservation Foundation, *Protecting America's Wetlands: An Action Agenda, The Final Report of the National Wetlands Policy Forum*, 1988 (hereinafter cited as *National Wetlands Forum*), at 9-10. It is questionable, however, whether wetlands can or should be used to "treat" heavy metals or other toxic pollutants.

21. *Id.*; General Accounting Office, *Wetlands, The Corps of Engineers' Administration of the Section 404 Program*, 1988 (hereinafter cited as *GAO Wetlands Report*), at 8. *See also* Office of Technology Assessment, *Wetlands: Their Use and Regulation*, 1984.

22. 33 U.S.C. § 1344. This program is administered by the U.S. Army Corps of Engineers. Section 404 allows states to assume the wetlands program from the Corps, but few states have done so.

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23. 33 U.S.C. § 1344(f)(1)(A). Other exemptions include maintenance of existing structures; the construction of irrigation or drainage ponds or ditches; temporary sedimentation basins on construction sites, or farm, forest or temporary mining roads. 33 U.S.C. § 1244(f)(1). These exemptions do not apply to any discharge of dredge and fill material "incidental to any activity having as its purpose bringing an area of the navigable waters into a use to which it was not previously subject." 33 U.S.C. § 1344(f)(2).

24. *See GAO Wetlands Report*, 1988, *supra* note 21, at 19.

25. The full range of problems with the section 404 program and its implementation is beyond the scope of this report. Many of these problems are chronicled in two recent reviews of the wetlands issue. *See generally National Wetlands Forum*, 1988, *supra* note 20; *GAO Wetlands Report*, 1988, *supra* note 21.

26. *GAO Wetlands Report*, 1988, *supra* note 21, at 20; *National Wetlands Forum*, 1988, *supra* note 20, at 12.

27. *National Wetlands Forum*, 1988, *supra* note 20, at 14.

28. *GAO Wetlands Report*, 1988, *supra* note 21, at 20; *National Wetlands Forum*, 1988, *supra* note 20, at 14.

29. 33 U.S.C. § 1370.

30. Recently, the Commonwealth of Pennsylvania denied water quality certification for a hydroelectric project on the Susquehanna River, in part because the project would inundate adjacent wetlands that both provide critical fish and wildlife habitat and protect water quality. Commonwealth of Pennsylvania, *Notice of Final Action on Request for Certification under Section 401 of the Federal Water Pollution Control Act for the Dock Street Dam and Lake Project*, March 2, 1988.

31. U.S. EPA, *America's Wetlands - Our Vital Link Between Land and Water*, February, 1988, at 8.

32. *Id.*

33. *Id.*

34. Enclosures in correspondence from Leo Snead, Chesapeake Bay Foundation, to Paul Thompson, Natural Resources Defense Council, January 20, 1989. A notable exception to state programs that exempt agriculture is the New Hampshire program, which does not provide for any statutory exemptions, general permits or size limitations. *Id.* In New Hampshire the cumulative impacts of proposed developments within wetlands must also be assessed. *Id.*

35. Puget Sound Water Quality Authority, *1989 Puget Sound Water Quality Management Plan*, adopted October 19, 1988, at 144-145.

36. *Id.*

37. *Id.* at 145-148.

38. *Id.* at 148.

39. *See* House Bill No. 1037 (1988 Session).

40. *Id.* at § 10-262.6.

41. *Guidebook for Screening Urban Nonpoint Pollution Management Strategies,* 1979, *supra* note 7, at 29.

42. Buresh, James C. "State and Federal Land Use Regulation: An Application to Groundwater and Nonpoint Source Pollution Control," 95 *Yale L. J.* 1440 (1986).

43. *Id.* at 1440-1441; Rich Peters, Olmsted County Department of Health, March 29, 1988 (personal conversation).

44. Rich Peters, March 29, 1988, *supra* note 43; *See* Olmsted County Public Health Regulation No.1, Olmsted County, Minnesota, Board of Health.

45. Rich Peters, Olmsted County Department of Health, March 29, 1988, *supra* note 43; Minnesota Public Health Regulations 1, 40, 41 (1985).

46. U.S. EPA, *Water Quality Management of Planning and Urban Runoff Control: Financial and Institutional Issues* (Draft), December 1981, at IV-15; *see*, Buresh, 1986, *supra* note 42 at 1441.

47. U.S. EPA, December, 1981, *supra* note 46, at IV-15.

48. *See* Buresh, 1986, *supra* note 42, at 1454. See Chapters Nine and Ten for a more detailed discussion of how state and local water quality planning can be integrated. This does *not* mean that land use controls in different localities should be identical, or even use the same approach to water quality protection. They must, however, provide approximately the same degree of water quality protection.

49. Buresch, 1986, *supra* note 42, at 1454-1455; *See, e.g.,* Fla. Stat. § 163 et *seq.* (1986); Fla. Admin. Code Chapter 9J-5 (1986).

50. Buresh, 1986, *supra* note 42, at 1455; *see, e.g.,* Fla. Stat. § 163 et *seq.* (1986).

51. New York State has also developed guidance for local governments seeking to protect water quality through land use controls. *See* Morton, William, *Stream Corridor Management: A Basic Reference Manual,* New York State Department of Environmental Conservation, Albany, New York, January, 1986, at Appendix C (Sample Overlay Zoning Provisions; Appendix I (Sample Provisions for Site Plan Review); and Appendix R (Sample Land Use Standards for a Stream Corridor Management (Overlay) District).

52. *See* National Research Council, 1986, *supra* note 9, at 152-164.

53. *See* Md. Nat. Res. Code Ann. §§ 8-1801 - 1816 (1986); Md. Admin. Code tit. 14 §§ 15.01 - 15.11 (1986).

54. *See generally* Md. Nat. Res. Ann. Code §§ 8-1803, 8-1807, 8-1808 (1986); Md. Admin. Code tit. 14 §§ 15.02-15.11 (1986).

55. Md. Nat. Res. Code Ann. §§ 8-1808 - 8-1809 (1986).

56. Md. Admin. Code tit. 14 § 15.02. (1986). The three land use categories are: Intensely Developed Areas; Limited Development Areas; and Resource Conservation Areas. Md. Admin. Code tit. 14 §15.02.02 (1986). In Intensely Developed Areas, emphasis is on accommodating additional development as long as water quality is not impaired; assessing water quality improvement needs and implementing a program to address existing water quality problems; and controlling the impact of development in this area on "Habitat Protection Areas." Md. Admin. Code tit. 14 §15.02.03 (1986). Additional low intensity development is allowed in the Limited Development Areas as long as stringent regulation is used to protect water quality and habitat. *See generally* Md. Admin. Code tit. 14 § 15.02.04 (1986). Development is strictly limited in Resource Conservation Areas, which must be maintained mainly for "agriculture, forestry, fisheries activities, other resource utilization activities and for habitat protection." Md. Admin. Code tit. 14 §§ 15.02.02, 15.02.05 (1986).

57. *See generally* Md. Nat. Res. Code Ann. § 8-1809 (1986). A public hearing must be held before a local plan can be adopted. Md. Nat. Res. Code Ann. § 8-1809(d) (1986). For an example of a proposed local program, *see generally*, Baltimore County Office of Planning and Zoning, *Chesapeake Bay Critical Area Local Protection Program*, August 6, 1987.

58. National Research Council, 1986, *supra* note 9, at 52-53.

59. *Id.*

60. *Id.*; *see* Fla. Admin. Code Chapter 17-3.403 (1986).

61. *See generally* National Research Council, 1986, *supra* note 9, at 77; Horsley, Scott W., "Delineating Zones of Contribution for Public Supply Wells to Protect Groundwater," paper presented at the National Well Association Eastern Regional Conference - Groundwater Management, Orlando, Florida, October 30 - November 2, 1983; Cape Code Planning and Economic Development Commission, *Model Water Resource District Bylaw*, July 22, 1981.

62. *See generally* National Research Council, 1986, *supra* note 9, at 38-39, 158-159, 282-294; Horsley, 1983, *supra* note 61; Tom Cambareri, Cape Cod Planning and Economic Development Commission, January 13, 1989 (personal communication).

63. Tom Cambareri, CCPEDC, January 13, 1989, *supra* note 62; *see* Gallagher, Tara and Susan Nickerson, *The Cape Code Aquifer Management Project: A Multi-Agency Approach to Groundwater Protection*, presented at the National Well Water Association Third Annual Eastern Regional Ground Water Conference, July 28-30, 1986.

64. Tom Cambareri, January 13, 1986, *supra* note 62.

65. Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Special Ground-Water Protection Area Project*, Long Island Regional Planning Board, 1986, at xii.

66. *Id.*

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67. *See generally* Koppelman, Tanenbaum and Swick, 1986, *supra* note 65.

68. National Research Council, 1986, *supra* note 9, at 153; Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 1 (Land Use).

69. National Research Council, *supra* note 9, at 153; Koppelman, Tanenbaum and Swick, 1986, *supra* note 65, at 2-10; Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 1-5 (Land Use).

70. Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 16 (Land Use); Robert Berry, Nassau Planning Commission, October 6, 1988 (personal communication). The portion of land that can be dedicated as parkland is only 3%. However, larger quantities of land could be required based on a detailed site-specific evaluation of land use characteristics and water quality.

71. To facilitate implementation, localities should set a fixed, minimum percentage, such as 10% of each development preserved as open space, with a provision to allow stricter requirements where necessary for an individual subdivision.

72. Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 17 (Land Use).

73. *Id.*

74. *Id.*

75. *Id.*

76. *Id.*

77. *Id.*

78. *Id.*

79. *Id.*

80. Site plan and subdivision review is described previously in this chapter.

81. Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 35-40 (Site Plan Review).

82. *Id.*

83. *Id.*

84. *Id.* at 42-65.

85. *Id.*

86. *Id.* at 18-23 (Land Use). LIRPB has developed a list of the steps needed in the site plan and subdivision review process. Essentially, developing a site plan involves a series of distinct steps that include:

1. site selection;
2. data collection;
3. site analysis;

4. site plan development (conceptual plan, schematic plan, preliminary conference, plan revision, preliminary plan);
5. submission of preliminary plan to the municipality and other agencies, as required;
6. revision and refinement of the preliminary plan; and
7. submission of final plan. *Id.* at 47 (Site Plan Review).

87. Healey, Robert G. and Jeffrey A. Zinn, "Environmental and Development Credits in Coastal Zone Management," *APA Journal*, Summer, 1985, at 299.

88. *Id.* at 300.

89. *Id.*

90. *Id.* at 300-301; *see* 16 U.S.C. § 1451 et *seq.* There are many areas in which the CZMA requires substantial strengthening. In the sixteen years since the law was enacted, rapid coastal development has continued, and coastal water quality in many areas has continued to decline sharply. *See* Houck, Oliver A., "America's Mad Dash to the Sea," 10 *The Amicus Journal* 1988 (Summer), at 21-36; Houck, Oliver A., "Ending the War: A Strategy to Save America's Coastal Zone," 47 *Md. L. Rev.* 358-405 (1988); Office of Technology Assessment, *Wastes in the Marine Environment*, Washington D.C., 1987, at 99-140.

91. Healy and Zinn, 1985, *supra* note 87, at 300-301; 16 U.S.C. § 1452.

92. *See* U.S. EPA, *National Water Quality Inventory: 1986 Report to Congress*, November, 1986, at 41 (hereinafter cited as *National Water Quality Inventory*).

93. 16 U.S.C. § 1456(f).

94. *See* 16 U.S.C. § 1458.

95. *See* Healy and Zinn, 1985, *supra* note 87, at 303-309; *National Water Quality Inventory*, 1984, *supra* note 92, at 51.

96. *See generally* Buresh, 1986, *supra* note 42, at 1440, 1446; Hague, Bart, "Handling Cumulative Impacts in Nonpoint Source Programs," in *Lake and Reservoir Management: an International Journal, Volume III*, North American Lake Management Society, Washington, D.C., 1987, at 131-137.

97. Buresh, 1986, *supra* note 42, at 1440, 1446, 1455-1458.

98. *National Water Quality Inventory*, 1984, *supra* note 92, at 139; Archer, Jack H. and Robert W. Knecht, "The U.S. National Coastal Zone Management Program - Problems and Opportunities in the Next Phase," 15 Coastal Management 109-110 (1987).

99. *See generally*, Buresh, 1986, *supra* note 42, at 1440-1445.

100. Healy and Zinn, 1985, *supra* note 87, at 303-308.

101. *Id.* at 303.

102. *Id.* at 303-305.

103. *Id.* at 305.

104. *Id.* at 305-306.

105. *Id.* at 306.

106. *Id.* at 305.

107. *Id.* at 306.

108. *Id.* at 307.

109. *Id.*

110. *See* 15 N.C. Admin. Code 2H .0408.

111. *Id.*

112. *See generally* South Carolina Coastal Council, *Storm Water Management Guidelines*, revised September 1, 1988.

113. *Id.*

114. *Id.* at 3-18.

115. *See* 19 *Coastal Zone Management* 1-2 (July 30, 1988).

116. *Id.*

117. See Chapter Ten for a discussion of how coastal protection considerations can be incorporated into local comprehensive plans. Fla. Admin. Code Chapter 9J-5 (1986); Fla. Admin. Code 9J-11 (1987); Fla. Stat. § 186 et *seq.* (1985); Fla. Stat. § 187 (1985).

118. *See, e.g.,* Fla. Admin. Code Chapters 9J-5.015, 9J-5.021, 9J-11.008(5), 27E-4 (1986); Fla. Stat. §§ 186.502, 380.012 et *seq.* (1986).

119. *See* Fisher, Michael L., "California's Coastal Program–Larger-than-Local Interests Built into Local Plans," *APA Journal*, Summer, 1985, at 312; Healy and Zinn, 1985, *supra* note 87, at 301, 304.

120. For a comprehensive analysis of the California Coastal Zone Protection Program, *see*, DeGrove, John M., "California: Planning and Managing the Coast," in *Land Growth and Politics*, APA Planners Press, Chicago, 1984; Sabatier, Paul A. and Daniel A. Mazmanian *Can Regulation Work? The Implementation of the 1972 California Coastal Initiative*, Plenum Press, New York, 1983: Scott, Stanley, *Governing California's Coast*, Institute of Governmental Studies, University of California, Berkeley, 1975; Squire, Peverill and Stanley Scott *The Politics of California Coastal Legislation: The Crucial Year, 1976*, Institute of Governmental Studies, University of California, Berkeley, 1984. Fisher, 1985, *supra* note 119, at 321.

121. Fisher, 1985, *supra* note 119, at 312; *See, e.g.,* Cal. Pub. Res. Code § 30602, §§ 30340.5, 30500, 30513 (1984).

122. Fisher, 1985, *supra* note 119, at 313.

123. Fisher, 1985, *supra* note 119, at 313; Cal. Pub. Res. Code § 30000 et *seq.* (1984).

124. Fisher, 1985, *supra* note 119, at 315.

125. Fisher, 1985, *supra* note 119, at 315-316; Cal. Pub. Res. Code §§ 30510-30525 (1984).

126. Fisher, 1985, *supra* note 119, at 315; *see* Cal. Pub. Res. Code §§ 30150-30170, 30600-30603 (1984).

127. Fisher, 1985, *supra* note 124, at 316; *see* Cal. Pub. Res. Code §§ 30300-30355 (1984). As of 1985, 98 out of 128 planning areas had approved land use plans and 52 also had approved implementation programs. Fisher, 1985, *supra* note 119, at 318. Coastal permitting authority has been assumed by 34 of these 52 local governments. *Id.*

128. *See* Fisher, 1985, *supra* note 119, at 316.

129. *Id.* at 317-318. The separation of this function from the Coastal Commission is thought to have been a poor decision since it has created interagency turf battles and tension. State programs such as Michigan and North Carolina, with combined functions in a single agency, are considered by some to be politically more feasible (and popular). *Id.*

130. Replacing existing wetlands with artificial substitutes is, at best, a controversial proposition. *See National Wetlands Forum*, 1988, *supra* note 20, at 61-63.

131. Fisher, 1985, *supra* note 119, at 319-320.

132. 33 U.S.C.A. § 1342. *See generally Natural Resources Defense Council, Inc. v. Train*, 396 F.Supp. 1393 (D.D.C. 1975), *affirmed*, 568 F.2d. 1369 (D.C.Cir. 1977).

133. EPA recently proposed regulations governing point source discharges of contaminated runoff. 53 Fed. Reg. 49,416-49,487 (December 7, 1988). It is beyond the scope of this report to address the adequacy of this proposal. However, EPA's proposal would apply only to incorporated cities and towns, and only to approximately 25% of the U.S. population. *Id.* at 49,430. While this limitation is of questionable legality, *see*, 33 U.S.C. § 1362(4), it underscores the need for good stormwater control programs elsewhere.

134. Livingston, et al., 1988, *supra* note 4, at 4-4 - 4-5.

135. Puget Sound Water Quality Authority, *Nonpoint Source Pollution* (Issue Paper), May 1986, at 4-115.

136. *Id.*

137. *Id.*

138. Retention of stormwater results in "nearly total treatment of the diverted water." Livingston, Eric, "Stormwater Management in Florida: An Evolving Regulatory Program," paper presented at the American Society of Civil Engineers Urban Runoff Quality Seminar, Henniker, New Hampshire, June 22-27, 1986, at 5. Earl Shaver, Maryland Department of the Environment,

Sediment and Stormwater Administration, September 14, 1988 (personal conversation).

139. Maryland is attempting to develop a comprehensive approach to stormwater management that would coordinate the controls developed for individual drainages under 400 acres. Shaver, 1988, *supra* note 138.

140. *Id.*

141. *Id.*

142. *See* Livingston, 1986, *supra* note 138, at 7.

143. Livingston, *et al.*, 1988, *supra* note 4, at 4-8. Adverse effects of "piecemeal" stormwater management include: negative spillover effects (especially in multi-jurisdictional watersheds); negligible flood control because of emphasis on minor flooding; poor runoff control because locational differences of potential detention sites are not evaluated; high maintenance costs and poor operation (because of the number of facilities and responsible parties); and high costs for the benefits received compared to a well-planned watershed plan. *Id.*

144. *Id.* at 4-6 - 4-8.

145. Puget Sound Water Quality Authority, 1986, *supra* note 135, at 4-122 -4-124.

146. Bissonnette, Pam, "Bellevue Experiences with Urban Runoff Quality Control Strategies," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, May, 1985, at 280.

147. Buresh, 1986, *supra* note 42, at 1440.

148. Puget Sound Water Quality Authority, 1986, *supra* note 135.

149. *See* Livingston, 1986, *supra* note 138, at 5.

150. *See* Livingston, 1986, *supra* note 138, at 6-7; Livingston, *et al.*, 1988, *supra* note 4, at 4-9.

151. *See* Livingston, Eric, "The Stormwater Rule: Past, Present and Future," paper presented at Stormwater Management: An Update, Orlando, Florida, July, 1985, at 5; Eric Livingston, Florida Department of Environmental Protection, May 27, 1988 (personal conversation); Shaver, 1988, *supra* note 138.

152. *See, e.g.*, Malcolm, Rooney H., Avera, Bullard and Lancaster, *Stormwater Management in Urban Collector Streams*, North Carolina Water Resources Research Institute, June, 1986, at 24-25, 128-131; Shaver, Earl, "Institutional Stormwater Management Issues," presented at a Conference on Current Practice and Design Criteria for Runoff Water Quality Control, Engineering Foundation, ASCE and EPA, Potosi, Maine, July 10-15, 1988.

153. Shaver, 1988, *supra* note 152, at 8.

154. *Id.* at 9. A utility approach to stormwater management could even make it possible to integrate agricultural poison runoff controls into the stormwater

program in areas where detention and retention of surface flows alongside roadways is possible. Shaver, 1988, *supra* note 138.

155. Examples of stormwater utilities encompassing two or more political jurisdictions are Louisville/Jefferson County, Kentucky; Everett, Washington; and Seattle/King County, Washington. Another multi-jurisdiction utility (Vancouver/Clark County, Washington encompasses a specific watershed with recognized water quality problems. Lindsey, Greg, *A Survey of Stormwater Utilities*, Sediment and Stormwater Administration, Maryland Department of the Environment, March 1988, at 3.

156. Livingston, 1985, *supra* note 151, at 5.

157. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 24-25; *see* Maryland Department of the Environment, *Sample Stormwater Utility Ordinance*, May, 1988, § 1.2 (Intent).

158. Lindsey, 1988, *supra* note 155, at ii.

159. *Id.* at 20-21.

160. *See* Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 24-25; Maryland Department of the Environment, 1988, *supra* note 157, at § 5.2 (Calculation of Fees in General).

161. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129; Maryland Department of the Environment, 1988, *supra* note 157, at § 1.1 (Findings).

162. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152 at 128-129; Shaver, 1988, *supra* note 152, at 1.

163. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129.

164. *Id.* at 130.

165. *Id.*

166. Lindsey, 1988, *supra* note 155, at 3.

167. Livingston, 1985, *supra* note 151, at 5-6; Livingston, May 27, 1988, *supra* note 151.

168. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129-130; *see generally* Lindsey, 1988, *supra* note 155; Earl Shaver, Maryland Department of the Environment, Sediment and Stormwater Program, November 16, 1988 (personal conversation).

169. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129; Boulder Rev. Code Tit II § 11-5-1 (1981).

170. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129; Boulder Rev. Code §§ 11-5-5 - 11-5-7, 4-20-44, 4-20-45 (1981).

171. Malcolm, Avera, Bullard and Lancaster, 1986, *supra* note 152, at 129-130; Boulder Rev. Code §§ 4-20-45(b), 4-20-45(c) (1981).

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172. Bissonnette, 1985, *supra* note 146, at 279-280.

173. *Id.*

174. *Id.* For example, the city has adopted land use controls that establish standards for cleaning and maintaining public and private parking lots, streets and drainage systems. *Id.*

175. *See*, U.S. EPA, *Results of the Nationwide Urban Runoff Program (Volume 1-Final Report)*, December, 1983, at 6-1 - 6-64.

176. Livingston *et al*, 1988, *supra* note 4, at 4-6.

177. U.S. EPA, December, 1983, *supra* note 175 at 9-13.

178. Livingston *et al*, 1988, *supra* note 4, at 4-6.

179. U.S. EPA, December, 1983, *supra* note 175, at 8-2 - 8-14; Livingston *et al*, 1988, *supra* note 4, at 4-6. Although the terminology often differs, "detention" is described in the Florida stormwater regulations as "the collection and temporary storage of stormwater in such a manner as to provide for treatment through physical, chemical, or biological processes with subsequent gradual release of the stormwater." Fla. Admin. Code Chapter 17-25.020(5) Wet detention basins are areas that perform this function through the maintenance of a permanent pool of water. U.S. EPA, December 1983, *supra* note 175, at 8-2. Retention "means the prevention of, or to prevent the discharge of, a given volume of stormwater runoff into surface waters." Fla. Admin. Code Chapter 17-25.020(12). This can be accomplished by "the holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass." Schueler, Thomas R., *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Metropolitan Washington Council of Governments, July, 1987, at G.5.

180. Livingston *et al*, 1988, *supra* note 4, at 4-6.

181. *Id.*

182. *Id.*

183. *Id.*

184. U.S. EPA, December, 1983, *supra* note 175, at 8-14. The use of recharge devices to promote infiltration should be conditioned on such factors as shape, soil characteristics, depth to groundwater and location of water supply wells. *Id.*

185. *Id.* at 8-15.

186. *Id.*

187. U.S. EPA, *NPDES Best Management Practices Guidance Document*, December, 1979, at 4.

188. *Id.* at 9-20.

189. Md. Nat. Res. Code Ann. § 8-11A-01 - 11A-08 (1986).

190. *See* Md. Admin. Code tit 8 § 5.05.01-.10 (1986).

191. Md. Admin. Code tit 8 § 5.05.01(A) (1986).

192. Md. Admin. Code tit 8 § 5.05.03(A)(2) (1986).

193. Md. Admin. Code tit 8 § 5.05.03(A)(3-9) (1986).

194. Md. Admin. Code tit 8 § 5.05.03(C) (1986).

195. Md. Admin. Code tit 8 § 5.05.04(B) (1986).

196. Md. Admin. Code tit 8 § 5.05.05(A) (1986).

197. Md. Admin. Code tit 8 § 5.05.05(B) (1986).

198. Md. Admin. Code tit 8 § 5.05.05(C) (1986).

199. Md. Admin. Code tit 8 § 5.05.06 (1986).

200. Md. Admin. Code tit 8 § 5.05.08 (1986).

201. Md. Admin. Code tit 8 § 5.05.08(A)(1) (1986). For an explanation of the distinction between "retention" and "detention", *see* note 179 *supra*.

202. Md. Admin. Code tit 8 § 5.05.08(A)(2) (1986).

203. Md. Admin. Code tit 8 § 5.05.08(B)-(C) (1986).

204. Md. Admin. Code tit 8 § 5.05.08(C)(1)(d) (1986).

205. Md. Admin. Code tit 8 § 5.05.08(C)(3)(b) (1986).

206. Md. Admin. Code tit 8 § 5.05.09 (1986).

207. Md. Admin. Code tit 8 § 5.05.10 (1986).

208. Md. Admin. Code tit 8 § 5.05.10(A) (1986).

209. Md. Admin. Code tit 8 § 5.05.10(C) (1986).

210. Md. Admin. Code tit 8 § 5.04(B)(6) (1986).

211. *See* Fla. Admin. Code Chapter 17-25.025 (1988); Livingston, 1986, *supra* note 138, at 3.

212. Livingston, 1986, *supra* note 138, at 7.

213. *Id.*; Livingston *et al.*, 1988, *supra* note 4, at 4-7.

214. Livingston, Eric, and John H. Cox, "Urban Stormwater Quality Management: The Florida Experience," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, May, 1985, at 290.

215. Livingston, 1986, *supra* note 138, at 3; Fla. Admin. Code Chapter 17-25.025 (1988).

216. Livingston, 1985, *supra* note 138, at 4; Fla. Admin. Code Chapter 17-25.025(9) (1988).

217. Livingston *et al.*, 1988, *supra* note 4, at 4-7.

218. Livingston, 1985, *supra* note 151, at 3-4; Fla. Admin. Code Chapter 17-25.035(1)(b) (1988). Using statistical information based on rainfall records, Florida officials conducted an analysis of the variability and intensity of individual storms which revealed that almost 90% of all storms in a year produce one inch or less of rainfall, and that 75% of total rainfall volume occurs in storms of this intensity. The "first flush effect," or the high concentration of pollutants in the runoff from the first part of the storm, was recognized in developing the state's performance standard. Livingston, 1985, *supra* note 151, at 3.

219. Florida Department of Environmental Regulation, *Florida's Nonpoint Source Management Program*, September 1986, at 2; Fla. Admin. Code Chapter 17-25.035(1)(b) (1988).

220. The "first flush" effect is the process which causes the initial runoff generated by a given storm to contribute the highest proportional loadings of NPS pollution. Livingston, *et al.*, 1988, *supra* note 4, at 4-1 - 4-2.

221. Livingston, 1986, *supra* note 138, at 4.

222. Livingston and Cox, 1985, *supra* note 214, at 290; Eric Livingston, May 27, 1988, *supra* note 151; *see* Fla. Admin. Code Chapter 17-25.025 (1988).

223. Fla. Admin. Code Chapter 17-25.040(1) (1988).

224. *See* Fla. Admin. Code Chapter 17-25.050 (1988); Fla. Stat. §§ 403.182, 403.812 (1988).

225. Livingston, 1985, *supra* note 151, at 4-5; Fla. Admin. Code Chapter 17-25.040(6) (1988).

226. Livingston, 1985, *supra* note 151, at 5; Fla. Admin. Code Chapter 17-25.027(4)(d) (1988).

227. Livingston, 1986, *supra* note 138, at 5-7. Proposals to address many of these problems have been made. For example, local governments could be required either to be responsible for the operation and maintenance of stormwater systems or for enforcing provisions regarding maintenance against those responsible for maintaining the systems. Livingston, 1986, *supra* note 138, at 7.

228. Livingston, 1986, *supra* note 138, at 5-7.

229. *Id.*

230. *Id.*

231. Puget Sound Water Quality Authority, *1989 Puget Sound Water Quality Management Plan*, Seattle, Washington, adopted October 19, 1988, at 131-132 (hereinafter cited as *Puget Sound Plan*).

232. *Id.* at 131-135; *see generally* Wash. Rev. Code §90.70 (1985); Wash. Admin. Code R. Ch. 400-12-630 (1988).

233. *Puget Sound Plan*, 1988, *supra* note 231, at 133; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-630 (1988).

234. *Puget Sound Plan*, 1988, *supra* note 231, at 134-135; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-630 (1988).

235. *Puget Sound Plan*, 1988, *supra* note 231, at 135-139; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-210, 400-12-630 (1988).

236. *Puget Sound Plan*, 1988, *supra* note 231, at 135; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-520, 400-12-630 (1988).

237. *Puget Sound Plan*, 1988, *supra* note 231, at 135; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-520, 400-12-630 (1988).

238. *Puget Sound Plan*, 1988, *supra* note 231, at 136-137; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-520, 400-12-630 (1988).

239. *Puget Sound Plan*. 1988, *supra* note 231, at 137-138; Wash. Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-560, 400-12-630 (1988). Ordinances must control stormwater and water used for cleaning or maintaining construction, maintenance and street cleaning equipment from both new and existing developments. *Puget Sound Plan*, 1988, *supra* note 231, at 137-138; Wash Rev. Code § 90.70 (1985); Wash. Admin. Code R. Ch. 400-12-630 (1988). Other state guidelines will address:

1. acceptable approaches to stormwater management from new development, including policies used in making State Environmental Policy Act (SEPA) decisions related to water;
2. land use controls to limit development density in sensitive areas;
3. standards to limit the amount of impervious surfaces;
4. regional detention ponds and drainage ordinances, erosion control, and wetlands preservation;
5. guidelines for operating and maintaining existing stormwater systems; and
6. the review of existing ordinances.

Puget Sound Plan, 1988, *supra* note 231, at 136-137.

240. *Puget Sound Plan*, 1988, *supra* note 231, at 138.

241. *Id.*

242. *Id.*

243. *Id.* at 138-139.

244. *Id.*

245. Metropolitan Washington Council of Governments, *First Annual Work Plan for the Restoration of the Anacostia River - October 1, 1988 to September 30, 1989*, September 14, 1988, at 1.

246. *Id.* at 8.

247. *Id.*

248. *Id.* at 9-13.

249. Koppelman, Tanenbaum and Swick, 1984, *supra* note 9, at 24-25 (Stormwater).

250. *Id.* at 26-55.

251. Just as stormwater management programs often are incorporated into local land use controls, programs to control erosion and sedimentation from construction sites sometimes are a part of general stormwater management efforts (when these efforts are undertaken). *See, Puget Sound Plan,* 1988, *supra* note 231, at 134-138.

252. *See, e.g.,* Water Resources Administration, *1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control,* 1983. The Maryland ESC Manual is undergoing revisions which will be finished in early 1989. Bob Kort, Maryland Sediment and Stormwater Administration, January 13, 1989 (personal conversation).

253. *See, e.g.. Implementation Effectiveness of the Virginia Erosion and Sediment Control Program,* House Document No. 15, Richmond, Virginia, 1988, at 13-32.

254. *See* Garner, Mary M., *Summary of Principal Provisions of State Laws Providing for Erosion and Sediment Control as of July 1, 1985,* National Association of Conservation Districts, (no date); Klein, Susan B., *State Soil Erosion and Sediment Control Laws,* National Conference of State Legislatures, November, 1980.

255. *See generally* Pennsylvania Bureau of Soil and Water Conservation, *An Evaluation of Pennsylvania's Erosion and Sedimentation Control Program,* August, 1984; *An Evaluation of the Virginia Erosion and Sedimentation Control Program,* Smith Demmer Norman, Hampton, Virginia, June, 1987.

256. *See* Cox, William E. and Lorraine M. Herson, *Control of Nonpoint Source Pollution in Virginia: An Assessment of the Local Role* (Bulletin 158), Virginia Water Resources Research Center, November, 1987. The following discussion is based on the program structure provided in this study.

257. *Id.* at 28.

258. Although some state ESC programs apply to silvicultural, agricultural and urban stormwater NPS pollution, this section focuses on developing programs designed to address NPS pollution from construction activities. *See* the discussion of Olmsted County's Erosion and Sediment Control ordinance in Chapter Three for an example of an ESC program applicable to agriculture.

259. Cox and Herson, 1987, *supra* note 256, at 28.

260. *See An Evaluation of the Virginia Erosion and Sedimentation Control Program,* 1987, *supra* note 255, at IX-2 - IX-3.

261. *Id.* at IX-5.

262. For example, the confusion between applicable regulations and guidelines has been cited as a problem in the Virginia ESC program. *Implementation Effectiveness of the Virginia Erosion and Sediment Control Program*, 1988, *supra* note 253, at 3.

263. Cox and Herson, 1987, *supra* note 256, at 29-30.

264. *Id.* Fees can be set according to different criteria (*e.g.*, higher fees for full cost recovery to account for all adverse impacts caused by an activity with only private benefits, or lower fees to reflect the social benefits of the development).

265. *Implementation Effectiveness of the Virginia Erosion and Sediment Control Program*, 1988, *supra* note 253, at 55.

266. *An Evaluation of the Virginia Erosion and Sedimentation Control Program*, 1987, *supra* note 255, at IX-9.

267. *Id.* at IX-9 - IX-10.

268. *Id.* at IX-11.

269. Cox and Herson, 1987, *supra* note 256, at 30.

270. *Id.*

271. *Id.*; *An Evaluation of the Virginia Erosion and Sedimentation Control Program*, 1987, *supra* note 255, at IX-12.

272. *Implementation Effectiveness of the Virginia Erosion and Sedimentation Control Program*, 1988, *supra* note 253, at 60.

273. *An Evaluation of the Virginia Erosion and Sediment Control Program*, 1987, *supra* note 255, at IX-2.

274. Cox and Herson, 1987, *supra* note 256, at 31; Shaver, 1988, *supra* note 168.

275. Cox and Herson, 1987, *supra* note 256, at 31; Shaver 1988, *supra* note 168.

276. Cox and Herson, 1987, *supra* note 256, at 31; Shaver, 1988, *supra* note 168.

277. Cox and Herson, 1988, *supra* note 256, at 32; *Implementation Effectiveness of the Virginia Erosion and Sediment Control Program*, 1988, *supra* note 253, at 60.

278. *An Evaluation of the Virginia Erosion and Sedimentation Control Program*, 1987, *supra* note 255, at IX-4.

279. Cox and Herson, 1987, *supra* note 256, at 32.

280. *Id.*, at 31.

281. *An Evaluation of the Virginia Erosion and Sedimentation Control Program*, 1987, *supra* note 255, at IX-13.

282. Maryland's ESC regulation *requires* a minimum of one inspection every two weeks for compliance with the approved ESC plan. Written reports must be prepared after every inspection. Md. Admin. Code Tit. 8 § 5.08(C) (1986).

283. *An Evaluation of the Virginia Erosion and Sedimentation Control Program*, 1987, *supra* note 255, at IX-1 - IX-13.

284. *See generally An Evaluation of Pennsylvania's Erosion and Sedimentation Control Program*, 1984, *supra* note 255.

285. *See generally* Md. Admin. Code tit. 8 § 5.01-10 (1986).

286. Md. Admin. Code tit. 8 §§ 5.02 - 5.03 (1986).

287. Md. Admin. Code tit. 8 §§ 5.02-1, 5.08 (1986).

288. Md. Admin. Code tit. 8 § 5.08 (1986).

289. Md. Admin. Code tit. 8 § 5.08(C)(7) (1986).

290. Md. Admin. Code tit. 8 § 5.08(C)(7) (1986).

291. Md. Admin. Code tit. 8 § 5.02-1(B)(2) (1986).

292. Md. Admin. Code tit. 8 § 5.02-1(B)(3) (1986). Suspension of delegation requires an opportunity for a hearing in which the locality may defend its actions. *Id.*

293. Md. Admin. Code tit. 8 § 5.03 (1986).

294. Md. Admin. Code tit. 8 § 5.03(C) (1986). Additional regulations include procedures that establish the required scope of ESC program coverage; certification that personnel associated with earth moving or sediment control activities are trained in ESC practices; and procedures for submission and approval of applications for ESC plans and permits. Md. Admin. Code tit. 8 §§ 5.04, 5.05, 5.06, 5.07 (1984). The discretionary evaluation is based on compliance with the intent of the stormwater water management regulations. Md. Admin. Code tit. 8 § 5.03(A) (1986).

295. Md. Admin. Code tit. 8 § 5.02(C) (1986). This periodic evaluation includes an assessment of several factors, including whether local plans have approved ESC plans and permits that provide "effective erosion and sediment control strategies" and the "information necessary to ensure proper installation and maintenance of these strategies by the field personnel; and whether the plans comply with the principles, methods and practices of the *1983 Maryland Standards and Specifications for Soil Erosion and Sediment Control* (as well as other requirements). Md. Admin. Code tit 8 §§ 5.02(C)(1)(b), 5.02(C)(1)(b) (1986).

296. Md. Admin. Code tit. 8 § 5.08(D) (1986).

297. Senate Bill No. 118. § 1(E).

298. *Id.*

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299. In ESC programs, stabilization usually involves planting grasses or covering with a non-erosive material.

300. Md. Admin. Code tit. 8 § 5.06((B)(3)(e)(iv) (1986).

301. Md. Admin. Code tit. 8 § 5.06(B)(3)(g)(i) (1986); Benner, Roy E., "Urban Sediment and Stormwater Control: The Maryland Experience," 40 *JSWC* 73 (1985).

302. Md. Admin. Code tit. 8 § 5.04(A)(2) (1986); Benner, 1985, *supra* note 301, at 73.

303. Benner, 1985, *supra* note 301, at 74.

304. Pa. Admin Code tit. 25 §§ 102.42-43 (1972).

305. Pennsylvania Department of Environmental Resources, *Soil Erosion and Sedimentation Control Manual*, (no date), at 26.

306. *Id.* at 27.

307. Pennsylvania Department of Environmental Resources, *Proposed Revisions to Erosion Control Regulation*, December 2, 1987, at 15 (Annex A).

308. *Id.* at 4 (Annex A).

309. *Implementation Effectiveness of the Virginia Erosion and Sediment Control Program*, 1988, *supra* note 253, at 13-15.

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Less intensive or prevalent land uses, such as silviculture, mining and grazing can also destroy aquatic habitat.

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Chapter Five

Silviculture, Mining and Rangeland Programs

Introduction

This chapter discusses programs designed to reduce poison runoff from silvicultural, mining and rangeland activities. Aspects of effective programs are identified based on general information as well as evaluations of individual state programs. Where possible, examples of programs that reflect some of these management needs are provided.

Poison runoff from silvicultural (forestry), mining and rangeland (grazing) operations are controlled through programs that often differ significantly from those designed to address agricultural and urban sources.[1] This difference could be due to many factors: often localized pollution impacts, relatively few polluters, and similar types of pollution (and associated BMPs) within each particular source category. However, the severity of pollution from timber cutting in Idaho and California, mining in Pennsylvania and Montana and cattle grazing in Oregon and Washington State all testify to the need to control these sources of pollution adequately.

Obviously, the control of poison runoff from silviculture, mining and grazing varies according to the specific environmental and management characteristics of each source category. However, the fact that each activity takes place on federal, state and private lands creates a common management requirement—the integration and coordination of control programs on all classes of land ownership.

Programs to Control Silvicultural Water Pollution

On state and private lands, controls on logging operations are imposed through state and local programs (commonly called forest practices). However, a large portion of silviculture in the United States is conducted on federal lands.[2] States still have a major role to play in controlling water pollution from federal lands through agreements between state forestry and water quality management agencies and the U.S. Forest Service (USFS) (as well as general state authority under the Clean Water Act).[3] State forestry programs to reduce silvicultural water pollution vary a great deal. They can include voluntary and regulatory programs, tax incentives, education, and technical assistance. Programs are designed to protect water quality, encourage reforestation, control the location and type of timber harvesting and protect forests from disease and fire.[4]

USFS has had limited success in protecting water quality through its planning and enforcement activities.[5] For example, severe fisheries and wildlife habitat impacts in the Clearwater, Boise and Payette National Forests in Idaho have occurred due to logging and road building sanctioned by USFS planners.[6] Similar adverse water quality impacts are documented from silvicultural operations on private and nonfederal lands.[7] While water quality protection is a *stated* objective of the National Forest Management Act and most state forestry programs, it is often questionable whether or not associated controls have been adequate to achieve this objective.

Programs to protect water quality in private and nonfederal forests are mostly voluntary, especially in the south.[8] Western and northeastern states, by contrast, have established a signifi-

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Forestry activities, particularly clearcutting and roadbuilding, often result in severe sedimentation and stream channel alterations.

cant number of regulatory programs designed to protect water quality.[9] However, officials in 21 states have identified the need for regulatory programs (as opposed to voluntary guidelines) in efforts to protect water quality in logging operations.[10]

Because this report seeks primarily to assist state and local water pollution programs, this chapter mainly addresses state forest practice programs. But since some states have attempted to negotiate with USFS to make various aspects of the state program apply to USFS activities, the information provided in this chapter also applies indirectly to the substance of those negotiations.[11]

Incorporating Water Quality Standards Into State Forest Practices Acts

As with other types of poison runoff control programs, silvicultural controls should be driven by water quality standards. If water quality standards are to be used meaningfully, state

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programs can not contain exemptions or loopholes for compliance with water quality standards just because BMPs have been, or will be, implemented.[12] BMPs are only tools to be used in achieving state water quality standards.[13] They are not program goals in themselves.[14] States not only have the right but also the responsibility to ensure that state water quality standards are not violated because of silvicultural activities on all lands within the state, including private, state and *federal* forests.[15]

This water quality "performance standard" is vital because the range of potential BMPs needed to protect water quality is so large that it is very difficult to reproduce and enforce them as specific technical requirements.[16] In turn, however, the difficulties of large scale enforcement and administration of a performance standard make the use of an aggressive set of technology-forcing prescriptive BMPs an important minimum program requirement.[17]

In determining the potential for water quality standards violations, states should consider cumulative impacts[18] from surrounding operations and the impacts of major erosion events, such as landslides.[19] Mean sediment loadings averaged over a long period of time do not adequately reflect real water quality conditions.[20] In addition to numerical criteria, beneficial uses and physical, biological and habitat criteria all must be available in case costs or data limitations make the application of numerical criteria infeasible.[21] For example, water uses are impaired where benthic organisms or spawning beds are smothered due to sediment deposition, whether or not numeric water quality criteria are violated.[22]

Applying EPA's antidegradation regulation (40 CFR § 131.12),[23] or the required state analogue, can be particularly valuable. Antidegradation should be used to avoid the contamination of "pristine waters" (often the kinds of waters in forested land), particularly in the area of sediment pollution (the primary silvicultural water pollutant).[24]

Moreover, as mentioned previously, forestry activities can result in water quality standards violations even with the full use of field-level BMPs. Therefore, states must use their CWA authority to reduce or preclude logging and road building operations altogether in specific locations, or to control the timing of multiple logging operations in a single watershed, where

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necessary to ensure compliance with water quality standards.[25] When the timing, location and intensity of a particular harvest are generally acceptable, *then* BMPs can be used to protect water quality.

Therefore, water quality standards should provide an objective basis on which to develop and review long- and short-term plans for specific harvesting proposals (both private and federal). State programs then can go beyond merely requiring specific field-level controls, to approving timbering proposals only when state water quality standards will be met.

BMPs, in this context, become more than individual site applications of particular technical controls. BMPs include planning and management activities that determine *where* and *when* timber harvesting can occur, as well as the technical standards to determine *how* timber harvesting will be conducted. This planning component is a vital part of state forest practice programs.

Unfortunately, the ability of current state forestry programs to achieve these objectives is limited by budgetary constraints. The median budget for state forest resource planning in 1985 was just $8,000.[26] Adequate state forestry programs, therefore, require significantly increased funding. Such funding could be obtained through permit fees, assessments based on the amount of timber proposed to be cut, or both.

Review and Enforcement Issues. Since individual silvicultural operations can have devastating water quality impacts, a mechanism is necessary by which water quality standards can be incorporated into state forest practices regulations in an enforceable manner. A water quality standards-based forest practices program requires the technical capacity to review and, if necessary, modify timber harvesting proposals. An effective inspection and monitoring process is needed to determine if a plan is being followed and is avoiding desirable impacts on water quality.

Timber plans should be reviewed by a multi-agency team with substantive authority over final decisions.[27] Water quality, fish and wildlife and silvicultural experts all should be a part of the review process.[28]

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State officials need to conduct site inspections, carry out monitoring activities, and if necessary, modify original plans and BMPs after logging begins.[29] Inspections must determine whether or not the requirements for both the prescriptive BMPs and the performance standards are being met. Thus, inspections should be conducted not only by silvicultural experts to determine compliance with BMPs, but also by biologists and water quality specialists to monitor the actual effects of logging operations on the waterbody.

To accomplish this, procedures must be in place to judge the overall health of the affected waterbody. Monitoring activities are necessary to understand the actual impacts of BMPs in order to alter prescriptive requirements, when necessary, and to carry out long-range planning and cumulative impact studies. Civil and administrative penalties, in addition to criminal sanctions, should be available since state forestry personnel are less likely to be willing to brand a fellow forester as a criminal than to levy fines.[30]

Case Study: California

California's forest practice program, generally considered the most aggressive in the nation,[31] provides examples of progressive state forest practices rules and regulations. However, even the advanced California program has shortcomings in protecting water quality. California's Forest Practice Act of 1973 established the current structure of the state program as applicable to private and nonfederal land.[32] The program is one of the few (if not the only) in the nation with a stated policy of treating timber productivity and water quality protection as equal, first priority goals.[33] (That so few states have made water quality protection a first priority in state forestry program is astonishing since, as explained in Chapter Two, compliance with water quality standards is a minimum, mandatory requirement of the Clean Water Act.)

In reality, however, rules and regulations are issued by the Board of Forestry (BOF), which is composed of five members of the general public and four members from the forestry and range and livestock industry.[34] It has been described as "... [leaning]

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more to the industrial views than to the pleadings of environmentalists."[35]

The California forest practice program can be described as consisting of two basic components: 1) an administrative and management framework, and 2) substantive forest practice rules (BMPs). Both of these components contain interesting models for state silvicultural programs designed to control poison runoff.

The Board of Forestry must solicit the input of the California Departments of Forestry (CDF) and Fish and Game (DFG) and the State Water Resources Control Board (SWRCB) when developing new forest practice rules.[36] Recently, the BOF has been negotiating an agreement with the SWRCB to develop the silvicultural pollution control portion of the State Water Quality Management plan.[37] Many of the issues discussed below resulted from the interaction of the CDF (a multi-purpose management agency) with the SWRCB and the DFC (environmentally focused, resource protection agencies).

To maintain good professional and technical qualifications in the industry, all timber operators must obtain a state timber operator's license, which must be renewed annually. All practicing foresters must meet certain qualifications (including a minimum level of experience and the successful completion of a written exam) before they can be registered to practice in the state.[38]

The timber harvester and owner must file a timber harvesting plan (THP), to be prepared by a registered professional forester. The plan must be approved by the Department of Forestry before harvesting activities can begin.[39] The specific requirements of the plan are numerous, but generally must describe:

1. the site;
2. activities to be conducted;
3. methods to be used to avoid excessive erosion on sites near streams; and
4. provisions to protect unique areas.[40]

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These plans must be sent to DFG, the relevant regional water quality control board (RWQCB) and the county where the land is located. Interdisciplinary review teams then are assembled to evaluate environmental impacts and compliance with forest practice rules.[41] CDF personnel act as the review team chairpersons and have sole authority to approve or deny the plan. If other team members disagree with approval or denial by the chairperson, they can file a report of nonconcurrence with the BOF. The chairperson then must respond to the complaints in writing although the final decision remains with the BOF chairperson.[42] County Boards of Supervisors, which at their request and with the approval of CDF can have county-specific forest practice rules promulgated by BOF, may request public hearings to discuss any plan filed for lands within their boundaries.[43]

Administrative deadlines are established for various points in California's regulatory process.[44] Under various circumstances, the program also requires inspections before, during and after the operation.[45] Any inspector can issue a stop work order if an operation is found to be (or is about to be) in violation of the program's rules and regulations.[46] A violation of the Act can be treated as a criminal offense, and any necessary costs incurred to correct violations can be attached as a lien on the property where the violation occurred.[47]

The BMPs included in the California forest practice program are extensive, and cover the following areas:

1. silvicultural methods;

2. harvesting practices and erosion control;

3. watercourse and lake protection;

4. hazard reduction;

5. fire protection;

6. forest insect and disease protection; and

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7. logging roads and landings.[48]

Many of the rules prescribe certain restrictions such as the size of clear-cut stands in areas with various erosion hazards and reforestation requirements.[49] Other BMPs are less exact and prescriptive in nature, such as: "the number of [watercourse] crossings should be kept to a minimum"; "logging roads and landings shall be planned and located, when *feasible,* to avoid known unstable soils or known slide-prone areas" (emphasis in original); "existing crossings shall be used wherever *feasible*" (emphasizing original); and "[i]f those areas are unavoidable, site-specific measures shall be planned ... by the RPF to minimize slope instability due to construction."[50]

The watercourse and lake protection measures include:

1. a policy statement recognizing the protection of beneficial uses of water as a consideration equal in importance to the maintenance and enhancement of timber productivity;

2. rules regarding the placement and removal of debris in watercourses;

3. rules regarding the location of various roads and trails in relation to streams;

4. rules regarding the cutting of trees within the watercourse and lake protection zones;

5. requirements for mapping and classifying water bodies according to their beneficial uses;

6. rules regarding the width of watercourse and lake protection zones based on the classification of the waterbody and the slope of the surrounding land as well as information on the application of other BMPs; and

7. procedures for developing alternative watercourse and lake protection measures.[51]

One distinctive feature of the watercourse and lake protection rules for the Northern Forest District in California is a performance standard which states that:

> [d]uring timber operations, the timber operator shall not place, discharge, or dispose of in such a manner as to permit to pass into the water of this state, substances or materials, including, but not limited to, soil, silt, bark, slash, sawdust, or petroleum, in quantities deleterious to the beneficial uses of water.[52]

In addition, the State of California, through one of its regional water quality control boards, has adopted water quality standards for turbidity in northern California that are applicable to forestry activities.[53] These standards state that "[t]urbidity shall not be increased more than twenty percent above naturally occurring background levels," and that "[t]he suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause a nuisance or adversely affect beneficial uses."[54]

Even these relatively specific standards, however, pose problems in application due to a lack of internal consistency. For example, the performance standard *prohibits* discharges deleterious to beneficial uses (and supported by state WQS) while the prescriptive standard calls for *minimum* impacts from watercourse crossings and tractor roads.[55]

However, the California forest practice program has produced a number of desirable outcomes. Many Timber Harvest Plans (THPs) are modified as a result of the review process.[56] Preharvest inspections, thought to be the most important element in achieving compliance with the program, are performed by CDF for 80% of the THPs received.[57] CDF estimates that approximately 25% more land currently is reforested than would be expected without the program,[58] and CDF personnel believe that water quality is protected very well by the current system.[59] While the public and private costs of the program are high relative to the forest practice programs in other states, it is not thought to have reduced the level of investment by the timber industry in the state or to have contributed significantly to the cost of consumer products.[60]

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Lessons from the Nation's Most Stringent Forestry Program. In spite of, or perhaps because of, the fact that California's forest practice program is considered among the most advanced in the nation, many important problems have been identified with its forestry pollution control provisions. These problems generally concern the influence of politics in the state forest practices program, the role of the resource protection agencies (such as the State Water Resources Control Board and the Department of Fish and Game) in the California Department of Forestry (CDF) decisionmaking process, and the enforcement of important program requirements. In this sense, the problems associated with silvicultural controls are similar to those in agricultural situations. The problems pertain generally to: the dominance of agencies traditionally in charge of a land-based resource; a lack of involvement of water quality and fish and wildlife officials; and enforcement of existing water quality protection requirements. The problems described below apply generally to any state suffering significant water quality impacts from silviculture.[61]

Because of mistrust between industrial and environmental interests, it has not been possible to develop a state- or region-wide land management plan for nonfederal forests, similar to those required for National Forests by the National Forest Management Act.[62] Each THP is normally evaluated individually without regard to the cumulative impacts of total harvesting activities within a watershed, and the rules and regulations include no mechanism to address large-scale geographic considerations (*e.g.*, which areas in a region are suitable for particular kinds and levels of harvesting).[63]

While the State Water Control Board and CDF currently are attempting to develop a cumulative impact review capacity,[64] an ongoing data collection process is needed to determine the ecological conditions in sensitive areas possibly subject to harvest.[65] This is necessary for long-range planning purposes and to provide in-depth, long-term and large-scale information for use in THP reviews by the multi-disciplinary team.[66] This process also would assist in setting priorities for timber harvest plan review and enforcement.

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Officials in California point to the need to improve long-range planning, and propose to develop a computer database to record the conditions of the natural resources within a given area and to estimate the impacts of THPs and decisions affecting the forest.[67] The database would include the location and types of existing and potential beneficial uses, important habitat, sensitive terrain, timber production and other land use locations and impacts.[68]

California's program also is hampered by the limited authority of the State Water Resources Control Board (SWRCB), the Department of Fish and Game (DFG), regional water quality control boards and local governments to affect the final decisions regarding the approval of Timber Harvest Plans.[69] After the multi-agency review, these entities effectively are precluded from any formal process to evaluate and influence the final revisions made in the Timber Harvest Plan by CDF, as well as from formal review of the final approved plan, which ultimately is controlled by the Board of Forestry.[70] An effort currently is underway to give the heads of these agencies the right to appeal final plans. This would broaden scrutiny of the plans by both the resource protection agencies and the public.[71]

The performance standards mentioned above, along with the stated intent of the section of the rules addressing watercourses, need to be applied consistently to the final review and revision of THPs–not only when violations of specific prescriptive BMPs have been identified.[72] The standards should be implemented through appropriate water quality or biological parameters, or beneficial use designations, and extensive data collection and analysis.[73]

The use of variances in the California program also has been criticized. In one evaluation, alternative and "in lieu" practices allowed nearly 50% of the program standards applicable to watercourse and lake protection requirements to be altered.[74] Such provisions should be used only when the prescriptive standards are not feasible (but alternative measures will provide adequate protection) or when the standards will not provide adequate protection.[75] Explanations for alternative actions should provide enough detail and justification for plan reviewers to make an informed decision.[76]

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Plan developers and reviewers often either do not properly recognize or do not admit to the potential adverse effects that timber operations may have on off-site beneficial uses, particularly those impacts not explicitly stated in the rules and regulations.[77] This has led to inadequate protection in many cases.[78] For example, the parts of the THP that address resource protection issues often are vague and unsupported.[79] In many cases, information about the impacts of various harvesting activities on natural resources is not available to plan developers and reviewers.[80] In addition, increased efforts are needed to provide guidance, training and other education to private and public parties involved in the state forestry program.[81]

California's program also has had compliance problems due to inadequate implementation requirements, poorly worded regulations and inconsistent enforcement.[82] Compliance has been a very significant problem particularly because THPs often contain poorly written, vague and unenforceable provisions and because program enforcement is not effective.[83] Recommendations for improvement include better compliance monitoring[84] and enforcement options that include civil and administrative penalties, not just criminal charges.[85]

The problems associated with California's relatively stringent forest practices program indicate the kinds of issues that states should consider when developing their own silvicultural programs. As evidenced by California's experience, serious management problems (and resulting water quality impacts) can occur even in states with the most advanced forest practice programs.

Summary

Although the intensity of timber operations varies radically among and within states, certain components are needed in any program designed to ensure that sediment and herbicides do not damage the beneficial uses of state waters. Long-range timber harvest planning is needed to account for both short-term and cumulative impacts of timbering, as well as to provide a rational basis for reviewing the adequacy of water quality and other resource protection measures. Performance standards should be used, along with prescriptive BMPs, to ensure that compliance

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with water quality standards is incorporated into individual timbering proposals. In addition to these general program needs, specific recommendations for state programs to control water pollution from timber operations are given at the end of this chapter.

Mining Water Pollution Control Programs

Poison runoff can be generated from most of the operations characteristic of mining activities, including exploration, development, extraction, transport, reclamation, product storage and waste disposal.[86] Pollution from these activities can result from a variety of mining settings: active and abandoned; coal and noncoal; and surface and underground.

Pollution from mining activities includes sediment, metals, acids, heat, and stream and habitat modifications.[87] Surface and groundwater are affected through suspended and dissolved solids that are transported to surface waters by direct surface runoff, and by infiltration and subsurface flow (baseflow).[88]

At the outset, it should be clear that many pollutant discharges from mining operations are from *point* sources. Clearly, these include piped discharges from milling, processing dewatering, and other operations. But any other contaminated waters on mining sites that are discharged to surface water from discrete conveyances constitute point source discharges.[89] This includes discharges from impoundments, sumps, channels, ditches and gullies.[90]

The implications of this legal distinction are very important. Mine operators can be required to control runoff by building sedimentation ponds, diversion ditches and similar controls. By diverting as much water as possible around active mining areas, the amount of contaminated runoff can be minimized. Any contaminated water that is collected in control facilities (which are regulated as point sources) is more easily subject to conventional water treatment methods. And any discharge to surface waters requires an NPDES permit.

In addition to point source controls administered under the CWA, the Surface Mining Control and Reclamation Act of 1977[91] provides a system for addressing environmental (including water quality) problems resulting from surface and underground

Both above- and below-ground mining cause water pollution in the form of sediment, channel alteration and acid drainage.

coal mining on private, state and federal lands. In many ways, this program (described below) provides a useful model for programs applicable to water pollution from noncoal mining.

The Bureau of Land Management (BLM) is charged under the Federal Land Policy and Management Act of 1976[92] with regulating the environmental effects of noncoal mining[93] on lands under BLM control. However, states are not ensured that such regulation will result in adequate control of poison runoff.[94]

States should ensure that federal programs are effective in controlling pollution from coal mining on all lands, and noncoal mining on federal lands. But states also need to address water quality problems caused by noncoal mining on state and private lands, which is not governed by any specific federal statute or program. While some technical research is available relevant to the environmental quality aspects of mining and mine reclamation,[95] there has been little analysis of how to manage effective controls on noncoal mining.

During the CWA § 208 planning process, however, EPA prepared several manuals that, among other things, describe the management and programmatic aspects of a mining-related nonpoint source pollution control program.[96] These documents are somewhat dated and were never used by EPA to enforce state controls. But they provide a useful framework for assessing and structuring mining-related efforts to control poison runoff.[97]

A Regulatory Process for Attaining Beneficial Uses

Like programs to control other kinds of poison runoff, mining controls (especially those applicable to abandoned or inactive mines) often may be constrained by institutional rather than technical barriers.[98] Common characteristics of EPA recommendations for controlling mining-generated pollution include: a prominent role for the state water management agency;[99] tying general programs and individual controls to the achievement of beneficial uses of water;[100] and integrating mining nonpoint source programs with water quality management and pollution control within the context of a watershed-wide pollution control plan.[101]

An initial (and essential) step is to revise water quality standards so that beneficial uses of water are protected from all mine-related pollutants.[102] Once this task is complete, specific programs can be developed to achieve these standards. The primary components of an effective mining-related program are also described in EPA guidance. These include:

1. a regulatory process to identify and require the use of BMPs to control pollution from all sources (including agency authority to modify all aspects of the mining operation with potential water quality impacts);

2. provisions to ensure adequate pollution control during all post- and inactive-mining periods;[103]

3. provisions to prevent and control surface and groundwater pollution, sedimentation, thermal pollution, dust sources and hydrologic disturbances;

4. a process to examine new control practices and to require their prompt adoption when practicable;

5. provisions to designate areas such as riparian or other sensitive areas intimately tied to water quality as unsuitable for mining operations or for denying permits (including the right of local zoning actions after other government permits have been obtained);[104]

6. penalties stringent enough to discourage violations and that make mine operators responsible for correcting adverse water quality impacts (whether willful, negligent or accidental);

7. as part of the permit approval procedure, a water quality management process to evaluate individual mining operations in relation to existing and future sources of water pollution (both point and diffuse sources); and

8. specific provisions to address the water pollution potential of roads, sediment basins, and other structures remaining after the mine-related activity is completed (including maintenance requirements).[105]

In addition to these management needs, an effective bonding requirement is necessary to ensure that sufficient funds are available to reclaim mine sites in cases where responsible parties are unwilling or unable to carry out reclamation requirements. Funds also must be available for the long-term maintenance of areas associated with the mining operation (such as waste piles) that have the potential to generate significant water pollution *after* normal closure activities.

Abandoned Mine Pollution Control Programs. Abandoned mine sites often can be the most significant contributors of mining-related pollution. For this reason, an effective program for abating the poison runoff from abandoned mines is essential to meeting water quality goals.[106]

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Sources of pollution from abandoned mines include abandoned surface and underground waste and tailings piles, roads, storage and processing areas, already-polluted aquifers, and stream and lake sediments. From a purely technical perspective, these pollution sources are similar to the ones at active mining sites. Therefore, most of the physical pollution controls at active mining operations also apply to abandoned mines. An important initial step in addressing abandoned mines is to ensure that programs applicable to currently operating mines require adequate closure and post-closure activities so that additional water quality problems from abandoned sources are avoided.

From an institutional perspective, abandoned mines pose many challenges. Eliminating pollution from abandoned mines may be extremely costly. Where responsible parties can be identified, steps must be taken to force these parties to abate the ongoing pollution through legal action, if necessary. Where responsible parties cannot be identified or cannot abate the pollution, for example, due to insolvency, a more challenging problem exists. To address the water quality problems at orphaned mines requires the establishment of state funding mechanisms and site reclamation planning procedures. Decisions must be made as to how site owners, industry or taxpayers will share abatement costs.[107] Abatement principles and techniques need to be established, as well as strategies for implementation.[108] Individual abatement plans should be developed and implemented after priorities and schedules have been established for addressing specific watersheds and specific sites within watersheds.[109] Priority should be based on the levels and types of both point and nonpoint sources within the watershed, current and potential water quality, and other factors.[110] Finally, once abatement plans are being implemented, monitoring should be implemented to evaluate resulting water quality improvement.[111] Ways to address these issues are suggested by the programs described below.

SMCRA: A Model for State Mining Pollution Control Programs

Programs designed to address mine-related pollution could take many forms. SMCRA, however, provides a general model for controlling poison runoff in both coal and noncoal mining situations. Although many of the specific provisions of SMCRA have been described as unsuited to the control of very large or very small noncoal mining operations,[112] the SMCRA framework for collecting data, reviewing permit applications, establishing performance standards and enforcing program requirements is relevant to mining in general.[113]

Water quality is protected under SMCRA through a series of requirements contained in Titles IV, V and VI of the Act. These requirements address, respectively, reclamation of abandoned coal mine sites, regulation of active coal mining operations and prevention of coal mining in sensitive areas.[114]

SMCRA prohibits the surface mining of coal without a permit. To obtain a permit, mine operators must develop detailed plans to control the environmental impacts of the entire mining operation (pre-mining activities, the actual mining operation and reclaiming the mined land).[115] The permit must incorporate a number of specific environmental protection requirements, including measures to protect water quality.[116]

Water quality is protected during mining operations through a complex series of performance standards defined in the SMCRA legislation and specified in the attendant regulations. The regulations establish a comprehensive system of control designed to prevent pollutants generated in the mining process from reaching water sources. Basically, this system provides a hierarchy of controls ranging from the most to the least desirable. First, water pollution is *prevented* through the diversion of surface runoff around potentially contaminated sites such as active mining areas, roads and coal storage and spoil piles.[117] For surface runoff that does cross the mining areas, contamination is *minimized* by requiring stabilization, regrading and reclamation of the site during the operation as well as after all mining activity has ceased.[118] Finally, any surface water diverted through discrete conveyances or that otherwise becomes polluted is *collected* and *treated* so that any resulting discharges do not cause adverse water quality impacts.[119] In addition to the requirements SMCRA imposes on active mining operations, the law also provides for the establishment and maintenance of a fund to

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reclaim abandoned mine sites by, among other things, restoring the area's natural vegetative cover.[120]

Many of the environmental protection requirements of SMCRA refer explicitly to protecting water quality, often through the use of performance standards. For instance, there is a requirement that water pollution be prevented during certain land disturbing activities.[121] All surface areas, including spoil piles, must be stabilized and protected to control water pollution.[122] Permanent water impoundments must be consistent with existing water quality standards.[123] Stream hydrology and water quality must be maintained by controlling acid and toxic mine drainage.[124] Sediment loads must be minimized using "best technology currently available" and, in any event, be in amounts below "requirements set by applicable State or Federal law."[125] Many other provisions of SMCRA make it clear that compliance with state water quality goals and objectives is an important part of the overall program.

Permit applicants and the regulatory authority must provide notice of the plans to begin mining, and any affected parties (including individuals and state and local agencies) are entitled to an informal conference to discuss objections to these plans.[126] After the regulatory authority has issued a decision regarding the permit, those affected parties objecting to the decision (or some part of the decision) can request a formal adjudicatory hearing leading to a written decision that describes the final permit conditions.[127] (An appeals process also is provided.)[128]

SMCRA also establishes requirements that states must follow for federally-approved abandoned mine reclamation plans.[129] A state reclamation plan must identify areas to be reclaimed, the criteria for establishing priorities among reclamation projects, legal authority and program structure.[130] Water pollution control is one of the goals of the reclamation program.

A Federal Abandoned Mine Reclamation Fund is established to disburse money to approved state reclamation programs.[131] The fund can be used for a variety of reclamation purposes, including the purchase of land from uncooperative landowners.[132] The fund is financed through fees charged to active coal mine operators for each ton of coal mined (a variable rate is provided for coal extracted from surface and underground mines).[133]

In addition, SMCRA provides for the designation of land as unsuitable for coal mining.[134] A person who may be adversely affected can petition the state regulatory authority "to have an area designated as unsuitable for surface coal mining regulations..."[135] After a public hearing, a written decision must be furnished by the state regarding the status of the land in question.[136] A state must designate lands as unsuitable for all or certain types of coal mining if it determines that adequate reclamation of the site is not "technologically or economically feasible."[137] Operations that are incompatible with existing state or local land use plans or that could significantly damage "aesthetic values and natural systems" also can be prevented, as can those that might "result in a substantial loss or reduction of long-range productivity of water supply" (including aquifer recharge areas and land overlying aquifers).[138] The entire process that must be in place to designate lands as unsuitable for coal mining must "be integrated as closely as possible with present and future land use planning and regulation processes at the federal, state and local levels."[139]

Finally, an important component of SMCRA is its detailed, structured enforcement program. Most important, performance bonds must be posted before mining begins to ensure that funds are available to carry out any reclamation activities specified in the permit but not carried out by the mine operator.[140] Bonds are not released until the reclamation covered by the bonds is performed, and are forfeited for noncompliance. SMCRA also has requirements for inspections and monitoring to determine compliance with permit conditions,[141] substantial penalties for violations of permit requirements[142] and citizen enforcement of the requirements of the SMCRA program.[143]

Improving SMCRA Effectiveness. A number of problems have been identified with both state and federal implementation of SMCRA.[144] In implementing SMCRA itself, and in adapting SMCRA principles to noncoal mining, state and local water quality officials should correct these problems.

Water quality protection under SMCRA (and SMCRA-based programs applicable to noncoal mining) depends on strict compliance with various standards and requirements designed to control runoff and leaching.[145] Unfortunately, compliance and enforcement activities under SMCRA have been inadequate.[146]

Poor enforcement can affect compliance with performance standards, specific control techniques and data collection.[147] The size and complexity of the operation and the political influence of mining interests both can contribute to lax enforcement.[148] The permitting process and the designation of areas as unsuitable for mining also are sensitive to political influence.

Because state SMCRA programs cannot be approved unless they meet the minimum requirements set by federal law, there is little substantive difference in the relevant statutes and regulations in most states. Where there is a difference, it is usually in the number of positions and person-hours, and the level of funding devoted to carrying out a given task—such as permit reviews, site inspections and enforcement proceedings.[149] Since no two states have the same management requirements in these areas, each must assess its own needs and ensure that adequate resources are provided.

In the noncoal mining area, however, there is a wide difference in the stringency with which environmental amenities are protected at both the state and local levels.[150] While there is no current and comprehensive inventory, there seems generally to be a lack of programs that can serve as models for effective control of particular types of noncoal mining activities.[151] One exception is the program recently established in Wisconsin to control metallic mining and mine reclamation impacts.

Wisconsin Statutes Controlling Metallic Minerals Mining

Like SMCRA, Wisconsin's program controls environmental impacts through permitting, data collection, operations, financial responsibility and reclamation.[152] In fact, many aspects of Wisconsin's metallic minerals program go beyond those imposed under SMCRA. All metallic mineral mining is subject to the program.[153] Notification of intent to collect data (for purposes of obtaining a permit to mine) must be submitted to the Department of Natural Resources (DNR) along with background information including a preliminary project description and a future data collection quality assurance program.[154]

After the notice is submitted to DNR, a public hearing must be held to solicit comments (including those of the affected community) concerning potential environmental impacts, data collection needs, necessary pollution controls, and other factors.[155] After the hearing, DNR must inform the potential applicant of the specific data collection requirements (including methodology, type and amount of information and quality assurance measures) needed for submission of a formal permit application and environmental impact report, if required.[156]

Affected localities and the general public must have an opportunity to be present at a public hearing on the permit application (held by DNR), and must be provided with copies of the completed application.[157] A fee of $10,000 is charged to cover the cost of evaluating the application.[158]

As under SMCRA, a mining plan must be included in the application. The plan must detail the techniques for erosion prevention and drainage control (including a water management plan showing source, flow paths and rates, storage volumes and release points) as well as other water collection, treatment and discharge plans.[159] Minimum standards must be met to ensure that surface and groundwater is not contaminated through improper grading, backfilling and stabilization of the excavation, or inadequate diversion and drainage of water.[160]

The DNR must deny the mining permit if the operation would not comply with applicable ground and surface water laws and rules (including local zoning ordinances).[161] DNR also must deny permits if the site is deemed unsuitable for surface mining.[162]

Special requirements exist for the protection of wetlands. Generally, the site chosen for mining must constitute the alternative that causes the least overall adverse environmental impact and preferably avoids the use of any wetlands (but in any case minimizes their use).[163] Location criteria are used to keep mining operations out of floodplains, wetlands and areas that would result in violations of federal and state law.[164] Operations must be at least 1,000 feet from lakes and ponds and 300 feet from rivers and streams.[165]

A reclamation plan, describing how the mine site will be reclaimed and monitored to prevent pollution of ground and

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surface waters, also is required.[166] Once a permit is issued (but before the mining operation begins) the mine operator must file with DNR a bond or other security equal in amount to the costs of fulfilling the reclamation plan.[167]

Monitoring, inspection and enforcement provisions require the mine operator to assess environmental impacts and allow DNR to make unannounced state inspections[168] and to issue stop work orders.[169] DNR must review the mining and reclamation plans annually and require a resubmission of the mining permit as necessary to reflect changing environmental conditions or knowledge concerning the adequacy of the original plans.[170]

Other state regulations call for the development and implementation of plans to dispose of mining waste.[171] Waste disposal sites must be "located, designed, constructed and operated in such a manner so as to ... [c]omply with water quality standards."[172]

As with mining and reclamation, waste disposal sites require an operating license approved by DNR.[173] Significant data collection activities are required when preparing an application for a license.[174] A detailed feasibility report and plan of operations must be prepared before a waste site can be operated.[175] Consideration of local and regional land use and zoning issues is a part of this process.[176]

A set of groundwater standards governs the requirements for containing any harmful quantities of contaminated water on the waste site. For substances that do not have specific standards, the site cannot have a "substantial deleterious impact on a current beneficial use or on a significant future beneficial use."[177]

The regulations also provide for extensive and specific site planning and facility design and operation requirements.[178] Like the regulations for mining and reclamation, requirements for waste sites provide for inspections, monitoring, and financial responsibility.[179] In addition, a waste management fund is established, through fees on each ton of mining waste deposited in an approved site, to provide funds for the long term maintenance of approved sites.[180]

Summary

Mining is an intensive land use with the potential to create severe adverse water quality impacts. In fact, in some states with a history of widespread mining activities, such as Montana and Pennsylvania, mining-related pollution is among the major causes of water quality degradation in the state.[181] Unlike pollution from agricultural, urban or silvicultural sources, pollution from mining stems from relatively few individual sources. Therefore, water quality impacts from mining can be localized but very severe.

However, in some ways the localized nature of mining operations makes them easier to control than more dispersed sources, and programs are available to address poison runoff from mines. An essential component of an effective program is the political willingness to enforce water quality protection measures by ensuring that necessary human and financial resources are available and that available controls are implemented. The basic elements of an effective program to control poison runoff from mining activities are summarized at the conclusion of the chapter.

Rangeland Pollution Control Programs

Pollution from livestock grazing in rangelands is a major problem primarily in western states.[182] However, protecting water quality by limiting damage to riparian areas due to direct contact by livestock also is an important consideration in managing pasturelands[183] in eastern states. Of course, eastern and western livestock and grazing control programs may differ substantially.

Livestock grazing can affect water quality in a number of ways. Overgrazing can compact soils, decreasing water infiltration, thereby reducing streamflow during certain periods of the year.[184] Livestock grazing can increase runoff and erosion at other times so as to elevate sediment loadings and flood damage.[185] Grazing too close to the stream can destroy important riparian vegetation (thereby causing water temperature increases and unstable streambanks and flow volumes) and can introduce fecal bacteria, nutrients and sediments directly into the waterbody.[186]

Especially in the west, a large amount of grazing occurs on federal lands. But nonfederal entities (state, local and private)

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Improper livestock grazing can reduce groundcover and lead to sediment deposition and streambank destruction.

own the majority of the rangeland in the United States.[187] Therefore, it is important to assure adequate rangeland controls independent of land ownership. States also must coordinate the implementation of these controls. Within a given watershed, controls should be applied to a sufficient number of owners in a timely manner so that any potential benefits gained by good management in one ownership class are not negated by poor management or delayed implementation in another.

As discussed in Chapter Three, the basic controls needed in a pollution control program for unconfined livestock grazing (in either rangeland or pastureland settings) are fairly easy to categorize and understand generally. These include: the use of effective erosion controls; controlling livestock densities in particular areas; limiting access to riparian areas and streams; dispersing livestock facilities[188] to reduce manure accumulation, soil compaction, and other effects, and maintaining good forage and ground cover. Ensuring that such measures are taken and that streams are protected or improved to the point of achieving compliance with state water quality standards is complex and challenging.

Effective Programs for Control of Grazing-Related Water Pollution

Managing poison runoff from rangelands involves the application and coordination of controls on both public and private lands.[189] Current federal rangeland management practices do not ensure adequate water quality protection.[190] Moreover, the use of public versus private rangelands is so interrelated that enhancing or degrading one can cause similar effects on the other.[191] Along with state and federal involvement, it is also important that localities and private individuals participate in the development and implementation of rangeland programs.[192]

Federal rangeland must be managed for multiple uses, including not only economic uses such as grazing, but resource enhancement uses such as watershed and natural habitat protection.[193] This is not necessarily the case for private lands. However, the application of state water quality standards to waters running through both public[194] and private rangeland[195] means that, at the very least, nonfederal rangeland must be managed for water quality protection in addition to any other uses.[196]

Rangeland management needs to address both riparian and upland areas in order to protect water quality.[197] Water quality protection and restoration efforts must go beyond the stream and riparian area and take into account the carrying capacity[198] of particular range areas.[199] State officials need to assure that plans are developed and implemented to control the timing, location and intensity of grazing in a manner that is compatible with water quality protection objectives.[200] Structural controls, such as fencing, dams and channel modifications, should not replace sound rangeland management designed to prevent impacts to water quality and riparian habitat.[201] Such structural controls should only be used to supplement sound management in areas where past practices have caused acute problems and where habitat *restoration* is required.

While controls applied in particular rangeland settings may differ according to the owner and the ownership class, the general methods for maintaining range productivity and protecting stream quality are more or less universal. Broadly speaking, range improvements and land treatments are a primary method of improving range productivity and associated water quality by ensuring that the carrying capacity of the land is not exceeded by grazing activities. Their purpose is "to make the range more productive or to restore it to some real or imagined ecological state that has occurred in the past."[202] Although land treatments encompass methods that work both with and against the natural processes of the rangeland ecosystem, those methods that complement the ecosystem are most likely to contribute to the attainment of multiple use goals that include water quality protection.[203]

Depending on the specific purpose of managing the rangeland, land treatments and improvements can include a variety of activities. The activities can be characterized as: adjusting animal numbers; controlling animal use; and reseeding and rehabilitation.[204] The first two of these can be characterized more as management prescriptions while the second two involve more mechanical approaches. Controlling animal numbers and their use of the range can be accomplished through a variety of methods ranging from the simple (herding, placement of salt, development of new water holes, etc.) to the complex (limiting animal densities in particular pastures and areas, rotating the use of fields by season or intensity of use).[205]

Some of the more complex approaches, called *planned grazing systems,* divide the rangelands into similar units which are then rotated, deferred and retired in some combination based on an understanding of the unique soils, vegetation and ecology of the site.[206] Productivity also can be enhanced through the control of plants that have artificially displaced those that could improve forage in desired grazing areas.[207] Preferably, grazing areas should be managed for diverse, native plant species. Around the riparian area itself, fences, planned crossings and other structural measures can be used to supplement broader management prescriptions, especially in areas with severely degraded stream habitats.[208]

Land Use Planning for Pollution Control in the Rangeland Setting. All of the management needs mentioned above indicate that control programs for rangeland, as for other sources of poison runoff, require sound land use planning.[209] More specifically, the mix of federal, state and private lands and objectives tends to require a coordinated "resource management" approach among all governmental levels and interested parties similar to that described for silvicultural and mining programs.[210]

Rangeland controls in individual areas should be developed based on an extensive land use and water quality inventory and with the direct involvement of an interdisciplinary resource management team.[211] As with all other source categories, the establishment of water quality standards appropriate to range environments is a necessary first step in assessing problems and carrying out water quality protection measures.[212]

A classification scheme for ranking the existing and potential quality of riparian areas also is needed to set priorities for the implementation of controls and to select the appropriate BMPs.[213] This scheme should take into account the impacts on water quality of other activities in the surrounding watershed.[214]

In order to determine range management (including water quality protection) controls, it probably will be necessary to evaluate each grazing area with similar flora, soils, carrying capacity, and other factors for the specific needs in that region.[215] Controls on private lands are likely to differ from those on public lands because of the multiple use planning requirements for federal lands, although state regulation may be needed to ensure that private land managers do not damage public resources.[216] For example, the use of differential grazing fees[217] for upland and riparian areas could be useful on public rangelands but can not readily be applied to private lands.

Nevertheless, water quality improvement on nonfederal lands requires grazing management programs similar to those needed on federal lands. The Bureau of Land Management (BLM) is responsible for the management of the majority of the 250 million acres of federally-owned rangeland.[218]

In addition to the land use plans required of BLM,[219] the agency's regional and state offices also prepare individual permits and management plans that apply to particular rangeland areas (divided into 31,000 grazing allotments averaging 8,500 acres).[220] Permits specify the conditions (based on local or regional rangeland conditions) under which individual users of the public rangeland can graze cattle and sheep (*e.g.*, number and type of livestock, time and duration of use).[221] Management Plans that describe how grazing will be conducted in order to meet sustained yield and multiple use goals and special conditions established to improve rangeland conditions are prepared on many allotments.[222]

The BLM also prepares Allotment Management Plans (AMPs) to manage individual rangeland areas on federal lands.[223] These plans apparently have not sufficed to protect water quality on BLM lands.[224] However, if implemented with increased focus on water quality, AMPs could furnish a useful framework for water quality planning and riparian protection in state and private rangeland settings. These plans consist of the following:

1. an analysis of the present resource value and uses, including problems and conflicts;

2. objectives to be achieved which are specific and quantitative and which resolve or mitigate resource problems and conflicts;

3. a grazing system which will achieve these objectives;

4. range improvements to implement the grazing plan; and

5. monitoring and evaluation activities to determine whether or not objectives are being met.[225]

Under the leadership of state water quality and rangeland experts, comprehensive water quality and riparian enhancement plans could be established in partnership with private land owners and with assistance from USDA, BLM, U.S. Fish and Wildlife, and other federal agencies.

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A Dearth of Model State Rangeland Management Programs

Unlike programs to control other types of poison runoff, NRDC failed to identify existing state activities that demonstrate innovative control of grazing-related pollution on nonfederal rangelands. Current efforts seem to focus on management activities on federal land, and many states have developed Memoranda of Understanding (MOU) with the Bureau of Land Management (BLM) providing for the management of public rangeland to protect water quality.

For example, Oregon (considered by many to be a leader in rangeland management) negotiated an MOU with BLM in 1978 that would allow the state Department of Environmental Quality to submit lists of priority waterbodies for special attention by BLM officials developing rangeland management plans.[226] However, the MOU is considered outdated and is being renegotiated.[227]

The BLM also is working with Oregon and Washington State resource management agencies on the development of a riparian enhancement plan to improve over 650 miles of riparian areas located on public lands through the development of site-specific riparian area improvement programs.[228] One of the goals of the plan is to "improve water quality to meet or exceed state water quality standards."[229]

Special treatments in riparian zones will be implemented along with controls applicable to upland areas.[230] The joint federal, state and local program will involve extensive data collection and monitoring to allow priority areas to be addressed ahead of others and to ensure that desired changes in water quality are achieved.

Oregon has established a cooperative network of state and federal agencies to assist in voluntary efforts by land owners to develop general grazing management plans.[231] However, overall little, if any, action is being taken systematically to address pollution from grazing on nonfederal lands in Oregon.[232] Apparently, this could change with the development of the state's Nonpoint Source Management Program under CWA § 319.[233]

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Summary

A lack of existing programs does not mean solutions to rangeland water pollution are not possible. And if solutions are available, political willingness to implement controls may be a more crucial issue.[234] Using the resource management concepts that have been developed (if not put into practice) in federal grazing programs, state and local officials could take into account site specific factors and could develop the controls needed to improve upland range conditions, riparian areas and, ultimately, the quality of state waters. Recognizing that such controls would apply to private, and not public lands, states would have to be careful to limit management prescriptions to those needed to achieve the water quality goals required under the CWA. In addition, states also need to ensure adequate oversight of BLM and USFS rangeland management activities since there is no assurance that federal officials will focus their planning efforts on the achievement of state water quality goals. Specific recommendations for controlling the water pollution caused by grazing are provided below.

Conclusions and Recommendations

This chapter addresses some of the requirements for controlling three types of poison runoff. Many characteristics are common to each type of pollution and, in many cases, each type of management program. The variety of factors affecting the problem of poison runoff in these three settings dictates that emphasis move away from a strict dependence on BMPs to address water quality issues, and towards the use of sophisticated resource management and land use plans. Interspersed land ownership patterns make close coordination of many federal, state and local control programs essential in order to address all significant problems and prevent controls used by one ownership class from being wasted because of inaction by another.

As with all types of poison runoff controls, a strong link must be forged between programs and water quality standards in order to provide a rationale by which states can gauge program performance. The following recommendations are provided to control the poison runoff associated with three important source categories - silviculture, mining and grazing.

Silvicultural Controls.[235]

1. A clear identifiable performance standard, based on compliance with state water quality standards, should be established and enforced (through the inspection process). The performance standard should supplement minimum technology-based standards.
   a. The relevant water quality standards should include, in addition to specific numeric criteria, an antidegradation policy and enforceable policies and guidelines for protecting beneficial uses, fish and wildlife habitat and sensitive stream parameters.
   b. Compliance with water quality standards should be assured not only through prescribed operational practices, but by controlling the location, timing and intensity of harvest, road building, and other operations. Where necessary to assure compliance with water quality standards, timber harvesting should be prohibited.

2. A long-term planning effort should be initiated to classify and estimate the conditions of natural resources and associated forestry impacts. It should be used to limit cumulative impacts and prevent water quality impacts on sensitive land areas and on pristine, or otherwise highly valuable, water resources.
   a. Watershed management plans offer the most effective way to control the long term aspects of silvicultural pollution and should be developed by regulatory agencies and industry so that entire hydrologic areas can be considered (including the habitat and water quality aspects of the entire area).
   b. State forestry and water quality officials should require that federal plans for National Forests conform to the water quality protection needs of the state.

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3. A set of guidelines for preparing individual timber harvest proposals should be developed and enforced to ensure that maps, descriptions, explanations, justifications and other information are adequate to allow the plan to be reviewed from the standpoint of environmental protection; plans should include, at a minimum, descriptions of the:
   a. site;
   b. proposed activities;
   c. means of compliance with all design and performance standards; and
   d. special area protections.

4. Silvicultural operations should be regulated by multidisciplinary teams, including specialists in silviculture, water quality, and fish and wildlife. The roles, responsibilities and authorities of each party in the timber proposal review process should be clear and should include:
   a. specific decisionmaking roles and responsibilities based on expertise, and a formal process for negotiating and appealing disagreements that arise in the timber plan review process; and
   b. adequate funding, staffing and training for each agency involved, and consistent agency procedures in different regions of the state to disperse and collect data and resolve conflicts more easily. Funding should be ensured through permit fees or timber harvest assessments.

5. After forest plans are approved, adequate inspection and enforcement are necessary to ensure compliance. Enforcement and inspection requirements include the following:
   a. adequate personnel;
   b. administrative, civil, and criminal penalties and stop work orders;
   c. frequent, unannounced inspections;
   d. involvement of multiple agencies in the inspection process;

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e. agencies represented in the multiagency review team periodically must monitor implementation of timber plans and specific BMPs, to ensure that inspection procedures protect relevant resources adequately;
f. before a timber operation begins, the responsible private forester must meet with the timber operator at the site to discuss the timber plan; the timber operator should then verify, in writing, that he understands the plan and agrees to follow its provisions; and
g. timber operators must be required to perform in-house monitoring and supervision to ensure that protection measures are followed and data from this process can be retrieved by forestry personnel for use in planning and feedback activities.

Mining Controls.

6. Pollution controls should address all sources of mining runoff, including active and abandoned coal and noncoal mines, both above and below the ground.

7. The state water quality protection authority should participate in the development, implementation and enforcement of mining controls.

8. To the extent possible, the control hierarchy established in SMCRA should be used to address all mining-related pollution by requiring mine operators to:
   a. prevent contamination by diverting as much surface water as possible around active operations;
   b. minimize contamination of surface water that traverses active operations through contemporaneous stabilization and reclamation;
   c. collect and treat any contaminated water; and
   d. stabilize and reclaim all areas after mining ends.

9. In addition to specific design and operation standards, mining permit approval should be conditioned on compliance with water quality standards, after

consideration of both point and diffuse discharges from the operation. The location, timing, and intensity of mining should be controlled where necessary to achieve this goal.

10. Sites should be designated as unsuitable for mining where water quality standards or other minimum environmental requirements cannot be met.

11. Permit requirements and other program requirements should be enforced through:
    a. regular, detailed inspections, including unannounced inspections;
    b. compliance orders where violations are found;
    c. stop work orders, fines, and other enforcement actions where needed to achieve compliance; and
    d. performance bonds of adequate size to ensure proper reclamation, with bond release withheld until adequate, permanent stabilization and reclamation is completed.

12. An abandoned mine reclamation fund and program should be established.
    a. Where responsible parties are known (and are solvent), legal action should be take to require cleanup;
    b. Where responsible parties are unknown or are insolvent, cleanup of abandoned mines should be funded through permit assessments and tonnage fees from active mines;
    c. An abandoned mine fund should be used to reclaim mines in order of environmental priority, based on water quality, public safety and other factors.

13. Since state officials cannot assume that the control of mining on federal lands by the BLM and USFS will lead to compliance with state water standards, necessary state controls on federal lands should be achieved through the development and enforcement of detailed management agreements or other enforceable methods.

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Grazing Controls.

14. Programs to protect water quality in rangeland settings should take place in the context of a comprehensive, interdisciplinary resource management plan that integrates controls on both federal and nonfederal lands.
    a. State water quality officials should carefully review federal grazing permits and management plans for individual watersheds to ensure that adequate measures are being taken to maintain or improve water quality on federal rangeland.

15. Within this overall plan, subplans should be prepared and coordinated to achieve water quality standards within individual watersheds.

16. Management plans for grazing lands should protect water quality and overall habitat and productivity by:
    a. controlling livestock densities;
    b. controlling livestock location, especially access to riparian areas and water bodies; and
    c. ensuring adequate forage and ground cover, with diverse, native plant species wherever possible.

17. Structural and instream controls, such as fencing and controlled stream crossings, should be used for addressing acute water quality problems, but preference should be given to sound land use and management requirements.

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Notes - Chapter Five

1. Together, programs to control poison runoff from urban and agricultural settings typically involve a variety of activities, including educational and research activities, regulatory programs and financial incentives that are applicable statewide through the involvement of a plethora of state and local agencies. In contrast, other nonpoint sources often are not controlled that way. For example, the federal Surface Mining Control and Reclamation Act (SMCRA), while a very detailed regulatory program, does not contain a mass of diverse, loosely coordinated program approaches; applies to a relatively well-defined (both geographically and substantively) set of activities; and is usually self-contained within a single agency of the state government.

2. The U.S. Forest Service, the Bureau of Land Management and other federal agencies collectively own 39% of all the forested land in the nation (72% of western forest lands are in federal ownership). U.S. Department of Agriculture, *An Assessment of the Forest and Range Land Situation in the United States* (Forest Resource Report No. 22), October 1981, at xiii, 15-16.

3. Both the Forest Service and the Bureau of Land Management are required by the Clean Water Act and the National Forest Management Act to comply with state water quality standards. *See* 33 U.S.C. § 1323(a); 43 U.S.C. § 1712(c)(8); *see also* Exec. Order No. 12,088, 3 CFR § 243 (1979), *reprinted in* 42 U.S.C.A. § 4321, app. at 172-174 (1988).

4. *See generally* Henly, Russell K. and Paul V. Ellefson, *State Forest Practice Regulations in the U.S.: Administration, Costs, and Accomplishment,* (Bulletin AD-SB-3011), University of Minnesota, Agricultural Experiment Station, 1986; *Management Agency Agreement Between the State Water Resources Control Board, State of California and the Forest Service, United States Department of Agriculture,* February 26, 1981 (hereinafter cited as MAA-USFS); *Management Agency Agreement Between the Water Resources Control Board, the Board of Forestry, and the Department of Forestry and Fire Protection, State of California,* revised December 11, 1987 (hereinafter cited as MAA-California); Idaho Department of Health and Welfare, *Forest Practices Water Quality Management Plan–State of Idaho,* January, 1988.

5. *See generally* U.S. EPA Region X, *Planned and Actual Impacts on Fish and Water Quality in Three National Forests in Northern Idaho,* November, 1987 (hereinafter cited as *Impacts on Fish and Water*); Anderson, H. Michael, "Water Quality Planning for the National Forests," 17 *Envtl. Law* 591-641 (1987); Anderson, H. Michael, and Craig Gehrke, *National Forests: Policies for the Future–Water Quality and Timber Management* (Volume 1), The Wilderness Society, Washington, D.C., August, 1988.

The CWA requires federal land management activities (including those in National Forests) to comply with state water quality standards. The National Forest Management Act (NFMA) provides the basic framework under which most USFS NPS pollution control activities are conducted. The NFMA requires that timber can only be harvested from a National Forest when (among other things):

1. soil, slope, or other watershed conditions will not be irreversibly damaged;
2. protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperature, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat.

16 U.S.C. § 1604 (g)(3)(E).

These water quality protection measures are most directly addressed through the development, review and implementation of regional guides and forest plans. Regional guides establish tentative objectives for individual National Forests and the management standards for all the forests in a particular region. 36 CFR § 219.4(b)(2-3); Wilderness Society *et al.*, *National Forest Planning–A Conservationists Guide* (2nd ed.), 1983, at 17-18. Forest plans constitute the specific goals and management activities (including water quality protection activities) for each national forest over a particular time period. Final forest plans are developed through an exhaustive 10 step process including the identification of issues and concerns, development and evaluation of management alternatives, and selection and monitoring of the preferred alternative. Wilderness Society *et al.*, 1983, at 18-20.

6. Anderson and Gehrke, 1988, *supra* note 5, at 15-20. The USFS has resisted the adoption of strict state controls on forestry operations on federal lands. Specifically, the USFS has been reluctant to accept compliance with state water quality standards as a strict condition on forest plans and management procedures. *See Northwest Indian Cemetery Protection Association v. Peterson*, 565 F. Supp. 586, 604-605 (N.D. Cal. 1983), *aff'd*, 764 F.2d 581 (9th Cir. 1985), *reh'g granted, aff'd on reh'g*, 795 F.2d 688 (9th Cir. 1986).

7. *See generally* Henley and Ellefson, 1986, *supra* note 4; MAA-USFS, 1981, *supra* note 4; MAA-California, 1987, *supra* note 4; Idaho Department of Health and Welfare, 1988, *supra* note 4; Idaho Department of Health and Welfare, *Idaho Water Quality Status Report and Nonpoint Source Assessment–1988*, May, 1988; Montana Department of Health and Environmental Science, *Nonpoint Sources of Water Pollution in Montana* (draft), May, 1988.

8. Henly and Ellefson, 1986, *supra* note 4, at 8.

9. *Id.*

10. *Id.* at 10.

11. *See, e.g.*, Idaho Department of Health and Welfare, 1988, *supra* note 4, at 117-133; *see generally* MAA-USFS, 1981, *supra* note 4. Federal guidance and recent court cases indicate that states have the right to influence activities on

federal land that result in water pollution in violation of state water quality standards. *See generally* 565 F. Supp. 586 (1983);
CWA § 313, 33 U.S.C. § 1323 (1982); Exec. Order No. 12,088, 3 C.F.R. § 243 (1979), 42 U.S.C.A. § 4321, app. at 172-174 (1988); U.S. EPA, *Water Quality Standards Handbook*, December, 1983, at 3 (Chapter 2) (hereinafter cited as *State Water Quality Standards Handbook*).

12. *See* Anderson, 1987, *supra* note 5, at 612.

13. *Id.* at 602; *Water Quality Standards Handbook*, *supra* note 11, at 7 (Chapter 2); 764 F.2d at 588.

14. 764 F.2d at 588-589. "BMPs ... are merely a means to achieve the appropriate ... water quality standards" and "[a]dherence to the BMPs does automatically ensure that ... state standards are being met." *Id.*

15. *See* CWA § 313; 33 U.S.C. § 1323; Executive Order No. 12,088, 3 C.F.R. § 243 (1979) *reprinted in* 42 U.S.C.A. § 4321, app. at 172-174 (1988).

16. Gaylon Lee, California State Water Resources Control Board, June 8, 1988 (personal conversation).

17. *Id.*; *see generally Final Report of the Forest Practice Rules Assessment Team to the State Water Resources Control Board* (California), April 24, 1987 (hereinafter cited as *Rules Assessment Team*).

18. Cumulative impacts are environmental impacts from "two or more forest practices, separated over time and/or space" that "interact to cause a combined impact on the environment which may or may not be greater than the sum of their individual effects." Henly and Ellefson, 1986, *supra* note 4, at 86.

19. Anderson, 1987, *supra* note 5, at 604-605.

20. Deborah Caldon, Environmental Scientist, U.S. EPA, San Francisco, California, October 27, 1988 (personal conversation).

21. *Id; see generally* U.S. EPA Region X, *Development of Criteria for Fine Sediment in the Northern Rockies Ecoregion*, April, 1987.

22. *See generally* U.S. EPA, April, 1987, *supra* note 21.

23. See Chapter Two for an explanation of the antidegradation standards of the CWA.

24. Anderson, 1987, *supra* note 5, at 613-614.

25. *Id.* at 605.

26. Gray, Gerald J. and Paul V. Ellefson, *Statewide Forest Resource Planning Programs: An Evaluation of Program Administration and Effectiveness* (Bulletin 582-1987), University of Minnesota Agricultural Experiment Station, 1987, at 69.

27. *See Rules Assessment Team*, 1987, *supra* note 17, at 5-5 - 5-7, 11-4 - 11-5, 12-4.

28. *Id.*

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29. *See generally Rules Assessment Team*, 1987, *supra* note 17; (California) State Water Resources Control Board, *Responsiveness Summary*, 1987, at 39-41.

30. State Water Resources Control Board, October, 1987, *supra* note 29, at 39-41.

31. Ellefson, Paul V. and Frederick W. Cubbage, *State Forest Practice Laws and Regulations: A Review and Case Study for Minnesota* (Bulletin 536-1980), University of Minnesota, Agricultural Experiment Station, at 89, 1980, at 13; Henly and Ellefson, 1986, *supra* note 4, at 89.

32. Henly and Ellefson, 1986, *supra* note 4, at 89; *see* Cal. Pub. Res. Code § 4511 *et seq.* (1974); Cal. Admin. Code Tit. 14 (1974).

33. Henly and Ellefson, 1986, *supra* note 4, at 96; California Department of Forestry, *California Forest Practice Rules, Northern Forest District* (1985 edition), Article 6, Rule 936, at 40 (hereinafter cited as *California Forest Practice Rules*).

34. Henly and Ellefson, 1986, *supra* note 4, at 90.

35. *Id.* at 96. In contrast, the State Forest Practice Board in Washington State is composed of 11 officials, only two of whom represent logging and timber interests. *Id.* at 70.

36. *Id.* at 90.

37. *See generally* MAA-California, 1987, *supra* note 4.

38. Henly and Ellefson, 1986, *supra* note 4, at 91.

39. *Id.*

40. *Id.*; Ellefson and Cubbage, 1980, *supra* note 31, at 12.

41. Henly and Ellefson, 1986, *supra* note 4, at 92.

42. *Id.*

43. *Id.*

44. *Id.* For example, CDF has 35 days to review plans, and approved plans are effective for three years. *Id.*

45. *Id.* at 94-95.

46. *Id.*

47. *Id.* at 95.

48. *See generally California Forest Practice Rules*, 1985, *supra* note 33.

49. *See id.* at 29 (§§ 933.2-3), 36-37 (§ 934.6(c)).

50. *Id.* at 39 (§ 934.8(a)), 62 (§ 943.1(c)), 66 (§ 943.1(c)).

51. *See id.* at 40-49 (Article 6).

52. *Id.* at 41-42 (§ 936.3).

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53. *See generally* North Coast Regional Water Quality Control Board, *Water Quality Control Plan for Klamath River Basin 1-A*, *quoted in* 565 F. Supp. at 605.

54. *Id.* at 57 (*quoted in* 565 F. Supp. at 605).

55. *See California Forest Practice Rules*, 1985, *supra* note 33, at 41 (§ 936.3), 61-62 (§ 943(e), § 943.1(c)), 65 (§ 943.2(r)).

56. Henly and Ellefson, 1986, *supra* note 4, at 107.

57. *Id.*

58. *Id.* at 113.

59. *Id.*

60. *Id.* at 111.

61. Much of the discussion below is based on a review of the California forest practices program by an interagency task force (the Forest Practice Rules Assessment Team). *See generally Rules Assessment Team*, 1987, *supra* note 17; State Water Resources Control Board, 1987 *supra* note 29. Information was also gleaned from a report documenting a negotiating process to improve forestry programs in Washington state. *See generally* Northwest Renewable Resources Center, *Timber/Fish/Wildlife - A Better Future: Our Woods and Streams* (Final Report), Seattle, Washington, February 17, 1987 (hereinafter cited as *TFW*).

62. Lee, 1988, *supra* note 16; Henly and Ellefson, 1986, *supra* note 4, at 99; *see* 16 U.S.C. §§ 1600-1614. Washington state at least has the rudimentary framework for such large-scale planning. The state Forest Practices Act (Wash. Rev. Code § 76.09 (1986); Wash. Admin. Code R. Ch.222-08 - 222-50 (1986) has defined different forest practices as falling into five classes -Classes I, II, III, IV-General, and IV-Special. Basically, each class involves progressively more protective practices on land of increasing environmental sensitivity. The most sensitive lands are Class IV-Special, which "have a potential for substantial impact to the environment" and therefore are subject to the theoretically stringent requirements of the State Environmental Policy Act. Henly and Ellefson, 1986, *supra* note 4, at 71.

63. Henly and Ellefson, 1986, *supra* note 4, at 91-93, 99; *Rules Assessment Team*, 1987, *supra* note 17, at 12-4; see State Water Resources Control Board, 1987, *supra* note 29, at 41-43.

64. State Water Resources Control Board, 1987, *supra* note 29, at 41-43; Henly and Ellefson, 1987, *supra* note 4, at 99; MAA-California, 1987, *supra* note 4, at A-1, D-2.

65. *Rules Assessment Team*, 1987, *supra* note 17, at 11-10, 12-4; State Water Resources Control Board, 1987, *supra* note 29, at 41-43.

66. *Rules Assessment Team*, 1987, *supra* note 17, at 11-10, 12-4; State Water Resources Control Board, 1987, *supra* note 29, at 41-43.

67. *Rules Assessment Team*, 1987, *supra* note 17, at 12-4.

68. *Id.* For example, unstable slopes with a high potential for mass erosion could be identified with a database consisting of soils and geologic maps, data from timber companies, areas of known hazard potential, topographic, rainfall, hydrologic and climatic data, etc.

69. Lee, 1988, *supra* note 16; *Rules Assessment Team,* 1987, *supra* note 17, at 11-4 - 11-5; State Water Resources Control Board, 1987, *supra* note 29, at 33-35. Henly and Ellefson, 1986, *supra* note 4, at 92, 103-104.

70. Lee, 1988, *supra* note 16; *Rules Assessment Team,* 1987, *supra* note 17, at 11-4 - 11-5; State Water Resources Control Board, 1987, *supra* note 29, at 33-35.

71. Lee, 1988, *supra* note 16; *see* State Water Resources Control Board, 1987, *supra* note 29, at 33-35.

72. Lee, 1988, *supra* note 16; *Rules Assessment Team,* 1987, *supra* note 17, at 11-8.

73. Lee, 1988, *supra* note 16; MAA-California, 1987, *supra* note 4, at D-1.

74. *Rules Assessment Team,* 1987, *supra* note 17, at 10-13.

75. *Id.* at 10-13 - 10-16; *see* State Water Resources Control Board, 1987, *supra* note 29, at 55.

76. *Rules Assessment Team,* 1987, *supra* note 17, at 10-16.

77. *Id.* at 11-2 - 11-10.

78. *Id.*

79. *Id.* at 11-3.

80. *Id.* at 11-3 - 11-4.

81. *Id.* at 12-3.

82. Lee, 1988, *supra* note 16; *Rules Assessment Team,* 1987, *supra* note 17, at 10-1 - 10-16; State Water Resources Control Board, 1988, *supra* note 29, at 38-41, 48.

83. *Rules Assessment Team,* 1987, *supra* note 17, at 11-5 - 11-8; State Water Resources Control Board, 1987, *supra* note 29, at 36-39.

84. *Rules Assessment Team,* 1987, *supra* note 17, at 11-9, 12-6; State Water Resources Control Board, 1987, *supra* note 29, at 38-41.

85. *Rules Assessment Team,* 1987, *supra* note 17, at 12-6; State Water Resources Control Board, 1987, *supra* note 29, at 38-40.

86. EPA lists the following sources of mine-related poison runoff and groundwater contamination: Roads (including haul and extraction roads); conveyers; rail and barge transport systems; mine shafts; buildings and construction sites; exposed deposits of minerals (in open pit, strip, and underground mines); refuse and tailings piles; areas for crushing and washing ore; water impoundments for tailings or slurry; and storage sites for ore and other

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materials. U.S. EPA, *Water Quality Management Guidance for Mine-Related Pollution Sources (New, Current, and Abandoned)*, December, 1977, at 1-8. As explained below, however, some of these discharges may be from *point sources.*

87. *Id.* at 1-9 - 1-10.

88. *Id.*

89. CWA § 502(14); 33 U.S.C.A. § 1362.

90. *See Sierra Club v. Abston Construction Co., Inc.*, 620 F.2d 41, 45-47 (5th Cir. 1980); *U.S. v. Earth Sciences,* 599 F.2d 368, 373-374 (10th Cir. 1979). The key is not the original source of the pollutants, but whether the pollutants are discharged to surface waters from "discernable, confined and discrete conveyance[s]." *Sierra Club,* 620 F.2d at 45. The discharge need not be intentional. For example, it can include unintentional overflows from impoundments. *Earth Sciences,* 599 F.2d at 374.

91. 30 U.S.C. § 1201 *et seq.*

92. 43 U.S.C. § 1701 *et seq.*

93. These include metallic minerals, such as iron, copper, gold and lead as well as some nonmetallic minerals.

94. For a discussion of BLM management of mining claims of federal lands, *see generally* U.S. General Accounting Office, *Public Lands: Interior Should Ensure Against Abuses From Hardrock Mining,* March, 1986; U.S. General Accounting Office, *Federal Land Management: An Assessment of Hardrock Mining Damage,* April, 1988.

95. *See, e.g.,* U.S. Department of the Interior, Bureau of Mines, *Control of Acid Mine Drainage—Proceeding of a Technology Transfer Seminar* (Information Circular 9027), 1985; Wells, Larry G., Andrew D. Ward and Ronald E. Phillips, *Predicting Infiltration and Surface Runoff from Reconstructed Spoils and Soils,* University of Kentucky, Water Resources Research Institute, 1983; Evangelou, V.P., J.H. Grove and R.I. Barnhisel, *Identification of Soil-Water Chemical Parameters for the Prediction of Suspended Solids in Surface Water Reservoirs of Coal Mine Lands,* University of Kentucky, Water Resources Research Institute, 1984; Meadows, Michael E. and George E. Blandford, *Improved Methods and Guidelines for Modeling Stormwater Runoff from Surface Coal Mined Lands,* University of Kentucky, Water Resources Research Institute, 1983.

96. *See generally,* U.S. EPA, *Processes, Procedures and Methods to Control Pollution from Mining Activities,* 1973; U.S. EPA, *Criteria for Developing Pollution Abatement Programs for Inactive and Abandoned Mine Sites,* 1975; U.S. EPA, *Inactive and Abandoned Underground Mines,* 1975; U.S. EPA, 1977, *supra* note 86.

97. As indicated below, while many of these documents are over 10 years old, they still share many attributes of more recent developments in the control of other poison runoff problems—particularly in their emphasis on using water

quality standards as a guide to controlling *all* of the point and nonpoint sources within individual watersheds as part of a comprehensive water quality management plan. Much of the discussion provided below was gleaned from the final EPA guidance document for mining pollution control developed in the late 1970s. *See generally* U.S. EPA, 1977, *supra* note 86.

98. *Id.* at v-vi.

99. EPA calls for a regulatory process "which either specifies, or is effective in identifying BMPs appropriate to each mine-related [NPS]" and that assures that the BMPs "are, in fact, utilized and that water quality goals are achieved and beneficial uses protected ... State WQM [water quality management] agencies ... are responsible for seeing to it that control systems for current mine-related sources are developed and implemented which are sufficiently effective on-the-ground to achieve water quality goals and to protect designated beneficial water uses." *Id.* at 3-1. Agencies other than the water quality management agency involved in developing or implementing NPS controls should be responsive to the need to achieve any established pollution load reductions and to protect designated beneficial water uses. *Id.* at 5-2.

100. Like other kinds of poison runoff control programs, those pertaining to mining-related NPS pollution control should attain and maintain water quality goals and beneficial uses of water. EPA recommends that state water quality management agencies be responsible "for seeing to it that control systems for current mine-related sources are developed and implemented which are sufficiently effective ... to protect designated beneficial water uses." *Id.* at 3-1.

101. *Id.* at 3-15 - 3-17. As with other types of runoff management programs, controls should be developed on a watershed-wide basis to produce tangible water quality benefits.

102. *Id.* at 2-5 - 2-6. EPA guidance states that "[t]he standards should take into account stream biology and sensitivity of aquatic life, benthic deposit transport and resuspension impacts, and additive or synergistic and cumulative pollutant impacts, as well as locally critical design flow conditions." *Id.*

103. Runoff should be controlled from all kinds of abandoned mines, not just coal; and from deep mines as well as from surface operations.

104. A fully effective program should include the land use controls that can prevent poison runoff when point and nonpoint technology-based controls are inadequate. These controls include: a general prohibition on operations in sensitive areas; designation of areas as fully, partially or conditionally unsuitable for specific activities; permit denial procedures for individual mining operations; and local zoning requirements. U.S. EPA, 1977, *supra* note 86, at 3-12, 3-13. Using land use planning to initiate and guide the development of mining pollution control programs is a prominent theme in an important National Research Council publication on the relevance of SMCRA to noncoal mining operations. *See* National Research Council, *Surface Mining of Non-Coal Minerals*, Washington, DC, 1979.

105. U.S. EPA, 1977, *supra* note 86, at 3-6 - 3-8 (paraphrased).

106. Reclaiming abandoned mines is desirable independent of water quality, for reasons related to public health and safety, sound public land management, and aesthetics. While this report focuses on water quality, complete reclamation of abandoned mines provides a permanent solution to water quality concerns, and addresses these other environmental goals as well.

107. *See* U.S. EPA, 1977, *supra* note 86, at 5-1 - 5-17.

108. *Id.* at 5-7.

109. *Id.* at 5-14 - 5-19.

110. *Id.* at 5-12 - 5-13.

111. *Id.* at 5-19.

112. *See generally* National Research Council, 1979, *supra* note 104.

113. *Id.* at 225-226, 244, 248-249, 254, 274; Jim Lyon, Environmental Policy Institute, October 18, 1988 (personal conversation).

114. SMCRA §§ 401-601; 30 U.S.C. §§ 1231-1281. CWA § 313, Executive Order 12,088 and EPA guidance require federal permitting activities to comply with state water quality standards. *See generally State Water Quality Standards Handbook*, 1983, *supra* note 11.

115. *See generally* SMCRA Title V, U.S.C. §§ 1251-1279.

116. SMCRA § 502(a); 30 U.S.C. § 1252(a).

117. *See, e.g.*, SMCRA § 515(b)(10)(A); 30 U.S.C. § 1265 (b)(10)(A); SMCRA § 516(b)(9)(A); 30 U.S.C. § 1266(b)(9)(A).

118. SMCRA §§ 515(b)(4)-(7), (11); 30 U.S.C. §§ 1265(b)(4)(7), (11); SMCRA § 508; 30 U.S.C. § 1258.

119. SMCRA § 515(b)(14); 30 U.S.C. § 1265(b)(14).

120. SMCRA §§ 401-413; 30 U.S.C. §§ 1231-1243.

121. SMCRA § 515(b)(3); 30 U.S.C. § 1265(b)(3).

122. SMCRA § 515(b)(4); 30 U.S.C. § 1265(b)(4).

123. SMCRA § 515(b)(8)(C); 30 U.S.C. § 1265(b)(8)(C).

124. SMCRA § 515(b)(10)(A); 30 U.S.C. § 1265(b)(10)(A).

125. SMCRA § 515(b)(10)(B); 30 U.S.C. § 1265(b)(10)(B).

126. SMCRA § 513; 30 U.S.C § 1263.

127. SMCRA § 514; 30 U.S.C. § 1264.

128. SMCRA § 526; 30 U.S.C. § 1276.

129. Implementation of reclamation plans for mining operations begun after passage of SMCRA (1977) is required as part of the permitting process described below. SMCRA § 508; 30 U.S.C. § 1258.

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130. SMCRA § 405; 30 U.S.C. § 1235.

131. SMCRA § 401(a); 30 U.S.C. § 1231(a).

132. SMCRA § 401(c); 30 U.S.C. § 1231(c).

133. SMCRA § 402; 30 U.S.C. § 1232.

134. SMCRA § 522; 30 U.S.C. § 1272. On federal lands, SMCRA also provides for the designation of land unsuitable for noncoal mining. SMRCA § 601; 30 U.S.C. § 1281.

135. SMCRA § 522(c); 30 U.S.C. § 1272(c).

136. SMCRA § 522(c); 30 U.S.C § 1272(c).

137. SMCRA § 522(a)(2); 30 U.S.C. § 1272(a)(2).

138. SMCRA § 522(a)(3); 30 U.S.C. § 1272(a)(3).

139. SMCRA § 522(a)(5); 30 U.S.C. § 1272(a)(5).

140. SMCRA § 509; 30 U.S.C. § 1259.

141. SMCRA § 517; 30 U.S.C. § 1267.

142. SMCRA § 518; 30 U.S.C. § 1268.

143. SMCRA § 520; 30 U.S.C. § 1270.

144. *See, e.g.,* U.S. Office of Technology Assessment, *Western Surface Mine Permitting and Reclamation,* Washington, DC, June, 1986; U.S. Government Accounting Office, *Surface Mining: Information on the Updated Abandoned Mine Land Inventory,* Washington, DC, July, 1988; Wiener, Daniel Philip, *Reclaiming the West: The Coal Industry and Surface-Mined Lands,* New York City, INFORM, Inc., 1980; Dunlap, Louise C. and James S. Lyon, "Effectiveness of the Surface Mining Control and Reclamation Act: Reclamation or Regulatory Subversion?" 88 *W.Va.L.Rev.* 547-559 (1986).

145. *See* Dunlap and Lyon, 1986, *supra* note 144, at 557.

146. *Id.*; *see generally* Johnson, Carolyn R. and Eric Hildebrandt, *Still Stripping the Law on Coal,* Natural Resources Defense Council, 1984; U.S. Government Accounting Office, *Surface Mining: Interior Department and States Could Improve Inspection Programs,* December, 1986; U.S. General Accounting Office, *Surface Mining: States Not Assessing and Collecting Monetary Penalties,* June, 1987.

147. Dunlap and Lyon, 1986, *supra* note 144, at 557; Lyon, 1988, *supra* note 113; *see generally* Johnson and Hildebrandt, 1984, *supra* note 146.

148. Dunlop and Lyon, 1986, *supra* note 144, at 553-554; Lyons, 1988, *supra* note 113.

149. Lyon, 1988, *supra* note 113.

150. *See* National Research Council, 1979, *supra* note 104, at 163-167.

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151. U.S. EPA, *Report to Congress: Nonpoint Source Pollution in the U.S.*, January, 1984, at 3-13.

152. *See generally* Wisc. Admin. Code § 132 NR (1986).

153. Wisc. Admin. Code § 132.02 NR (1986). "Metallic mineral" includes but is not limited to mined substances that contain iron, copper, zinc, lead, gold, silver, titanium, nickel, cobalt, and uranium as well as metals. Wisc. Admin. Code § 132.03(9) NR (1986).

154. Wisc. Admin. Code § 132.05 NR (1985).

155. Wisc. Admin. Code § 132.05(3) NR (1985).

156. Wisc. Admin. Code § 132.05(4) NR (1985).

157. Wisc. Admin. Code § 132.05(6), § 132.06(2) NR (1985).

158. Wisc. Admin. Code § 132.06(2)(3) NR (1985).

159. Wisc. Admin. Code § 137.07(3) NR (1986).

160. Wisc. Admin. Code § 132.07(4) NR (1986). This subsection specifically references state groundwater quality and drinking water standards. Wisc. Admin. Code § 132.07(4)(e)(1) (1986).

161. Wisc. Admin. Code § 132.10(b) NR (1985).

162. Wisc. Admin. Code § 132.10(c) NR (1985).

163. Wisc. Admin. Code § 132.06(4)(c)-(f) NR (1985).

164. Wisc. Admin. Code § 132.18 NR (1985).

165. Wisc. Admin. Code § 132.18(1)(b)-(c) NR (1985).

166. Wisc. Admin. Code § 132.08 NR (1986).

167. Wisc. Admin. Code § 132.09 NR (1985).

168. Wisc. Admin. Code § 132.14 (1986). DNR must hold a public hearing upon the verified complaint of 6 or more citizens and later must issue findings concerning these complaints. Wisc. Admin. Code § 132.16 NR (1986).

169. Wisc. Admin. Code § 132.11 and § 132.16 NR (1986).

170. Wisc. Admin. Code § 132.12 NR (1986).

171. Wisc. Admin. Code § 182 NR (1986).

172. Wisc. Admin. Code § 182.02(6) NR (1986). Wisc. Admin. Code § 182.11(1)(a) NR (1986) reiterates this connection to water quality standards by stating that "no waste shall be deposited in such a manner that the waste or leachings therefrom will result in a violation of any ground or surface water quality criteria or standards ...."

173. Wisc. Admin. Code § 182.05 NR (1985). Fees for reviewing the permit application range from $1,500-$4,500 (review can take place as often as once a year). Wisc. Admin. Code § 182.05

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(2)-(4) NR (1986).

174. Wisc. Admin. Code § 182.06 NR (1985).

175. Wisc. Admin. Code §§ 182.08-09 NR (1985).

176. Wisc. Admin. Code §§ 182.08(2)(C) NR (1985).

177. Wisc. Admin. Code §§ 182.075 NR (1985).

178. Wisc. Admin. Code §§ 182.08-09, § 182.11 NR (1985).

179. Wisc. Admin. Code § 182.12, § 182.13 and § 182.15-17 NR (1985).

180. Wisc. Admin. Code § 182.18 NR (1986).

181. *See generally* Department of Health and Environmental Sciences, *Nonpoint Sources of Water Pollution in Montana* (Draft), May, 1988; Pennsylvania Department of Environmental Resources, *Commonwealth of Pennsylvania–1988 Nonpoint Source Assessment*, 1988.

182. U.S. EPA, January, 1984, *supra* note 151, at 2-11.

183. See Chapter Three for a discussion of NPS management programs for dairy and livestock production in more confined environments.

184. Blackburn, Wilbert H., "Impacts of Grazing Intensity and Specialized Grazing Systems on Watershed Characteristics and Responses," in *Developing Strategies for Rangeland Management*, National Research Council, 1984, at 927; Elmore, Wayne and Robert L. Beschta, "Riparian Areas: Perceptions in Management," 9 *Rangelands* 260-262 (December, 1987); Platts, William S., Gebhardt and Jackson, "The Effects of Large Storm Events on Basin-Range Riparian Stream Habitats," in *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses–First North American Conference*, U.S. Forest Service, 1985, at 30-32.

185. Blackburn, 1984, *supra* note 184, at 927; Elmore and Beschta, 1987, *supra* note 184, at 260-262.

186. *See generally* Blackburn, 1984, *supra* note 184; Elmore and Beschta, 1987, *supra* note 184; Platts, Gebhardt and Jackson, 1985, *supra* note 184.

187. A recent USDA land use inventory classified 441,446,000 acres of land as nonfederal rangeland and 328,887,000 acres as federal rangeland. U.S. Department of Agriculture, *The Second RCA Appraisal–Soil, Water, and Related Resources on Nonfederal Land in the United States* (Review Draft), July-August, 1987, at 15-2. Of course, rangeland is a term used to define a particular ecosystem type. It is defined in the RCA Appraisal mentioned above as "[l]and on which the climax vegetation (potential natural plant community) is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing and browsing." *Id.* This general definition should not be construed to mean that all rangeland is appropriate for livestock grazing. Not all rangeland is productive enough to provide the *quantities* of grasses that are suitable for grazing *cattle* or *sheep* (as opposed to natural species). Moreover, this type of grazing is not always compatible with the rangeland ecology.

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188. These facilities include those used for feeding, watering and sheltering purposes.

189. Box, Thadis W., "Role of Land Treatments on Public and Private Lands," in *Developing Strategies for Rangeland Management*, National Research Council, 1984, at 1400-1401.

190. *See e.g.*, U.S. Government Accounting Office, *Some Riparian Areas Restored but Widespread Improvement Will Be Slow*, June, 1988.

191. *See* Box, 1984, *supra* note 189, at 1400-1401; Fairfax, Sally K., "Legal and Political Aspects of Range Management: Summary and Recommendations," in *Developing Strategies for Rangeland Management*, National Research Council, 1984, at 1707.

192. Kuasler, Jon A., "A Call for Action: Protection of Riparian Habitat in the Arid and Semi-Arid West," in *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses—First North American Conference*, U.S. Forest Service, 1985, at 9; U.S. EPA, *Livestock Grazing Management and Water Quality Protection*, November, 1979, at 86 (hereinafter cited as *EPA Grazing Guidance*).

193. Federal Land Policy and Management Act of 1976, §§ 102-103; 43 U.S.C. § 1701(a)(7).

194. *See* 13 U.S.C. § 1323(a); 43 U.S.C. 1712(c)(8); *see generally* Braun Richard H., "Emerging Limits on Federal Land Management Discretion: Livestock, Riparian Ecosystems, and Clean Water Law," 17 *Envtl. Law* 43-79 (1986).

195. The relationship of state water quality standards to private activities is discussed in Chapter Two as well as many other parts of this report. *See EPA Grazing Guidance*, 1979, *supra* note 192, at 7, 85-86.

196. Public intervention in private land management to protect water quality is exemplified throughout this report. The California Forest Practices Act provides an analogous example: private land use is controlled significantly to prevent water quality degradation. *See* Fairfax, 1984, *supra* note 191, at 1704.

197. Elmore and Beschta, 1987, *supra* note 184, at 265.

198. *Carrying Capacity* is an ecological concept that refers generally to the maximum population of a species or group of species that a given set of ecological conditions can support indefinitely. *See* Miller, G. Tyler, *Living in the Environment—Concepts, Problems and Alternatives*, Wadsworth Publishing Company, Inc., Belmont, California, 1975, at 105-107, A6.

199. Box, 1984, *supra* note 189, at 1405.

200. *EPA Grazing Guidance*, 1979, *supra* note 192, at 90-94, 109; Elmore and Beschta, 1987, *supra* note 184, at 262-263.

201. Elmore and Beschta, 1987, *supra* note 184, at 262, 264.

202. Box, 1984, *supra* note 189, at 1397.

203. *Id.* at 1398.

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204. *Id.* at 1405.

205. *Id.* at 1405-1412.

206. *Id.* at 1406-1407.

207. *Id.* at 14089.

208. *EPA Grazing Guidance*, 1979, *supra* note 192, at 16.

209. *Id.* at 85-88; Federal Land Policy and Management Act of 1976, § 102, § 202; 43 U.S.C. §§ 1701, §§ 1712.

210. *EPA Grazing Guidance*, 1979, *supra* note 192, at 96.

211. *Id.* at 48-49, 55-82.

212. *Id.* at 58-59. In rangeland settings, important standards are sediment and turbidity, fecal coliform bacteria, and dissolved solids as well as biological and habitat measures.

213. *Id.* at 48-49.

214. *Id.*

215. *Id;* Box, 1984, *supra* note 189, at 1406-1408.

216. *See* Box, 1984, *supra* note 189, at 1398; Fairfax, 1984, *supra* note 191, at 1704.

217. Grazing fees, usually based on units called "animal unit months" or AUMs, are charged to those using public rangelands to feed cattle. *See generally* The Taylor Grazing Act, U.S.C. §315 *et seq.* Riparian areas are included in the allotment of AUMs, and since they are more productive than upland areas they tend to be grazed more heavily. Some have considered the possibility of structuring grazing fee systems so that they take into account how well riparian areas are being managed. Elmore and Beschta, 1987, *supra* note 184, at 262.

Beyond the need to use differential fees, it is also important that the *absolute* grazing fees charged by BLM and USDA reflect the market price of the services provided by public rangeland as well as any hidden costs associated with, among other things, land and resource degradation. The fees charged in the past have been far below fair market value and have not covered even the administrative costs for the grazing program. Report of the House Committee on Government Operations Together with Additional and Dissenting Views, *Federal Grazing Program: All is Not Well on the Range*, H.R. Doc. No. 593, 99th Cong., 2d Sess. 5-10, 36-38 (1986). Such subsidies, like those provided to private agricultural and forestry interests, not only generate private profits at public expense but also contribute indirectly to the degradation of the streams, rivers and other water resources associated with the range. *Id.* at 26-27, 36-38.

Not only do artificially low grazing fees encourage overgrazing on public lands (the most prominent form of mismanagement); they also reduce the funds available for range improvements, including the restoration of riparian areas. *See generally* Wald, Johanna and David Alberswerth, *Our Ailing Public Rangelands: Condition Report - 1985*, National Wildlife Federation and Natural Resources

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Defense Council, December, 1985; Wald, Johanna H. and Faith T. Campell, *Testimony of the Natural Resources Defense Council Before the Subcommittee on Interior and Insular Affairs*, September 22, 1987. Thus, as with other problems with diffuse pollution sources, federal economic development policies must be addressed in order for effective management solutions to be developed.

218. The U.S. Forest Service controls a significant amount of federal rangeland used for grazing. Combined, the BLM and Forest Service have issued grazing permits or leases for approximately 365 million acres of rangeland in 16 western states. U.S. General Accounting Office, 1988, *supra* note 190, at 13. *See* Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. § 1604 *et seq.*). For a description of BLM rangeland management requirements, *see* the Public Rangelands Improvement Act of 1978 (43 U.S.C. § 1901 *et seq.*). This law establishes a national policy of managing and improving the conditions on public rangelands. The Federal Land Policy and Management Act of 1976 (43 U.S.C. § 1701 *et seq.*) requires the Secretary of the Interior (of which BLM is a part) to manage public lands for multiple uses and sustained yield through the development, use and periodic revision of land use plans.

219. *See* note 218, *supra*.

220. U.S. General Accounting Office, 1988, *supra* note 190, at 12.

221. *Id.*

222. *Id.*

223. *See* 43 U.S.C. § 1752.

224. *See generally* Government Accounting Office, 1988, *supra* note 190.

225. 43 U.S.C. § 1702(k); EPA Grazing Guidance, 1979, *supra* note 192, at 91.

226. *See* Memorandum of Understanding Between the Oregon Department of Environmental Quality and the Bureau of Land Management (U.S. Department of Interior), December 1978, at 3.

227. Letter from Nancy Lillquist (Oregon Department of Environmental Quality) to Paul Thompson (Natural Resources Defense Council), September 14, 1988; Nancy Lillquist, Oregon Department of Environmental Quality, September 12, 1988 (personal communication).

228. *See generally* U.S. Department of Interior, Bureau of Land Management (Oregon State Office), *Oregon/Washington Riparian Enhancement Plan*, June, 1987.

229. *Id.* at 7.

230. *Id.* at 8.

231. Lillquist, September 12, 1988, *supra* note 227; *EPA Grazing Guidance*, 1979, *supra* note 192, at 95.

232. Lillquist, September 12, 1988, *supra* note 227.

233. *Id.*

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234. Political opposition to rangeland controls can be strong. *See* Braun, 1986, *supra* note 194, at 50.

235. Many of these recommendations were gleaned from *Rules Assessment Team*, 1987, *supra* note 17; and *TFW*, 1987, *supra* note 61.

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Extensive data collection and analysis are at the center of an effective poison runoff control program.

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Chapter Six

Information Collection and Use

Introduction

As described below, properly collecting and evaluating data is one of the biggest challenges that officials and citizens concerned with controlling poison runoff must face. Many control programs today lack an adequate capacity to collect and use data. Without adequate data management capabilities, programs can suffer from a host of fundamental problems, including: inaccurate problem assessments and load reduction targets; poor priority-setting that wastes limited resources; false claims of victory over pollution problems; and reluctance to use much-needed mandatory control programs.

Fundamentals of Poison Runoff Data Collection

Many states lack baseline information concerning the current impacts of poison runoff on water quality and the degree to which these impacts could be reduced.[1] But estimating the potential water quality impacts of a program to reduce poison runoff in a given watershed is important to program success.[2] Adequate data collection and analysis is essential to determine:

1. existing program effectiveness;

2. needed program modifications; and

3. potential program options.

In addition, estimates are needed of the pollutant load reductions required to restore beneficial water uses within each watershed.[3]

This chapter discusses the collection and utilization of data, with a focus on the use of information gained from monitoring and modelling water quality, land use and socio-economic factors. Although limitations in the quality and usefulness of information today severely affect the success of many management efforts, progress in this area is being made. The recent developments and research addressed in this chapter, as well as the descriptions of actual programs with good data management activities, will help to illustrate how improvements in this critical area are possible.

Data Need Not be Perfect In Order to be Used Effectively. In the past, some states have justified their reluctance to use mandatory control programs by pointing to a lack of precise data about cause-and-effect relationships in poison runoff (both the relationship of land use to water quality, and the relationship of BMPs to improvements in water quality).[4] According to this reasoning, regulatory programs are unfair and unjustified since proving the need for mandatory controls on each individual polluter is necessary but not feasible.

But a lack of utter precision in data collection and analysis is not a valid reason to limit program options to the purely voluntary. Data collection and analysis activities have been used repeatedly to establish, implement, and enforce progressive, often regulatory programs,[5] even when they did not generate absolutely certain results.

The stringency of controls need not be slavishly dependent on absolute numerical certainty concerning individual nonpoint sources. Once basic water quality impact information has been collected, control programs often can begin to be implemented. To be sure, additional monitoring and modelling information can and should *enhance* the control of poison runoff by leading to

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the development of new approaches; improving the targeting of programs; and providing feedback on potential and actual program effectiveness. But waiting for absolute certainty can lead to permanent paralysis.

As can be seen from many other environmental management activities, such as land use controls, air quality regulation, and hazardous waste facility siting, precise quantification of program impacts from individual polluters is not always a precondition for choosing particular approaches to controlling environmentally harmful activities. Most of the programs described throughout this study are based on reasonable, and reasonably-well documented, approximations of water quality impacts based on land use and hydrologic modelling, on surrogates for water pollution such as erosion and other land-based measures, or on general knowledge of the risks posed by a particular activity.

A narrow view of the purpose of data collection activities sometimes is based on the assumption that the only alternative to a voluntary program is a discharge *permit* program similar to the water quality-based NPDES program under the CWA. Under such a program, the runoff (and, theoretically, groundwater) discharges from each farm or other individual nonpoint source would be monitored or otherwise estimated; its water quality impacts gauged; and appropriate BMPs assigned as part of the permit to discharge (*i.e.*, to farm, to build, etc.).

However, approaches to reducing poison runoff need not be limited to the point source, water quality-based permit approach. Policy-makers should consider the technology-based approach that forms the "floor" for NPDES permitting as a more useful analogue. Under this model, when a significant problem from dispersed pollution sources comes from a particular type or class of activity, a basic control approach is developed. With additional information, regulators can develop and implement innovative controls or can reduce controls where information indicates they are unnecessary. Essentially, the role that data collection should play can be broken into a few simple steps:

1. measure water quality and compare findings to water quality standards;

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2. calculate total load reductions for each pollutant that are necessary to meet water quality standards, with an adequate margin of safety and taking into account seasonal and hydrologic variations;[6]

3. *estimate* total loads from each category or group of diffuse sources;

4. *estimate* load reductions that can be achieved using various levels of control;

5. choose and implement the appropriate controls needed to comply with water quality standards;

6. measure water quality periodically as controls are imposed, in order to verify the initial analysis; and

7. modify controls if necessary.

Some of the main aspects of this process are described in greater detail in the following section.

Monitoring and Modelling: Using Data Effectively

A formal process should be a part of each state's water quality standards program whereby beneficial uses of water (such as fishing, swimming, drinking water supply) are designated for each waterbody and stream segment, and periodic assessments are conducted in specific waters to determine whether these uses are being attained or maintained.[7] This involves not only evaluation of whether chemical water quality criteria are met, but also whether the overall physical and biological health of the aquatic system is sound. The process is described briefly below.

The appropriate process for using chemical water quality information for controlling poison runoff is the process of (1) calculating Total Maximum Daily Loads (TMDLs), and (2) establishing water quality-based controls based on those TMDLs.[8] While no single, uniform procedure for calculating the nonpoint

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source component of a TMDL has been established by EPA, the Agency has published guidance on targeting controls. This guidance supports the approach of establishing pollution reduction goals and monitoring water quality to determine whether goals are achieved.[9] Although difficult, estimating needed reductions in poison runoff and developing appropriate control programs is a central part of many strategies to protect lakes, rivers and estuaries.[10]

The TMDL process requires that a state evaluate a variety of data and develop a prioritized list of waters that need new or revised TMDLs.[11] The TMDL process actually consists of two parts: the Load Allocation process (LAs), through which the State determines the degree to which particular nonpoint sources of pollutants must be reduced to attain beneficial uses, and the wasteload allocation process (WLAs), through which the state conducts the same exercise for point sources of pollutants.[12]

This regimen has been required by the CWA since 1972, yet few States have a fully developed TMDL and WLA/LA program.[13] To the extent that states have been reluctant to develop LAs for nonpoint sources, EPA bears much of the blame. EPA has not aggressively enforced its own load allocation regulations.[14] Moreover, while EPA has developed guidance on the data and monitoring required to conduct WLAs for *point* sources,[15] similar guidance for LAs and diffuse sources is only now being considered.[16]

A recent EPA report indicates that states need to reorient all of their monitoring activities more towards nonpoint source impacts.[17] The report found that data collection activities currently are focused on point sources to the exclusion of diffuse sources.[18]

Moreover, chemical water quality data provide an incomplete assessment of whether beneficial water uses are being achieved. Assessing the impacts of poison runoff requires biological, hydrologic, precipitation, topographic, census, land use and economic data as well as simple information on water quality.[19] There are numerous sources of such data that can be used in a management program. The Nonpoint Source Branch at U.S. EPA has identified over 20 sources of information that are readily available to state and local officials.[20] This information

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also can be used in various ways to describe water quality, to estimate pollutant loadings, and to predict land use trends. Very often the information can be input into models[21] to predict estimated water quality impacts. While the value of some of these models still is the subject of debate, and some require large amounts of site-specific empirical data, models have been used effectively in a number of situations.[22]

Sources of water quality information collected at the state level can be loosely grouped into four categories: the state's *fixed station system* that characterizes general water quality as well as state-wide and site-specific trends; *intensive surveys* which are more detailed studies that are used (if existing fixed station data are inadequate) to determine beneficial use attainment and specific water quality conditions; *special studies* (often one-time surveys) that investigate specific problems within a large geographic areas; and *other sources* of data that help to describe water quality.[23] Within each of these categories, data can be collected using various methods. Types of data collection methods are:

1. chemical screening - collection of ambient (in-stream) chemical data appropriate to the beneficial use and representing the water column, sediment, and fish tissue;

2. bioassay - biological tests that assess ambient and pollutant toxicity on aquatic life and that screen for human health effects;[24]

3. biosurveys - evaluations of the health of the aquatic system that measure factors such as the size, number, distribution and diversity of fish, macroinvertebrates and other populations, and overall habitat analysis;[25]

4. professional judgment/direct observation - where limits in quantitative information dictate, the application of information from one watershed to another, substituting different types of data (*e.g.*, chemical for biologic in situations of aquatic life impacts) and other qualitative assessments; and

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5. other data - modelling, citizen complaints, fish kills and other information are used to understand water quality conditions better.[26]

The first step in collecting water quality information is the development of an effective monitoring *strategy*. The EPA Nonpoint Source Branch has developed a useful guide to monitoring and evaluating poison runoff problems and programs.[27] Some of the general guidelines are presented below.

Water Quality Data Collection Plans

States and localities need baseline information to establish a benchmark against which to measure any long-term trends.[28] The first step is the selection of appropriate parameters to measure. Obviously, the State's long-range water quality goals will drive decisions about what parameters to monitor. Therefore, these goals must be defined clearly *before* baseline data are gathered.[29] When developing these goals, sampling error can be reduced by defining monitoring objectives as narrowly as possible, and by distinguishing between the testing of parameters (used primarily to determine pollutant loads and water quality impacts) and hypothesis testing (used primarily in program evaluation).[30] The choice of which parameters to monitor should be influenced by applicable water quality standards, the types of pollutant sources known to be present and the presence of certain naturally-occurring substances in the water.[31] In some instances, "surrogates" may be used as monitoring targets in place of specific problems caused by NPS pollution.[32] For example, chlorophyll *a* (a green pigment in plants used in the conversion of sunlight into energy) and phosphorus can be measured as surrogates for eutrophication.

Information concerning existing and projected land uses and the impact of various land use practices (including implementation of BMPs) is needed so that changes in water quality based on changes in land use can be estimated. Data also must be collected and evaluated for ongoing program implementation in order to determine compliance and enforcement priorities. This information includes population and agricultural census data;

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USGS, state and local land use and land cover information; state and local natural resource inventories; and state economic development information.[33]

The second step is to devise an overall monitoring plan. The plan must include both short-term and long-term data collection, since "snapshots" of water quality at any given time are not sufficient to draw reliable conclusions about pollution impacts or the effectiveness of controls. Some estimate of trends is needed to understand the impacts associated with poison runoff, including the effects of land use, climate and hydrology on water quality. Trend analysis also is needed to determine natural fluctuations in water quality over time, and the impact of management efforts on the long-term changes in water quality.[34]

Third, States need to expand their testing programs to look beyond the water column. EPA has found that information about sediment quality and biological and habitat conditions have not been collected in the past, but are needed to assess the problem of poison runoff and the effectiveness of controls.[35] The locations and sampling frequencies of the general fixed station network "have not been designed to support rigorous statistically-based conclusions about water quality over wide areas."[36]

Variability in many factors must be taken into account because it is extremely influential in determining the actual levels of poison runoff.[37] Long intervals between monitoring events coupled with the incremental manner in which BMPs and other controls usually are implemented can make it difficult to determine if changes in water quality are attributable to control programs. Perhaps more significant are the varying effects of climate and the impacts that different geographic areas have on poison runoff.[38] Changes brought about by individual storms and by changes in seasons are considered short and intermediate sources of variability, respectively. Both can be accounted for by designing monitoring programs properly.[39]

Monitoring above and below an area where BMPs have been implemented is probably more useful for establishing the severity of a nonpoint source problem than for evaluating the success of the control program.[40] This is so because changes in impacts over time can be determined reliably only if the monitoring strategy can account for variables associated with land use, hydrology and climate.[41] However, pairing watersheds (comparing water quality impacts in a control watershed with a similar watershed undergoing program implementation) may be the best quick way to measure improvements in water quality due to BMP implementation,[42] because paired watershed studies can be designed to take into account climatic and hydrologic variability.[43]

The proper location of sampling sites also is an important consideration. Determining proper site location is similar for point and nonpoint sources. For both baseline and intensive surveys, sampling stations should be located:

1. in areas with known or suspected water quality violations;
2. at major outlets from and inputs to lakes and coastal areas that have symptoms of eutrophication, to pinpoint cause and effect relationships;
3. in critical eutrophication areas within these water bodies to assist further in determining cause and effect;
4. at locations upstream and downstream from representative land uses to determine the effects of different general land uses on water quality;
5. at the mouths of significant tributaries to major streams or coastal waters to determine major pollution sources in these areas;
6. at representative sites in the above waters to determine general water quality; and
7. at sites of major uses such as water supply intakes, recreation, and fishing, to determine public health threats and to determine the general water quality in the area.[44]

Sediment and biological monitoring locations also are important. Sediment monitoring stations should be established to assess the accumulation of toxic substances.[45] Biological stations, needed to determine the impact of poison runoff on aquatic life, often will not coincide with the location of water column stations.[46] Normally, they should be located away from artificial structures.[47]

The desired number and frequency of samples depends on how the statistical and modeling data will be used as well as on the logistics of obtaining the samples.[48] It is beyond the scope of this report to describe individual designs for sampling or specific statistical techniques for analyzing the results of a sampling exercise. However, many methods have been developed to help determine the number and frequency of samples necessary to achieve specific levels of statistical certainty concerning the impacts of poison runoff.[49]

Officials also need information that allows them to analyze the cumulative impacts[50] of land uses within a watershed. While current management activities have been criticized as inadequate in addressing cumulative impacts,[51] a general outline for the consideration of cumulative impacts is available.

Collecting and evaluating the land use information needed to make judgments about potential water quality impacts requires significant involvement on the part of local land use planners.[52] For instance, information concerning individual developments is necessary, as are estimates of development patterns within entire hydrologic units.[53] Important environmental factors, such as hydrology, slope, soils and land use data also need to be assessed.[54] Water quality and habitat parameters should be evaluated to determine present trends, and estimates must be made of critical pollutant loadings.[55] From this background information, the impacts of various development scenarios on water quality can be determined by estimating the pollutant loads associated with alternative growth and control options.[56] By using this process, land use plans and controls and economic development policies can be chosen more intelligently according to their consistency with long-term state water quality objectives.[57]

Examples of Effective Data Management Programs

A wide range of strategies for collecting and using data have been developed around the country. These federal, state and local activities have helped to broaden the range of available controls. While some have only been suggested, others are being used today in state and local programs. Examples of these innovative approaches are given below.

Relatively simple strategies for targeting critical land areas for control efforts have been developed.[58] One method, which involves 9 steps, targets areas within watersheds from 2,000 to 30,000 acres in range, and allows planners to calculate the maximum water quality improvements that would be derived from a given level of BMP implementation.[59] Briefly, these steps are as follows:

1. quantitatively describe the nature and extent of water quality problems;

2. describe the hydrology of the waterbody of concern;

3. estimate pollutant reductions needed to protect, improve or restore the impaired waterbody using such measures as loadings, concentrations, frequency of standards violations, etc.;

4. estimate relative point and nonpoint-source impacts on water quality;

5. determine the largest nonpoint source contributors of pollutants based on information about development, land use practices, agricultural production practices, and other activities in the area;

6. determine the proximity of the nonpoint source to the water segment;

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7. determine upstream pollutant contributions to the water segment;

8. determine where current controls already are in place; and

9. perform on-site evaluations of potential sources to determine peculiarities in drainage or hydrologic characteristics.[40]

This process can be carried out (or modified) with varying degrees of sophistication. Publications are available that provide data on what particular factors to consider and what conclusions to draw from particular monitoring and modelling results.[41]

Wisconsin's nonpoint source program[42] is required by regulation to develop load reduction goals and to evaluate alternative management scenarios. It uses *modelling* as a central feature of its watershed planning process. A critical part of the Wisconsin Nonpoint Source Pollution Abatement Program is the Watershed Assessment that requires:

1. an identification of the water quality problems or threats to water quality caused by nonpoint sources of pollution in the watershed;

2. an identification of water quality objectives for the watershed;

3. an identification of target levels of pollutant control necessary to meet water quality objectives;

4. an identification and ranking of significant nonpoint source types and contributing areas; and

5. an identification of priority management areas.[43]

To assist in this assessment process, the Wisconsin Department of Natural Resources developed the Wisconsin Nonpoint (WIN) model.[44] The WIN model uses up to five computer files to determine sediment delivery; field inventory

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information (the largest and most difficult file to collect); stream inventory information; rainfall information; and crop rotation information.[65] This flexible model allows users to employ various land use, soil and hydrologic information to estimate existing and potential sediment delivery to specific streams within discrete portions of the watershed.[66]

The WIN model can be used in both the planning and the implementation phase of the Wisconsin Nonpoint Source program.[67] In the watershed planning phase the use of the model involves:

1. evaluation of existing water quality conditions and objectives;

2. inventory data collection;

3. model calibration;

4. evaluation of existing sediment sources;

5. evaluation of the management alternatives and resulting delivery; and

6. selection of a management plan.[68]

During plan implementation, the WIN model can assist in the evaluation of interim and long term results and help to identify the need for any plan modifications.[69] While the use of this model is only now being integrated fully into the watershed assessments, it will become increasingly valuable in the crucial "watershed management" approach used in Wisconsin.

Officials have developed procedures for estimating water quality conditions within a particular watershed and determining the potential impacts of various management strategies on these conditions. In one Wisconsin watershed, three tools (described briefly in Chapter Nine) were used to determine water quality problems. These were: the Hilsenhoff Biotic Index (HBI), which uses the insects living in the stream to estimate the degree of organic pollution; present and potential estimates of fishery uses through an inventory of stream flow, bed type, amount of riffles and pools, streambank conditions, temperature, pH, and other water quality parameters; and an assessment of the trophic status of lakes within the watershed using estimates of in-lake phosphorus and chlorophyll *a*, and turbidity and sunlight penetration measures.[70]

After the watershed was divided into 17 subwatersheds, assessments were performed to determine the contributions of pollution made by various nonpoint sources.[71] Estimates were made to determine which land areas potentially contributed the greatest sediment loads to each waterbody and what reductions could be expected from the implementation of soil conservation practices.[72] Streambank erosion estimates also were made.[73] All dairy operations were examined for their impact on water quality through the use of a USDA model modified by the Wisconsin Department of Natural Resources (DNR).[74] Estimates also were made of the amount of unsuitable land used each year for manure spreading.[75]

From these measurements, objectives for each waterbody were defined along with the pollutant load reductions needed to achieve the specific objectives.[76] Finally, the relative importance of each source category described above was ranked along with specific properties within each category that needed to be controlled in order to achieve the water quality objectives.[77] This determination was made by developing estimates of load reductions that could be achieved by controlling alternative proportions of the load from each source category.[78]

In Florida, under the Surface Water Improvement and Management (SWIM) Act, Florida's Water Management Districts have been challenged to determine (1) what point and nonpoint pollution load reductions are needed to restore and preserve the quality of priority waters, and (2) how those reductions can be achieved most effectively.[79] For instance, the draft SWIM plan for Lake Okeechobee prepared by the South Florida Water Management District uses results from modelling and monitoring to establish overall phosphorus load reduction goals and particular objectives for evaluating the success of various programs in individual subwatersheds.[80]

As mentioned above, eutrophication due to nutrient enrichment is often a difficult parameter to monitor directly. To address this problem, a method has been proposed to use the level of chlorophyll *a* present in water, which is a measure of algae production, as a surrogate water quality standard for eutrophication. This measure could be used to guide decisionmaking for watershed management programs and to estimate what controls are needed to achieve given levels of water quality.[81]

This standard measures directly the quantity of algae in a waterbody, while other parameters, such as clarity, nitrogen and phosphorus, are indirect measures.[82] Proactive controls should be based on a measure of the *mean*, rather than the *maximum* chlorophyll *a* levels in a system, because maximum levels of algal growth vary according to a number of other factors.[83]

In Olmsted County, Minnesota, county planners have developed an erosion control ordinance based on an extensive information gathering process and computer-assisted data management procedures at both the local and state levels.[84] This process is used as a basis for requiring early compliance with the ordinance for particularly erosion-prone areas, as well as for inspections to verify compliance.

Using data "cells" of one-tenth of an acre, Olmsted County generated land use information that distinguished 119 soil "mapping units" or soil types as well as a unit for water and other non-soil features.[85] Forty-six land use/cover classes were developed based on land use, erosion and runoff characteristics.[86] Twelve kinds of cropland were identified ranging from straight row continuous corn planting to permanent hayland, and including all mixes of crop rotation, contouring, terracing, and residue management.[87]

Using a micro-computer-based data analysis system developed by the state, a system of enforcement priorities was established by modelling wind erosion, sheet and rill erosion, and the runoff characteristics within the county.[88] Sheet and rill erosion, in turn, were modelled by adapting the soils and land use data to the Universal Soil Loss Equation.[89] Runoff levels were determined by adapting the 119 soil "units" to form hydrologic soil groups and combining those data with the land use/cover information.[90]

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Topographic and stream location information is used to determine runoff volumes and peak flows.[91]

Olmsted County also uses a Geologic Atlas, the development of which was funded equally by Olmsted County and the Minnesota Geologic Survey.[92] The atlas was developed to provide "accurate and retrievable information on: wells, springs, aquifers, sinkholes, glacial deposits and soil characteristics not mapped by the Soil Conservation Service."[93] Through the development of computer data bases and interpretive maps, assistance can be provided to local officials in the implementation of various pollution control and public health ordinances.[94] Additional data collection activities being considered include county-wide (or multi-county) private well testing programs to assist citizens and to monitor groundwater quality changes, and environmental studies of soils and groundwater at auto and metal scrapyards and old dumps to monitor for toxics contamination.[95]

The Washington D.C. Metropolitan Council of Governments has developed a manual for planning and designing urban BMPs, including information on data collection and utilization.[96] Details are provided for the cost-effectiveness, effectiveness in stormwater control and pollutant removal, maintenance requirements and other attributes of many of the most popular BMPs.[97] Methods are provided to screen BMPs for application to specific sites, and to calculate stormwater flows.[98] The manual provides information on pollutant export from urban development, based on data from the Washington, D.C. area National Urban Runoff Program (NURP) study, as well as national NURP data.[99] The methods can be used to determine the need for more precise modelling.[100] They also can be used to estimate the probability that pollutant concentrations (as opposed to total pollutant load) will exceed a given level. Several examples are given.[101]

The National Water Quality Evaluation Project of the North Carolina State University Agricultural Extension Service is currently reviewing literature to identify recent advances in methodologies to calculate nonpoint source loadings and associated water quality impacts.[102] Methods for calculating toxic and concentrated loadings to surface and groundwater in both the dissolved and sediment-bound phase are being examined.[103]

Conclusions and Recommendations

Poison runoff monitoring and modelling activities have limitations, especially when it comes to setting discharge standards for individual sources. But these limitations should not prevent the use of regulatory measures and other pollution controls. Where there is a willingness to develop new approaches to control poison runoff, data collection has been used to enhance management efforts rather than as an excuse for inaction.

Recommendations for data collection activities are as follows:

1. Regulatory programs can and should be developed using currently available data collection methods.

2. Monitoring and modeling protocols should be developed that take into account the proper statistical assumptions, the need for consistent measurements and analytical techniques, hydrologic variability and seasonal influences. To accomplish this, monitoring programs require:
   a. an adequate number of properly-located sampling sites; and
   b. an adequate frequency of sampling per site.

3. Generally, in developing a monitoring design, paired watershed studies should be used to measure changes in water quality due to BMP implementation, while monitoring above and below a watershed should be used to gauge the severity of a problem.

4. Monitoring and modelling should be designed to develop water quality goals (as well as to measure progress towards meeting these goals) within watersheds of a manageable size.

5. Cumulative impacts should be taken into account when assessing water quality impacts and estimating improvements that controls will achieve.

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6. Monitoring programs need to assess both chemical water quality parameters and the overall biological health of the aquatic system.
   a. In addition to ambient water quality assessments, evaluations of the biological health of aquatic systems should consider such factors as population size, diversity and distribution.
   b. Water quality parameters should be chosen on the basis of water quality standards, previous monitoring results, and types of pollutant sources. "Surrogate" parameters, such as chlorophyll *a*, can be used to measure water quality conditions such as eutrophication.

7. Water quality data can be used directly to design, modify, and measure the effectiveness of control programs as follows:
   a. *measure* water quality and compare findings to water quality standards;
   b. *calculate* total load reductions for each pollutant that are necessary to meet water quality standards, with an adequate margin of safety and taking into account seasonal and hydrologic variations;[104]
   c. *estimate* total loads from each category or group of diffuse sources;
   d. *estimate* load reductions that can be achieved using various levels of control;
   e. *choose* and *implement* the appropriate controls needed to comply with water quality standards;
   f. *measure* water quality periodically as controls are imposed, in order to verify the initial analysis; and
   g. *modify* controls if necessary.

8. To evaluate and predict existing and future impacts from poison runoff, states should collect and analyze data on land use, economic and census trends, hydrology, topography, geology, and other factors.

Notes - Chapter Six

1. U.S. EPA, *Surface Water Monitoring: A Framework for Change*, September, 1987, at 7, 17 and 18 (hereinafter cited as *Surface Water Monitoring*).

2. U.S. EPA, *Guidelines for Evaluation of Agricultural Nonpoint Source Water Quality Projects*, North Carolina State University, Raleigh, North Carolina, October, 1982, at 2, 4.

3. *See* U.S. EPA, Office of Water, *Setting Priorities: The Key to Nonpoint Source Control*, July, 1987, at 24 (hereinafter cited as *Setting Priorities*).

4. *See, e.g.*, Virginia State Water Control Board, *Best Management Practices Handbook Management (Management)* (Planning Bulletin 322), 1981, at 1-2.

5. See Chapters Three, Four and Five for a discussion of regulatory and other non-traditional poison runoff control programs.

6. CWA § 303(d)(1)(C), 33 U.S.C. 1313(d)(1)(c).

7. U.S. EPA, *Guidance for State Water Monitoring and Wasteload Allocation Programs*, October, 1985, at 9-12 (hereinafter cited as *Wasteload Guidance*); *see generally* U.S. EPA, *Water Quality Standards Handbook*, December, 1983 (hereinafter cited as *WQS Handbook*). 40 CFR § 130.7. Revisions to § 130.7 have been proposed. *See* 54 Fed. Reg. 1,310-1,312 (January 12, 1989).

8. *See WQS Handbook*, 1983, *supra* note 7, at 1-1 - 1-7. See Chapter Two for a discussion of the legal aspects of this process.

9. *Setting Priorities*, 1987, *supra* note 3, at 18-25.

10. Examples of runoff control programs designed to achieve the load reductions needed to restore beneficial uses of water within specific watersheds are provided in another section of this chapter, as well as in other portions of this report.

11. TMDLs must be approved by EPA. *Wasteload Guidance*, 1985, *supra* note 7, at 30-32. The lists of waters requiring TMDLs can be submitted as part of the states' biennial report required under CWA §305(b) that describes current water quality conditions within the state.

12. 40 CFR § 130.7.

13. U.S. General Accounting Office, *Water Pollution: More EPA Action Needed to Improve the Quality of Heavily Polluted Waters*, January, 1989, at 20-25.

14. *See Scott v. City of Hammond*, 741 F.2d 992, 996-998 (5th Cir. 1984); U.S. GAO, 1989, *supra* note 13, at 24-25.

15. *See, e.g.*, U.S. EPA, *Technical Guidance Manual for Performing Waste Load Allocations, Book II - Streams and Rivers*, November, 1983, at Chapter 2.

16. Bruce Newton, Alice Mayio and King Boynton, U.S. EPA, August 16, 1988 (personal conversation).

17. *See generally Surface Water Monitoring*, 1987, *supra* note 1.

18. *Id.* at 6.

19. U.S. EPA, *Nonpoint Source Monitoring and Evaluation Guide* (draft), February 26, 1988, at 41-51 (hereinafter cited as *Nonpoint Source Monitoring and Evaluation Guide*).

20. *Id.*

21. *See generally*, U.S. EPA, *Handbook- Stream Sampling for Wasteload Allocations*, September, 1986 (hereinafter cited as *Sampling Handbook*); U.S. EPA, *The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Model*, May, 1987 (hereinafter cited as *EPA Stream Model*). Modeling efforts to identify potential program target areas and to estimate possible program impacts also have become important in poison runoff management programs. At least 40 models exist to simulate the transport of nonpoint source pollutants in runoff and groundwater, to compare the value of different management scenarios and to simulate the impacts of these pollutants once they reach lakes, rivers and coastal waters. *See* U.S. EPA, *Guide to Nonpoint Source Pollution Control*, July, 1987, at 10-11. While the accuracy of many such models has been criticized, the use of models, in combination with data gained from monitoring, has led to the development of innovative programs in such areas as Wisconsin, Washington State's Puget Sound, the Chesapeake Bay and New England. For a discussion of nonpoint source modeling, *see generally* Giorgini, Aldo and Franco Zingales (eds.) Agricultural Nonpoint Source Pollution: Model Selection and Application, Elsevier, New York, 1986; *see also* Leonard, Ralph A. and Walter G. Knisel, Jr., *Selection and Application of Models for Nonpoint Source Pollution and Resource Conservation*, U.S. Department of Agriculture-Agricultural Research Service, Southeast Watershed Research Laboratory (no date).

22. Examples of effective applications of modelling include the use of the Wisconsin Nonpoint (WIN) model to (among other things) "evaluate the reduction of sediment from critical areas under various land management practices;" and the use of models by the South Florida Water Management District to estimate needed phosphorus load reductions and phosphorus/sediment interactions in Lake Okeechobee. *See generally* Baun, Ken, *The Wisconsin Nonpoint (WIN) Model (Version 1.0)—User's Manual*, Wisconsin Department of Natural Resources, August, 1987 (hereinafter cited as *WIN User's Manual*); *see* South Florida Water Management District, *Interim Surface Water Improvement and Management Plan for Lake Okeechobee* (draft), October 10, 1988. The use of these models is discussed further in this chapter.

23. *Surface Water Monitoring*, 1987, *supra* note 1, at 4.

24. James C. Plafkin, U.S. EPA, Monitoring and Data Support Division, December 30, 1988 (personal conversation). For more detail on this process, *see* U.S. EPA, *Technical Support Document for Water Quality-Based Toxics Control*, at Appendix C; Mount, D., *et al.*, *Effluent and Ambient Toxicity Testing and Instream Community Response on the Ottawa River, Lima, Ohio*, U.S. EPA, August, 1984; Mount, D.I., and T.J. Norberg King (eds.), *Validity of Effluent*

and Ambient Toxicity Tests for Predicting Biological Impact, Scippo Creek, Circleville, Ohio, U.S. EPA, June, 1985.

25. *See generally* Plafkin, James L., *et al., Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish,* U.S. EPA, July, 1988.

26. *Wasteload Guidance,* 1985, *supra* note 7, at 2-4, 31.

27. *See generally Nonpoint Source Monitoring and Information Guide,* 1988, *supra* note 19.

28. *Id.* at 10-11.

29. *Id.*

30. *Id.* at 53.

31. *Id.* at 56-57.

32. *Id.* at 41.

33. *Id.* at 41-51.

34. *Id.* at 10-11.

35. *Surface Water Monitoring,* 1987, *supra* note 1, at iii, 6.

36. *Id.* at 6.

37. *Nonpoint Source Monitoring and Information Guide,* 1988, *supra* note 19, at 13; Spooner, J., R. P. Maas, M. D. Smolen, and C. A. Jamieson, "Increasing the Sensitivity of Nonpoint Source Control Monitoring Programs," paper presented at a Symposium on Monitoring, Modeling, and Mediating Water Quality, American Water Resources Association, May, 1987, at 1.

38. *Nonpoint Source Monitoring and Information Guide,* 1988, *supra* note 19, at 13-18.

39. *Id.* at 13.

40. *Id.* at 55; Spooner, J., R. P. Maas, S. A. Dressing, M. D. Smolen, and F. J. Humenik, "Appropriate Designs for Documenting Water Quality Improvements from Agricultural NPS Control Programs," in *Perspectives on Nonpoint Source Pollution,* U. S. EPA, 1985, at 33-34.

41. *Nonpoint Source Monitoring and Information Guide,* 1988, *supra* note 19, at 54-55; Spooner, Maas, Dressing, Smolen and Humenik, 1985, *supra* note 40, at 33.

42. *Nonpoint Source Monitoring and Information Guide,* 1988, *supra* note 19, at 55; Spooner, Maas, Dressing, Smolen and Humenik, 1985, *supra* note 40, at 33-34.

43. *Nonpoint Source Monitoring and Evaluation Guide,* 1988, *supra* note 19, at 55; Spooner, Maas, Dressing, Smolen and Humenik, 1985, *supra* note 40, at 33-34.

44. *Nonpoint Source Monitoring and Information Guide, supra* note 19, at 69-71.

45. *Id.* at 71.

46. *Id.*

47. *Id.*

48. *Id.* at 74.

49. *Id.* at 74-79.

50. *See* Hague, Bart, "Handling Cumulative Impacts in Nonpoint Source Programs," in *Lake and Reservoir Management: An International Journal Volume III*, North American Lake Management Society, Washington, D.C., 1987, at 131-133.

51. *Id.* at 131. The implementation of land use programs to control NPS pollution is discussed in other chapters of this report.

52. *Id.* at 134-136.

53. Data on individual developments is needed to evaluate and control their environmental impacts as well as to design effective ordinances, BMP's, etc. Information concerning general land use patterns is needed to anticipate potential problems and opportunities in specific geographic and resource management areas and to address them through long range planning by appropriately altering zoning maps, surface water protection zones, economic growth policies, and other control measures.

54. Hague, 1987, *supra* note 50, at 133-134.

55. *Id.* at 134.

56. *Id.* at 134-135.

57. *Id.*

58. *See generally Setting Priorities*, 1987, *supra* note 3.

59. *See generally* Maas, R.P., Smolen and Dressing, "Selecting Critical Areas for Nonpoint-Source Pollution Control," 40 *JSWC* 68-71 (1985); Maas, R.P., M. D. Smolen, S. A. Dressing, C. A. Jamieson and J. Spooner, "Practical Guidelines for Selecting Critical Areas for Controlling Nonpoint Source Pesticide Contamination of Aquatic Systems," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, 1985, at 363-367.

60. "Selecting Critical Areas for Nonpoint-Source Pollution Control," 1985, *supra* note 59, at 70-71.

61. *See generally Wasteload Guidance*, 1985, *supra* note 7.

62. See Chapter Nine for a discussion of the Wisconsin Nonpoint Source Pollution Abatement Program.

63. Quoted from Wisc. Admin. Code § 120.08(1)(a) NR (1986).

64. *See generally WIN User's Manual*, 1987, *supra* note 22.

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65. *Id.* at 1.

66. *Id.*

67. Baun, Ken, *The Wisconsin Nonpoint (WIN) Model (Version 1.0)–Application Demonstration*, Wisconsin Department of Natural Resources, August, 1987, at 1 (hereinafter cited as *WIN Application Demonstration*).

68. *Id.* (paraphrased).

69. *Id.* at 2.

70. Wisconsin Department of Natural Resources, *A Nonpoint Source Control Plan for the Crossman Creek - Little Baraboo River Priority Watershed*, October 1985, at 5-7.

71. *Id.* at 8.

72. *Id.* at 9-10.

73. *Id.* at 10.

74. *Id.* at 10-11.

75. *Id.* at 11.

76. *Id.* at 12.

77. *Id.*

78. *Id.*

79. Fla. Stat. Ch. 87-97 (1987); Fla. Admin. Code 17-43 (1988). See Chapters Nine and Ten for a more general discussion of this program.

80. South Florida Water Management District, 1988, *supra* note 22, at 18-20, 62-63.

81. *See generally* Curran, Sidney J. Jr., John W. Wilkinson and Nicholas L. Clesceri, "Prediction of Quantiles in Distributions of Chlorophyll a Concentrations," in *Lake and Reservoir Management: An International Journal*, Volume III, North American Lake Management Society, Washington, D.C., 1987, at 202-212.

82. *Id.* at 202.

83. *Id.* at 203-204. While precisely determining the true maximum chlorophyll *a* level for a given waterbody often is not feasible, statistical techniques have been developed that indicate the likelihood that a maximum chlorophyll *a* level will be exceeded at a given frequency, based on average (mean) levels determined through a specified number of samples or observations. Also, mean levels can be determined more precisely than maximum levels. Using this process, a water quality standard (in this case, an average, or mean, standard) can be set such that a desired maximum will not be violated within an acceptable degree of certainty. Statistically inferring violations based on average values is more feasible and accurate than attempting to measure maximum levels or the frequency of violations directly. The data gathered to *establish the*

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standard could also be used to establish sampling programs to *monitor for compliance with the standard*. In addition, other models can be used in conjunction with this process to determine if mean chlorophyll *a* standards will be violated given various poison runoff management scenarios. Finally, it might be possible to incorporate seasonal and area-specific relationships into the modelling process. *Id.* at 204-211.

84. *See generally* Wheeler, Philip H., Rochester-Olmsted Consolidated Planning Department, *Olmsted County's Farmland Soil Loss Controls and Computerized Soil and Land Cover Data–Olmsted County Uses* (no date).

85. *Olmsted County's Farmland Soil Loss Control*, (no date), *supra* note 84, at 1.

86. *Id.* at 4.

87. *Id.*

88. *Id.*

89. *Id.* at 6.

90. *Id.* at 9.

91. *Id.*

92. Memorandum from Douglas Krueger, Chairman, Olmsted County Board of Supervisors, to City Councils, Township Officers, Planning Advisory Commission, *et al.*, December 2, 1986; Presentation Memorandum from Geri Maki to Olmsted County Commissioners (Topic: Minnesota Geologic Survey Maps Associated with the Geologic Atlas), presented November 22, 1988.

93. Krueger, 1986, *supra* note 92; *see* Maki, 1988, *supra* note 92.

94. Krueger, 1986, *supra* note 92; Maki, 1988, *supra* note 92.

95. Krueger, 1986, *supra* note 92; Rich Peter, Olmsted County Department of Department of Health, March 29, 1988 (personal conversation).

96. *See generally* Schueler, Thomas R., *Controlling Urban Runoff: A Practical Manual for Planning And Designing Urban BMP's*, Metropolitan Council of Governments, Washington, D.C., 1987.

97. *Id.*

98. *Id.*

99. *Id.* at 1.9-1.22.

100. *Id.* at 1.9.

101. For instance, the methods are used to:

1. calculate the annual increase in phosphorous and nitrogen loads from the development of a 38 acre woodland site to a townhouse community with a 45% impervious area;

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2. estimate the loss of storage volume in a 7,500 cubic yard pond draining a 106 acre, 55% impervious watershed over a 20-year period; and
3. determine whether a development will increase levels of trace metals beyond a specific numeric criterion for protecting aquatic life in a trout stream.

Id. at 1.18-1.20.

102. *NWQEP Notes*, No. 28, North Carolina State University, Agricultural Extension Service, September 15, 1987.

103. *Id.*

104. *See* CWA § 303(d)(1)(C), 33 U.S.C. § 1313(d)(1)(c).

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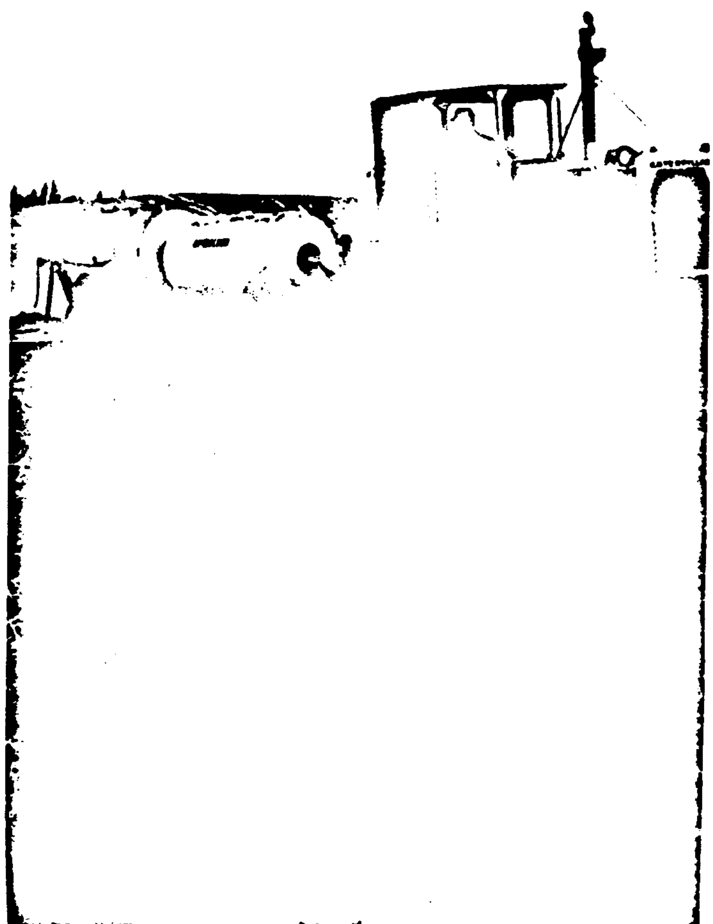

Funding for poison runoff control programs can be provided through a variety of taxes—such as a fee charged for the purchase of inorganic fertilizer.

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Chapter Seven

Funding: A Crucial Program Component to Which Everyone Must Contribute

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Introduction

Poison runoff constitutes the largest type of water quality impairment for waters not supporting designated uses.[1] Yet many states spend less per year on programs to control poison runoff than would be needed to build, or even substantially modify, a single sewage or drinking water treatment plant. States often fund programs primarily through general appropriations. They have been slow to develop alternative funding sources, such as special taxes, or otherwise to shift some of the funding burden to localities or to classes of landowners who are *responsible* for the water quality problems.[2]

The price tag for controlling poison runoff is high, but so is the cost of inaction.[3] The annual costs of the instream damages of soil erosion only (excluding many biological impacts) have been estimated at $4.1 billion annually.[4] Adequate funding obviously is critical to the development of an effective and efficient control effort. High levels of funding are especially crucial for programs that depend on cost sharing to implement all or most of the BMPs that are needed to restore beneficial water uses.

As an example, the costs of installing all of the BMPs needed to restore and protect the waters in two Wisconsin watersheds of 214 and 128 square miles have been estimated by the state to be $7,574,679 and $4,181,000, respectively.[5] Not surprisingly, in areas where aggressive controls are being developed, officials have established a wide variety of sources to generate the necessary funds.

There are two categories of funding issues. The first could be labeled "cost-effectiveness": getting the most control benefits for the dollars spent. Cost effective programs to control poison runoff are the subject of other chapters in Parts 2 and 3 of this report. The second category of funding issues, which is discussed in this chapter, is *how* programs can and should be funded. In other words, who should pay for control programs, and how?

States Cannot Rely on Federal Funding[6]

When Congress added section 319 to the Clean Water Act in 1987, it *authorized* $400 million over four fiscal years to fund state nonpoint source management programs.[7] However, Congress has yet actually to *appropriate* any funds for this program. This omission is ironic given federal expenditures of tens of billions of dollars to reduce water pollution from municipal sewage treatment plants.[8]

States and environmental groups should (and undoubtedly will) continue to press Congress to appropriate the funds authorized in the 1987 amendments. But given the federal budget deficit, states at least should plan for the possibility that the federal coffers may remain closed. Moreover, as explained above, the authorized level of federal funding would fall far short of the overall program needs of 50 states, not to mention local jurisdictions.

Therefore, states need to find other ways to fund programs to manage poison runoff. Some innovative examples of how this can be done, and how funding mechanisms can be used as a

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stimulus to induce better behavior by those generating the pollution, are given below.

Management Improves When the "Polluter Pays"

Cost sharing and other programs that are financed through general revenues result in taxpayers bearing the costs of pollution control.[9] It is questionable whether the public will or should accept these costs, especially as the cost of controls increases.[10] Moreover, using general revenues to "buy" pollution abatement fails to promote cost-effectiveness.

Many (often most) polluters will not participate in cost sharing programs unless the rate of payments leaves them better off than if they had done nothing at all—a rate of payment that may be unacceptably high to taxpayers.[11] In fact, from an efficiency standpoint, cost sharing generally is not favored by economists because it can lead to unnecessarily high pollution control costs.[12] This is partly because, if taxpayers as a whole are the ones who pay to solve pollution problems caused by individual sources, those sources will have little or no incentive to prevent or control problems on their own.

The "polluter pays" principle, the idea that polluters should be primarily responsible for the direct costs of pollution abatement, is supported by many researchers and many state and local programs.[13] Individual polluters (whether private or public) are given an economic incentive to remove themselves from the category of "polluter". In this sense, funding is both a *tool* for reducing poison runoff and a *resource* to support other controls.

For instance, variable taxes[14] or other fees that increase according to the potential for a particular activity to generate water pollution, are considered to be one of the two *most* effective means of controlling levels of poison runoff, *if* they are set at sufficiently high levels.[15] An example is a fertilizer sale or application fee set at a level sufficiently high to deter excess usage. The application of fertilizer at levels greater than that needed for crop productivity can be taxed based on allowable limits set by soil tests, cropping patterns and safety margins.[16]

Where these costs could cause significant economic impacts on the polluting class, however, it may be appropriate for the beneficiaries of the control programs (*i.e.*, the public) to contribute to program funding requirements.

Estimating the approximate costs associated with controlling poison runoff are important steps in designing a management program. Formulas and models have been developed to estimate the costs to the farmer, developer, locality, and other parties of installing individual BMPs.[17]

Examples of Innovative Funding

Methods of financing the public costs of nonpoint source pollution control include taxes on fertilizers and chemicals, taxes on land development or land transfer for purposes of development, stormwater utility fees, general tax revenues and a host of fees, assessments charges and penalties.[18] The remainder of this chapter provides examples of some of the many methods available for generating sufficient funds to develop and implement aggressive runoff controls, while deterring behavior that results in water pollution.

In Wisconsin, over $36 million in state revenue was appropriated for controlling poison runoff between 1979 and 1987, with less than 20% of these funds going to administrative costs.[19] Currently, funding has stabilized so that each year approximately $6.7 million is appropriated for carrying out the state's Nonpoint Source Pollution Abatement Program.[20] This program is funded through the state's general revenues.

In addition, the Wisconsin Groundwater Management Act (GMA) establishes a process for the development of state programs to control both nonpoint and point sources of groundwater contamination.[21] The GMA also requires that a set of fees (which amount to over $1.5 million per year) be collected to assist in the development and implementation of state groundwater protection programs. Among these fees, summarized in Table 7-1, are charges applicable to pesticide manufacturers and distributors as well as to purchasers of fertilizer:

Table 7-1
Summary of Annual Fees Imposed Under the Wisconsin Groundwater Management Act*

A. Department of Agriculture, Trade and Consumer Protection

1. Pesticides

Basic fee: $100 license fee

Groundwater fee: $2,000 for each manufacturer of the active ingredients of a pesticide [40 manufacturers]
$300 for distributors [660 distributors]
$100 for distributors of only one pesticide [100 distributors]

Total groundwater fees collected: $288,000

[Fee collected before the end of the year for an annual license issued for the following calendar year. Fee first collected in late 1984 for the 1985 licenses.]

2. Fertilizer

Basic fee: $0.10 per ton for inspections;
$0.10 per ton for research

Groundwater fee: $0.10 per ton [1,300,000 tons]

Total groundwater fees collected: $130,000

B. Department of Natural Resources

1. Septage Haulers

Basic fee: $25 license fee for residents;
$50 for nonresidents

Groundwater fee: $50 per license [705 licenses]

Total groundwater fees collected: $35,300

2. Wastewater and Sludge Land Disposal

Basic fee: None

Groundwater fee: $100 per permittee [1,010 permittees]

Total groundwater fees collected: $101,000

[Fee proposed by DNR to be collected before the end of the year for the subsequent calendar year. Fee proposed to be first collected for calendar year 1985.]

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* Source: Patronsky, Mark C. and Anne Bogan-Reick, *The New Law Relating to Groundwater Management [1983 Wisconsin Act 410]*, Wisconsin Legislative Council Staff, July 10, 1984, at 21-23 (paraphrased). The total fees collected are estimates based on recent information about each relevant activity. *Id.* at 21.

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3. **Solid and Hazardous Waste Disposal**

Basic fee:	Generally, \$0.035 per ton for solid waste; \$0.35 per ton for hazardous waste; \$0.001 for mine waste rock within this range. Other fees apply to different wastes.
Groundwater fee:	\$0.10 per ton [6,300,000 tons] \$0.01 per ton for prospecting or mining waste [no current disposal]
Total groundwater fees collected:	\$630,000

[Fee collected in April for the total amount of waste disposed during the previous calendar year. Fee first collected for waste disposed on or after January 1, 1984.]

C. **Department of Industry, Labor and Human Relations**

1. **Private Sewage Systems**

Basic fee:	Basic sanitary permit fee is \$41; counties may charge more
Groundwater fee:	\$25 per permit [14,000 permits]
Total groundwater fees collected:	\$350,000

[Fee collected whenever a county issues a sanitary permit. Fee first collected for permits issued on July 1, 1984.]

2. **Petroleum Product Storage Tanks**

Basic fee:	\$32 or \$43 for plan examination, depending on size of tank; \$43 for site inspection
Groundwater fee:	\$100 per inspection [425 inspections]
Total groundwater fees collected:	\$42,500

[Fee collected when an application for plan approval is submitted to the DILHR. Fee first collected for plan approvals submitted on May 11, 1984.]

Total Amount Collected Annually for the Groundwater Fund: **\$1,576,800**

Groundwater legislation enacted in Iowa,[22] largely to address the water quality impacts of such pollutants as nitrates and pesticides, also reflects the "polluter pays" principle. Over \$42 million will be raised over a five year period through fees on a variety of products that can pollute groundwater.[23] Manufacturers of pesticides and fertilizers will pay annual fees ranging from \$250 to \$3000 depending on sales. Farmers must pay taxes amounting to \$0.75 per ton for nitrogen fertilizer. Thus, there is a direct link between the fee and the amount sold or the amount used.

The Florida point/nonpoint source waterbody restoration program (called SWIM for Surface Water Improvement and

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Management and described elsewhere in this report) currently is funded by general revenues. However, legislative attempts are being made to provide a dedicated funding source by earmarking 5% of the revenue of the "documentary stamp tax" for the SWIM program.[24] The stamp tax is a 1 mill (.1 cent for each dollar of appraised value) fee that must be paid to the state every time titles to real estate are transferred.[25] If this proposal is adopted, more than $25 million a year would be provided for the state SWIM program.[26] In light of the impact that urban development is having on the state's water quality, such a tax seems logical and reasonable.

There are other examples of property taxes used to finance control programs. Florida's nine Water Management Districts each has statutory authority to levy ad valorem property taxes to be added on to county property tax assessments.[27] These modest taxes (below 1 mill) provide the entire operating budget for the Water Management Districts.[28] For instance, a tax of under 0.4 mill provided the St. Johns River Water Management District with $28 million in operating funds in 1987.[29]

Property taxes have the potential to be an important source of revenue for carrying out programs. The Natural Resources Districts (NRDs) in Nebraska (large multi-purpose regional environmental management agencies)[30] also obtain their funding from property taxes.

Property tax revenue for water pollution controls can and should be used to fund Soil and Water Conservation Districts (SWCDs) since, without this authority, SWCDs are limited in the projects that they can undertake.[31] SWCDs currently do not have the right to levy property taxes themselves largely because the right of taxation was not originally a part of the model enabling legislation developed at the federal level and used by states in establishing the soil conservation partnership in the 1930s.[32] But states can and should amend their current laws to enable SWCDs to impose such taxes.

To a greater extent, within SWCDs, taxes can be collected to implement programs in localized watersheds. However, in most states with legislation that still contains either of these provisions, the taxes can only be established after a referendum is passed at the local level and specific state authorization is provided.[33] Therefore, an important (and legitimate) source of revenue is being neglected almost completely.

Local governments currently provide approximately 50%[34] of the operating funds of SWCDs (which are units of state government), making it difficult to incorporate federal and state goals into SWCD programs or for SWCDs to plan projects based on steady, predictable income.[35] SWCD dependence on localities for funding also detracts from the separate program activities that local governments need to undertake.

The National Association of Conservation Districts (NACD) urges local SWCDs to use their taxation power when it is available, and to seek this authority when it is not available.[36] The SWCD is a unit of state government that can work toward state and regional goals. The SWCD needs the right to tax without the approval of local landowners, since they often are the sources as well as the victims of pollution impacts from land use activities.

In addition to property taxes, local governments have available a host of fees that they can (and in some cases do) charge to raise revenues for pollution control. Many of the land use controls described in Chapter Four are commonly associated with permits that individual developers must obtain before land-clearing, grading or construction can take place. These include permit fees charged for submitting site plans or obtaining building, grading or erosion control permits, variances from zoning ordinances, etc. At a minimum, these permit fees should cover the costs of processing the permit, inspecting the site, and related enforcement tasks.

An important new local charge that is fast becoming popular is the impact fee, designed to compensate local residents inconvenienced by a development as well as to provide the roads, schools, and other services needed to accommodate the new growth. By some estimates, over $340 million per year[37] (probably more than was provided in agricultural costsharing by all 50 states) is currently contributed by developers in impact fees in return for a "green-light" on development projects.

"Impact" fees can be problematic if they are used merely to "offset" or compensate for environmental impacts. This approach runs the risk of putting a price on permission to pollute the water—an approach that is not consistent with federal or state water quality goals and objectives. State and local water quality officials must incorporate specific water quality goals into a larger and more comprehensive state-wide management program to ensure that "impact" fees are used to secure real water quality benefits. These fees should not be charged as "fees to pollute," but instead should be used to provide for controls in situations where development is a desirable local addition *as long as water quality impacts can be avoided.*

If done properly, assessing fees that could be used to prevent or even decrease the impacts of poison runoff from otherwise desirable developments or activities is a powerful tool for designing state and local controls. In situations where the impacts of a development or activity cannot be avoided completely, fees can act as an incentive to the would-be polluter to mitigate the impacts as much as possible.

Stormwater, sewer and septic system maintenance utilities can be used to provide funds for control programs. For instance, Bellevue, Washington established a utility specifically for the management of surface runoff and stormwater.[38] The utility currently charges rates based on the amount of impervious surface, and hence runoff, generated from a site.[39]

Finally, in the past many localities actually have *encouraged* additional water pollution by providing property tax breaks and other incentives to invite new industrial, commercial, or other development.[40] These types of incentives should be reduced or eliminated in cases where increased water pollution will result. Where development occurs, the increased tax revenues can be used to fund programs to control poison runoff.

Conclusions and Recommendations

Given the low level of funding currently provided by the federal government, state and local officials must examine alternatives to traditional general revenue sources in order to fund programs to control poison runoff. These alternatives should serve the dual purpose of deterring behavior that causes pollution and providing the resources to carry out controls.

The following recommendations summarize the main points of this chapter:

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1. Funding for controls should not depend primarily on general revenues, and cannot rely on federal funds.

2. Where possible, the groups responsible for water quality problems should contribute to program funding.

3. Where possible, funding should be used as a tool to dissuade groups from undertaking activities that generate pollution. Examples of such negative incentives include:
   a. taxes on pesticide or fertilizer use, and other farm practices that could result in water quality degradation;
   b. stormwater utility fees based on percentage of impervious cover;
   c. taxes on land transfers for purposes of development; and
   d. timber or mineral assessments based on the amount of land disturbed.

4. Property taxes (charged by regional water or environmental management agencies or local governments) are an important source of funds for controlling poison runoff.

5. SWCDs should be given authority to raise revenue for water quality protection within the entire district through levying property taxes.

6. Fees and charges associated with local land use controls, such as impact fees and surface and storm water management utilities are important funding sources and should be high enough to be a significant source of local revenue for achieving state water quality goals.

7. Permit fees should, at a minimum, offset the costs associated with processing and enforcing the permits.

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1. U.S. EPA, *National Water Quality Inventory: 1986 Report to Congress*, November, 1987, at 3.

2. For instance, part of the regulatory program for soil erosion control in Iowa can only be enforced against a landowner found in violation (*i.e.*, the landowner has injured a private party) of the standard if the state provides 75% of the funds for the preparation and implementation of the necessary conservation measures. Cooperative Extension Service, *Iowa Agriculture and Water Quality: Sediment and Water Quality*, Iowa State University, August 1980.

3. Clark, Edwin H. II, Jennifer A. Haverkamp, and William Chapman, *Eroding Soils: The Off-Farm Impacts*, Washington, DC, The Conservation Foundation, 1985.

4. Clark, Edwin H., "The Off-Site Costs of Soil Erosion," 40 *JSWC* 20 (1985).

5. *See* Wisconsin Department of Natural Resources, *A Nonpoint Source Control Plan for the Crossman Creek - Little Baraboo River Priority Watershed*, October, 1985, at 77; Wisconsin Department of Natural Resources, *A Nonpoint Source Control Plan for the Oconomowoci River Priority Watershed Project*, 1986, at A, 9 (hereinafter cited as *Crossman Creek - Little Baraboo River Priority Watershed and Oconomowoci River Priority Watershed Project*, respectively).

6. This chapter addresses funding sources other than those provided through the federal government.

7. CWA § 319(j); 33 U.S.C. § 1329(j).

8. *See* CWA § 207; 33 U.S.C. § 1287; U.S. EPA, November, 1987, *supra* note 1, at 129-131.

9. *See generally* Braden, John B., "Financing Nonpoint Pollution Abatement: The Peculiar Case of Agriculture," paper presented at the Conference on Political, Institutional and Fiscal Alternatives to Adequate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987.

10. Dunn, James W. and James S. Shortle, "Agricultural Nonpoint Source Pollution Control in Theory and Practice," paper presented at the Conference on the Economics of Chesapeake Bay Management III, Annapolis, Maryland, May 27-29, 1987, at 16.

11. *Id.* at 17; *see* Miranowski, John A., "Macro-economics of Soil Conservation," in *Conserving Soil - Insights from Socioeconomic Research*, eds., Lovejoy, Stephen B. and Ted L. Napier, Soil Conservation Society of America, Ankeny, Iowa, 1986, at 23.

12. Krupnick, Alan J., "Economics and Nutrient Reductions in the Chesapeake Bay," paper presented at the Conference on Economics of Chesapeake Bay Management IV, Baltimore, Maryland, May 23-25, 1988, at 28.

13. See Chapter Three for a discussion of agricultural runoff control programs that require the polluter to assume some of the costs of pollution control. Chapters Four and Five describe programs where the "polluter pays" to control other types of water pollution. *See, e.g.,* Braden, 1987, *supra*, note 9.

14. See Chapter Three for a more thorough discussion of the effect of taxes on poison runoff.

15. Dunn and Shortle, 1987, *supra* note 10, at 18.

16. *Id.* at 17.

17. *See, e.g.,* Heimlich, Ralph E., "Economics of Size in Dairy Farm Adjustment to Water Quality Constraints", paper presented at AAEA Meetings in Logan, Utah, August, 1982; Crowder, Bradley M. and C. Edwin Young, *Modeling Agricultural Nonpoint Source Pollution for Economic Evaluation of the Conestoga Headwaters RCW Project,* U.S. Department of Agriculture, Economic Research Service, Washington, DC, 1985.

18. Many of these revenue sources are described in the preceding chapters of this report, in the context of the programs they were designed to support.

19. Susan Bergquist, Wisconsin Department of Natural Resources, September 5, 1986 (personal conversation). Appropriations from 1979-1985 totaled nearly $24 million. Konrad, John G., Baumann and Bergquist, "Nonpoint Pollution Control: The Wisconsin Experience," 40 *JSWC* 58 (1985).

20. Mike Llewelyn, Wisconsin Department of Natural Resources, August 8, 1988 (personal conversation).

21. *See* Wisc. Stat. § 160.001 *et seq.* This program is described more fully in Chapter Three.

22. 1987 Iowa Acts Ch. 255; Iowa Code Ann. Ch. 455E (1987).

23. Johnson, Paul W., "Iowa's 1987 Groundwater Protection Act: Purpose and Process," paper presented to the Freshwater Foundation Conference on Agricultural Chemicals and Groundwater Protection, St. Paul, Minnesota, October 22-23, 1987.

24. Gail Hankinson, Florida Department of Environmental Regulation, August 4, 1988 (personal conversation).

25. *Id.*

26. *Id.*

27. Fla. Stat. Chapter 373, Part V (1986).

28. Hankinson, 1988, *supra* note 24.

29. *Id.; see generally* St. Johns River Water Management District, *Final 1988-89 Budget October 1,* 1988 through September 30, 1989, September 28, 1988.

30. Such entities as Soil and Water Conservation Districts and Sewage and Drainage Districts have been incorporated into the NRDs.

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31. Schloesser, Lynn L., "Agricultural Non-Point Source Water Pollution Control Under Sections 208 and 303 of the Clean Water Act: Has Forty Years of Experience Taught Us Anything?," 54 *NDLR* 608 (1977-1978).

32. *Id.* at 609.

33. Eugene Lamb, National Association of Conservation Districts, August 5, 1988 (personal conversation); *see* "Major Provisions of Conservation Districts Laws Enacted by States and Possessions in Effect as of January 1, 1975–Table 4," enclosure in letter from Eugene Lamb, National Association of Conservation Districts to Paul Thompson, Natural Resources Defense Council, August 18, 1988.

34. Lamb, August 5, 1988, *supra* note 33. The other 50% comes from state and federal sources. *Id.*

35. Schloesser, 1977-1978, *supra* note 31, at 609.

36. National Association of Conservation Districts, *Conservation Districts into the 1990's*, 3rd Report of the Special Committee on District Outlook, February, 1986, at 5.

37. *See* Schneider, *Ann Arundel Puts Price on Development*, Washington Post, August 7, 1988, at A1, col. 2.

38. Puget Sound Water Quality Authority, *Issue Paper - Nonpoint Source Pollution*, May 6, 1986, at 4-115.

39. Stormwater utility fees are discussed in greater detail in Chapter Four.

40. *See* McCarthy, David, Jr., *Local Government Law in a Nutshell*, West Publishing Co., St. Paul, Minnesota, 1975, at 255-256; Elleckson, Robert C. and A. Dan Torlock, *Land-Use Controls -Cases and Materials*, Little, Brown and Company, Boston, Massachusetts, 1981, at 1041; Buresh, James C., "State and Federal Land Use Regulation: An Application to Groundwater and Nonpoint Source Pollution Control," 95 *Yale L.J.* 1439-1440 (1986).

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Authority to control Poison Runoff ultimately must be granted by Congress and state legislatures around the country.

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Chapter Eight

Poison Runoff Control and State and Local Legal Considerations

Introduction

A variety of legal tools are needed to control poison runoff. In addition to Federal laws,[1] states need to make the best possible use of their own legal authority to control this pervasive problem. This chapter focuses on the state-level legal authority needed to control poison runoff effectively. The development and implementation of the programs resulting from these laws is discussed in the following Part.

Various controls can use or require several types of legal authority. First, State Environmental Policy Acts (SEPAs) can be used to review the water quality impacts of actions proposed by private, local, state and federal entities and to require that any identified impacts (including long-term "cumulative" impacts) be avoided or otherwise mitigated. Also, poison runoff from existing and proposed land use practices can be reduced by laws that require the imposition of *source controls* (or BMPs) to address specific pollution-generating activities and situations, such as construction and urban development. In addition, an array of land use laws can be passed to regulate the location, type, and density of activities so as to prevent or reduce poison runoff. Finally, the exercise of common law also influences how well poison runoff is controlled.

State officials should ensure that all necessary types of legal authority are available to employ the range of controls that are needed.[2] State programs that use only source controls, as exemplified in many respects by the traditional soil conservation model, will miss many important cost-effective control opportunities. Moreover, programs based only on traditional source control approaches (such as voluntary BMP programs) may have no teeth when they come into conflict with other state and local laws designed to *encourage* urban development, agriculture, mining activities or timber cutting.[3] Recent efforts by states and localities, and a good deal of academic opinion, attest to the environmental and economic value of relying on broader, more comprehensive legal authorities to control land use and government decisionmaking when developing and implementing state management plans to control diffuse sources of water pollution.[4]

The legal framework for effective management often can be implemented *using existing–but re-oriented*–legal authority. Zoning or development planning authorities, for example, can be re-oriented to consider and mitigate poison runoff as part of the planning and zoning equation. And the benefits from this reorientation may go far beyond water quality. Land use planning to prevent poison runoff frequently enhances aesthetics and improves recreational opportunities.[5] With thoughtful planning, controls can achieve more pollution control for less money or provide benefits external to water quality protection, such as improved economic development or open space recreation.

This chapter discusses how to make better use of the legal tools relevant to nonpoint source pollution control. First, ways to overcome obstacles to an effective legal framework are discussed. The chapter then describes briefly the application of SEPAs, source control statutes, land use and common law to programs designed to control poison runoff. Emphasis is placed

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on the opportunities to expand and integrate land use controls into existing state and local activities. For the most part, these uses of legal authority are extensions, reorientations or alternatives to current interpretations of existing laws. They do not represent major shifts in existing state source control or land use control laws. The chapter concludes with a description of the key attributes of an effective legal framework for controlling poison runoff.

Overcoming Legal Obstacles

As discussed in Chapter Two, the Clean Water Act and state water quality protection laws provide ample legal authority to develop, implement and enforce whatever state and local controls are needed to control poison runoff. At times, however, states inadvertently may have created legal barriers that inhibit the development and implementation of successful controls. Some of these problems can have substantial impacts. Fortunately, these barriers usually can be removed by amending existing laws.

1. *Adequate Delegated Authority*

First, state law must ensure that local governments have adequate authority to control poison runoff. For example, localities in many states, particularly those whose local powers are conferred according to Dillon's Rule, have been reluctant to use land use controls for environmental protection purposes because of a feared lack of legal authority.[6] Under Dillon's rule, local governments have "only those powers that are expressly granted, those that are necessarily or fairly implied from expressly granted powers, and those that are essential and indispensable."[7]

However, localities may well be underestimating their powers. The Standard Soil Conservation Act, adopted by many states to establish the authority of soil and water conservation districts (SWCDs), contains provisions authorizing the development of land use regulations to conserve soil and water resources.[8] To the extent that local governments can work with SWCDs to develop and implement such land use controls, a method is available to use local land use controls as a management tool.

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While this authority has been retained in over half of the states, it seldom is used.[9] Therefore, in Dillon's Rule states, it is important that state law explicitly recognize the authority of local governments to utilize their land use powers to protect state waters and to comply with water quality standards.

2. *Preemption*

Second, state laws (such as erosion and sediment controls at construction sites or water quality standards) should not preempt the adoption of more stringent controls by localities. By ensuring that state law sets only *minimum* standards, states can allow localities to be more stringent as necessary to protect sensitive or valuable local features.

3. *Federal-State-Local Relationships*

Whether federal and state levels of government should become involved directly in managing dispersed pollution sources is another important issue. Because of the localized nature of the problem, a federal role that concentrates on overseeing and influencing state programs rather than on regulating individual polluters probably is the most effective.[10] For similar reasons, state laws should assign significant responsibility to localities and should concentrate on oversight and enforcement of local efforts (*e.g.*, developing minimum program requirements or load reductions, monitoring for compliance, assuring consistency in a watershed that crosses jurisdictional boundaries) rather than on the individual landowner.[11] In addition, funding and technical assistance should be provided to localities by the state to enable localities to develop such specialized controls.

Types of Legal Authority Applicable to Poison Runoff

State Environmental Policy Acts (SEPAs)

State environmental policy acts (SEPAs), which require state or regional reviews of activities with potentially adverse environmental consequences and the preparation of Environmental Impact Statements, present important opportunities for poison runoff control. They enable officials to ensure that developers consider alternative proposals and utilize innovative techniques—or limit projects—to mitigate water quality (as well as other environmental) impacts.[12] Of course, for these purposes, it is important that SEPAs and other similar laws extend to municipal as well as state actions so that private land use and development come under their coverage.[13] Some states, including Massachusetts and California, already require local agencies to prepare environmental impact statements in certain circumstances for government or private actions with greater than local significance.[14]

To perform this "watchdog" role, SEPAs should cover activities subject to governmental regulatory and licensing activities (as under the National Environmental Policy Act).[15] Obviously, activities that may either cause or promote water pollution should fall within the scope of such laws.

Generally, SEPAs worded in a fashion similar to NEPA have "low threshold" standards, making Environmental Impact Statements (EIS) necessary for public projects, such as state construction activities, as well as for state approval of potentially significant private actions, embodied in such public actions as annexation, changing a zoning ordinance, or approving subdivisions.[16] When both federal and state laws require the preparation of an EIS, the two processes should be coordinated.[17]

Specific criteria for reviewing EIS might include the application of such principles as best control technology, best management practices and maximum mitigation that must be used before a proposed activity can be approved by reviewing agencies or courts.[18] In addition to the pollution reduction achieved through the SEPA process, SEPAs are very important in raising the awareness and the understanding of local officials, developers and the public regarding the sources, and potential controls, of poison runoff.

Some localities in Long Island, New York use the requirements of the State Environmental Policy Act to obtain information about proposed development projects,[19] such as: a description of the project, topography and geology, water pollution and coastal impacts, and abatement measures.[20] This information is used to assess the potential environmental impacts (including water pollution) of a proposed development and as a basis for requiring modifications to (or prohibiting) the project.

"Source Control" Laws: Benefits from Mandatory BMP Implementation

Source controls reduce poison runoff through physical or engineering solutions, once a particular activity or land use has already begun. Although not sufficient by themselves, effective source controls are a necessary part of a successful effort to control poison runoff. Prime examples of source control laws include those to control erosion and sedimentation from construction activities and stormwater discharges from both existing and new urban development.

Erosion and Sediment Control Laws.[21] Erosion and Sediment Control Laws (ESCLs) applicable to construction sites are perhaps the most widely accepted and common method of controlling soil erosion through regulatory means. At least 24 states have enacted ESCLs over the past 15 years[22], primarily to control the off-site water quality impacts caused by construction activities.[23] These laws vary significantly in content. Enabling legislation can empower states with varying degrees of authority to develop guidelines, review and enforce individual permits and plans, and impose civil penalties.[24] (To be more effective for controlling sediment deposition, these enabling clauses should be revised to make clear that water quality protection is a specific goal of the ESCL.) In addition, most ESCLs allow at least some program authority to be granted to localities while also providing for state oversight of this local authority.[25]

ESCLs can be designed to apply to activities other than construction, including agriculture and mining.[26] For example, Pennsylvania's ESCL combines programs for erosion control in urban settings with agricultural erosion and runoff controls.[27] ESCLs also can be the basis for controlling post-construction erosion, sedimentation, and stormwater.[28]

It is important that the effectiveness of ESCLs for pollution control at construction sites not be diminished by excessive exemptions.[29] Another facet to consider is the relationship between ESCLs and stormwater management laws (discussed

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briefly below). Techniques (such as flow channelization) that control construction site runoff, but that lead to increases in stormwater flow or contamination should be prohibited by ESCLs.

Stormwater Management Laws.[30] State laws mandating stormwater management rapidly are coming into acceptance in more and more states, notably Maryland, Florida and Washington. Like ESCLs, of course, their effectiveness varies with the authority established in the enabling legislation. States need specific legal authority to control the unique characteristics of urban stormflows (other than the purely construction-related erosion and sediment traditionally covered by ESCLs) because a large variety of sources contribute to urban stormwater pollution.[31]

The CWA requires at a minimum that channelized stormwater discharges from municipal separate storm sewer systems that serve populations of over 100,000 be regulated as point sources.[32] Moreover, stormwater permits are required immediately for any stormwater discharge that "contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States."[33] But in addition to meeting these minimum federal requirements, state stormwater management laws need to address problems not covered by these point source discharge controls. The Federal permit program will not cover any direct storm runoff (*i.e.*, un-channelized flow) or direct baseflow inputs into waterbodies. In addition, because of the intimate relationship between land use management and stormwater management, stormwater management laws should recognize the importance of local land use controls in managing urban runoff and protecting water quality.[34]

Because pollution impacts from urban stormwater are so closely associated with the process of runoff, stormwater management laws need to take a comprehensive approach to controlling all major forms of damage caused by runoff from both existing and new urban development. These include flooding, erosion/siltation, and other types of water quality degradation (including contamination by toxics, hydrocarbons or nutrients).

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Like ESCLs, state stormwater management laws should mandate state oversight and enforcement to ensure local compliance. State laws also should provide the necessary technical and human resources to implement stormwater controls.

Land Use Law

> Civil title to a portion of the earth does not confer absolute ownership....Private property is good because of the benefits it confers on the many, not because of the advantages it gives to the few.[35]

Many state programs to control poison runoff still are dominated by reliance on the limited imposition of BMPs after the fact—once land use patterns already have been determined largely without considering environmental impacts. This "ex-post" BMP application has limited value because "[p]ollution is an inherent by-product of land-development."[36] Thus, once certain land uses are established, the use of BMPs for controlling poison runoff will have limited success.[37] A second drawback of "ex post" BMP installation is that it fails to account for the cumulative impacts of individual land uses that by themselves are relatively harmless but collectively wreak havoc with natural systems and water quality.[38]

It has been stated that "[t]here are no substantial legal limits to state and federal regulation of poor land use practices that result in soil erosion."[39] But it is *local* political jurisdictions that historically have been granted most important land use planning powers (including those designed to reduce soil erosion) by state authorities.[40]

Local land use laws traditionally have not been utilized as tools for environmental management. Ironically, in many cases local zoning and other land use planning have *contributed* to water quality problems and overshadowed improvements in water quality that otherwise might have been gained as a result of federal point source control programs.[41]

Finally, however, the tide is shifting. Efforts now are underway to use land use law to control poison runoff. Some states and regions, such as Florida, Minnesota and Washington State's Puget Sound, are beginning to require that water quality

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concerns (including poison runoff) be addressed comprehensively in local land-use planning.[42] Clearly, water quality concerns can be incorporated into local land use decisions if the requisite political support can be amassed.

These local efforts will complement statewide water quality management planning activities routinely undertaken by state governments. These activities focus on achieving specific, statewide water quality goals.

It makes sense that local land use planning (as well as federal land use planning and management activities)[43] should be treated as tools to achieve federal and state water quality goals, because water quality protection is both a federal mandate *and* an important local economic and public welfare goal. Zoning, subdivision development, the Local Comprehensive Plan, critical areas protection planning to protect groundwater recharge zones or other environmentally sensitive areas,[44] coastal zone or wetlands protection, and farmland conversion laws, are among the local land use laws relevant to controlling poison runoff which need to be integrated with the water quality management requirements of the CWA.

Officials have begun to employ expanded land use management authority to achieve more effective programs.[45] For example, Florida has developed a set of minimum requirements that local land use planners must follow in order to protect water quality.[46] Site plan reviews and subdivision ordinances that require developers to employ measures to reduce groundwater impacts have been established in Long Island, New York.[47]

Because general land development poses a recognized threat to water quality, focusing control programs away from basic land use planning is irrational as well as inefficient.[48] Land use decisionmaking logically should be considered by state water quality officials.[49]

It is no longer considered prudent for state and local lawmakers and planners to ignore the severe pollution that occurs when the basic planning, development and land use management decisions are made simply because localities historically have been granted relative autonomy in this area.[50] Indeed, there is every reason to believe that this local autonomy has led to many of the very water quality impacts that now must be addressed by land use regulation at all levels of government.[51] Many states, such as Vermont, Florida, Hawaii and Oregon, have enacted land use legislation to identify and reduce the environmental harm from both large-scale development projects with regional impacts, and long-term, small-scale development with potentially significant cumulative impacts.[52] The following discussion summarizes the basic principles that the land use laws described above should embrace, in order to protect water quality from poison runoff resulting from land development.[53]

A state's enabling legislation should spell out principles of planning that will govern local land use decisions. As a foundation, the legislation should state the principle that development must be compatible with surrounding natural features and that water, the hydrologic cycle, and the carrying capacity[54] of an area are the "framework of land use design and the guiding principle for allocation of land use."[55]

State laws should provide for state review, modification and approval or rejection of the environmental (including water quality) components of local land use plans. State laws should mandate local Comprehensive Plans, as well as interjurisdictional coordination and dispute resolution. Water quality standards should be the ultimate criteria by which the water quality aspects of these Plans are judged. Land use laws also should grant authority to local governments to enact specialized land use controls[56] designed to reduce poison runoff.

Area-Specific Land Use Protection Laws. A number of states and regions have enacted land use laws designed to protect special areas, such as Maryland's "Critical Areas Law" and Florida's Beach and Shore Preservation Act.[57] These laws provide important controls over diffuse pollution sources. To be most effective, they should require the creation of a formal state-level program approval process that ensures statewide consistency.[58] Obviously, such laws also should expressly adopt as a goal the attainment of water quality standards.

Farmland preservation[59] and "right-to-farm" laws,[60] which provide incentives and subsidies to farmers who keep their land in agriculture,[61] should be elements of many states' overall legal framework to control poison runoff. To be most effective, state

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farmland protection laws should incorporate state water quality goals that focus on preserving *prime* farmland, as opposed to *all* agricultural land.[62] And receipt of program benefits can be tied to implementation of BMPs and other controls.

Common Law Remedies

As indicated below, the exercise of common law alone (in this case, primarily tort actions brought by injured parties against a polluter) clearly is not adequate to limit poison runoff to desirable levels.[63] However, states can encourage individuals who are harmed by poison runoff to use common law remedies to *supplement* the state's regulatory program.

Generally, the use of common law in reducing or eliminating any type of environmental degradation suffers from a number of serious limitations. These include: 1) limited ability to address damages external to any single plaintiff (*e.g.*, damages to the public in general or to future generations); 2) a relatively low number of plaintiffs bringing and winning damage suits; 3) a focus on compensating individuals after damages have occurred rather than on preventing pollution; and 4) a lack of technical or environmental criteria for use in making judgments.[64]

Poison runoff is particularly difficult to address with the common law. Often a large number of dischargers contribute incremental amounts of a variety of pollutants, and it can be impossible to identify the precise effluent characteristics of an individual polluter. Therefore, individual plaintiffs are likely to have difficulty proving that harm has occurred due to the actions of a single defendant or group of defendants.[65]

These limitations do not mean, however, that states cannot promote the use of common law remedies to supplement and reinforce the state's statutory programs to control poison runoff, and *vice versa*.[66] In particular, state statutes can create presumptions that make private tort suits easier to win. For example, statutes can provide that noncompliance with BMPs constitutes unreasonable conduct for purposes of private nuisance cases, or that activities that result in violations of water quality standards presumptively harm downstream water uses.[67] If the use of certain pesticides in sensitive groundwater recharge zones is prohibited, a statutory clause could deem the use of those

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pesticides unreasonable conduct for purposes of any tort proceeding brought by injured parties such as owners of contaminated wells.

Conclusions and Recommendations

Effective state laws are essential to promote and further control of poison runoff. The following list summarizes the main management needs that should be incorporated into the general legal structure of a state:

1. States should not radically restructure laws to provide the legal authority needed to address poison runoff, but instead should re-assert and re-orient existing powers under federal and state water quality protection standards.

2. Enactment of comprehensive "source control" laws for reducing erosion and sediment from construction sites and stormwater runoff damages from existing and new development should be mandatory for local governments.
   a. Relevant laws should give local governments the primary responsibility for such programs and state oversight should ensure that local programs are effective in addressing state water quality goals.

3. Localities should be required (and given adequate authority) to employ their land use planning function to achieve state water quality goals based on an explicit state policy regarding the relationship between local development and the quality of state waters. State law should provide:
   a. requirements for the development and enforcement of land use management guidelines that localities must follow to address water quality issues in their Comprehensive Plans;
   b. authority for state review (and potential modification) of local plans to ensure that these guidelines have been followed and that state water quality protection goals are being met.

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4. State Environmental Policy Acts (SEPAs) should require that state officials review the pollution potential (including cumulative impacts) of proposed federal, state, local and private actions, and require the consideration of alternatives that may lower the amount of pollution and appropriate mitigation measures when adverse water quality impacts are identified.

5. State law should enhance the value of common law as a means to reduce poison runoff by providing that:
   a. noncompliance with programs requiring the implementation of BMPs constitutes unreasonable conduct for purposes of private nuisance cases;
   b. violations of water quality standards presumptively harm downstream water uses; and
   c. the use of pesticides in areas where their application is prohibited constitutes unreasonable conduct in any tort proceedings brought by allegedly injured parties.

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Notes - Chapter Eight

1. See Chapter Two for a discussion of the NPS management requirements contained in the CWA. Other relevant federal laws are mentioned in Chapters Three, Four and Five.

2. *See* Blatt, David, J. L., "From the Groundwater Up: Local Land Use Planning and Aquifer Protection" 2 *J. Land Use & Envtl. L.* 118, 148-149 (1986). See Chapter Four for a discussion of particular programs designed to regulate land uses contributing to NPS pollution by (among other things) making the use of BMPs mandatory, clear, and enforceable.

3. *Id.* at 118-119; *see* Buresh, James, C., "State and Federal Land Use Regulation: An Application to Groundwater and Nonpoint Source Pollution Control," 95 *Yale L.J.*, 1433, 1439-1440 (1986); Geier, Karl E., "Agricultural Districts and Zoning: A State-Local Approach to a National Problem," 8 *Ecology L.Q.* 655, 674 (1980).

4. *See generally* Geier, 1980, *supra* note 3, at 655-696; Buresh, 1986, *supra* note 3, at 1433-1458; Blatt, 1986, *supra* note 2, at 107-150; Jurgens, "Agricultural Nonpoint Source Pollution: A Proposed Strategy to Regulate Adverse Impacts," 2 *J. Land Use & Envtl. L.* 195-218 (1986).

5. For example, stormwater control ponds have been designed as beautiful landscaping improvements in hotel and convention center landscape architecture. The result has been poison runoff control that both enhances property and recreational values, and provides habitat for birds and other animals. *See, e.g.,* New York State Department of Environmental Conservation, *Stream Corridor Management - A Basic Reference Manual,* January, 1986, at 1, 100-103.

6. *See* Cox, William E. and Lorraine M. Herson, *Control of Nonpoint Source Pollution in Virginia: An Assessment of the Local Role,* Bulletin 158, Virginia Water Resources Research Center, November, 1987, at 34-40; David Bailey, Environmental Defense Fund, January 12, 1988 (personal conversation); Virginia Council on the Environment, *Virginia's River Basin Citizen Committees for the Chesapeake Bay—Annual Report,* August, 1987, at 2, 16.

7. *See* Cox and Herson, 1987, *supra* note 6, at 17, *citing Tabler v. Fairfax County Va.*, 269 S.E. 2d 358, 361, 1980.

8. Garner, Mary, "Regulatory Programs for Nonpoint Pollution Control: The Role of the Conservation District," 32 *JSWC* 202 (1977).

9. *Id.*

10. Buresh, 1986, *supra* note 3, at 1555-1556. If states do not succeed in controlling NPS pollution under CWA § 319 [33 U.S.C.A. § 1329 (1987)], however, Congress may well have to assign EPA a more direct role.

11. *Id.* at 1454-1456.

12. Rogers, William H., Jr., *Handbook on Environmental Law*, West Publishing Company, St. Paul, Minnesota, 1977, at § 7.11. Michigan, California, New York, Minnesota and Massachusetts are examples of states with comprehensive SEPAs. *Id.*

13. *Id.* at § 7.11(a).

14. *Id.*

15. *Id.*

16. *Id.*

17. *Id.* at § 7.11(b).

18. *Id.* § 7.11(e).

19. Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, 1984, at 15-17, 39 (Site Plan Review).

20. *Id.*

21. See Chapter Four for a discussion of the requirements of an effective ESCL.

22. *See generally* Garner, Mary M., *Summary of Principal Provisions of State Laws Providing for Erosion and Sediment Control as of July 1, 1985*, National Association of Conservation Districts (no date).

23. Klein, Susan B., *State Soil Erosion and Sediment Control Laws*, National Conference of State Legislatures, November, 1980, at 8-9; Cox and Herson, 1987, *supra* note 6, at 57-68.

24. *See generally* Klein, 1980, *supra* note 23; Cox and Herson, 1987, *supra* note 6, at 57-68.

25. *See generally* Klein, 1980, *supra* note 23; Garner, (no date), *supra* note 22.

26. For a description of an ESCL that applies to agriculture, *see* Pennsylvania Bureau of Soil and Water Conservation, *An Evaluation of Pennsylvania's Erosion and Sediment Control Program*, August, 1984.

27. *See* Penn. Admin. Code, Title 25, Chapter 102.

28. *See An Evaluation of the Virginia Erosion and Sediment Control Program*, Smith Demer Norman, Hampton, Virginia, June, 1987, at VII-1 - VII-2, VIII-1 - VIII-2.

29. Cox and Herson, 1987, *supra* note 6, at 34-35.

30. See Chapter Four for a discussion of stormwater management requirements as well as state and local programs that address those needs.

31. These include streets, lawns, golf courses, industrial land uses, sanitary dumps and hazardous waste storage facilities, air pollution, even overflows from existing sanitary sewers.

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32. *See NRDC v. Costle*, 568 F.2d 1369, 1380-1382 (D.C. Cir. 1977). Under CWA § 402(p), 33 U.S.C.A. § 1342(p) (1987), added in 1987, EPA must issue stormwater permitting regulations for industrial stormwater discharges and municipal separate stormwater system discharges by February 4, 1989 for systems serving populations over 250,000, and by February 4, 1991 for systems serving populations of 100,000-250,000. Other stormwater sources must be regulated based on the recommendations of an EPA study. *Id.*

33. CWA § 402(p)(2)(E), 33 U.S.C.A. § 1342(p)(2)(E) (1987). The CWA defines "municipality" broadly to encompass virtually any type of local jurisdiction, including stormwater utilities. CWA § 502(4), 33 U.S.C. § 1362(4).

34. *See* Livingston, Eric H., *et al.*, *The Florida Development Manual: A Guide to Sound Land and Water Management*, (in press), 1988, at 4-7 - 4-8; Livingston, Eric H., "Stormwater Management in Florida: An Evolving Regulatory Program," paper presented at ASCE Urban Runoff Quality Seminar, Henniker, New Hampshire, June 22-27, 1986, at 7.

35. Wilkinson, Hal, "Soil Conservationists and the Uses of the Law," 42 *JSWC* 310 (1987).

36. Blatt, 1986, *supra* note 2, at 134.

37. *Id.* at 134-144.

38. Buresh, 1986, *supra* note 3, at 1443-1444.

39. Wilkinson, 1987, *supra* note 35, at 308.

40. Buresh, 1986, *supra* note 3, at 1433.

41. *See generally* Blatt, 1986, *supra* note 2; Buresh, 1986, *supra* note 3; Jurgens, 1986, *supra* note 4; Geier, 1980, *supra* note 3; Donald Rice, Coordinator of Water Resources Programs, Northern Virginia Planning District Commission, January, 1988 (personal conversation).

42. See Chapter Ten.

43. See Chapters Three, Four and Five for descriptions of federal land use management activities. States and localities can affect the poison runoff impacts of *federal* land use through their authority under the Coastal Zone Management Act and the CWA. States and localities also can influence federal actions by commenting on Environmental Impact Statements required by the National Environmental Policy Act, and draft federal land use plans required by various laws such as the Federal Land Planning and Management Act (FLPMA) and the National Forest Management Act.

44. States should consider laws establishing riparian and lake protection areas, where restricting development adjacent to waterbodies is necessary to achieve water quality goals. This type of planning recognizes that the health of rivers and lakes depends on the integrity of the banks and, often, the riparian vegetation.

45. Roland Geddes, Director of the Virginia Division of Soil and Water Conservation, Richmond, Virginia, January 12, 1988 (personal conversation); Puget Sound Water Quality Authority, *Issue Paper - Nonpoint Source Pollution*, May, 1986, at 4-122.

46. *See generally* Fla. Admin Code 9J-5 (1988). See Chapter Ten for a discussion of state-local land use planning in Florida.

47. *See* Koppelman, Tanenbaum, and Swick, 1984, *supra* note 19, at 16-17 (Land Use), 24-25 (Stormwater Runoff), 1-27 (Site Plan Review).

48. *See* Buresh, 1986, *supra* note 3, at 1433-1434, 1437; *see generally* Blatt, 1986, *supra* note 2.

49. Buresh, 1986, *supra* note 3, at 1444. In the final analysis, BMPs are also a form of land use control, albeit a limited form.

50. *Id.* at 1433.

51. *Id.* at 1433-1434, 1439-1441.

52. See Chapters Nine and Ten for a discussion of some of these programs.

53. These principles obviously cannot be directly incorporated as they are described here. They are presented in order to indicate the *concepts* that are important for state legal systems to recognize. Dramatic differences in the importance of the concepts exists among different areas; therefore, these principles should be applied on a site-specific basis.

54. *Carrying capacity* is an ecological concept that refers generally to the maximum population of a species or group of species that a given set of ecological conditions can support indefinitely. *See* Miller, G. Tyler, *Living in the Environment–Concepts, Problems and Alternatives*, Wadsworth Publishing Company, Inc., Belmont California, 1975, at 105-107, A6.

55. Blatt, 1986, *supra* note 2, at 127. For an explanation of using an environmental perspective to improve decisions in local land use issues, *see* Chapin, F. and E. Kaiser, *Urban Land Use Planning* (3d. ed. 1979).

56. These can include critical groundwater recharge area or surface water protection, local hazardous waste ordinances, household hazardous waste collection days, local or regional pesticide bans, required BMPs in certain critical agricultural areas, etc.

57. See Chapter Four and Appendix A, respectively, for a description of these two laws.

58. Buresh, 1986, *supra* note 3, at 1440, 1452-1454.

59. While preserving farmland has important nonpoint source management benefits, such as slowing urban sprawl, keeping marginal land from being over-farmed and reducing the need to increase agricultural outputs with chemicals, many other issues involved in farmland preservation are beyond the scope of this paper. Chapter Three provides some of the aspects of preservation programs necessary to control agricultural runoff. *See generally* Geier, 1980, *supra* note 3.

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60. "Right-to-farm" laws generally seek to improve the legal position of established farmers in private nuisance suits brought by new neighbors and to reduce the impact on the farmer of unreasonable land use controls, building codes and anti-nuisance ordinances. *See generally* Keene, John C., *Agricultural Pollution: The Problem and its Remedies*, University of Pennsylvania, Philadelphia, Pennsylvania, 1984.

61. Non-federal incentives and subsidies can come to the farmer in many forms: differential tax assessment where a farmer's property is taxed according to its value as farmland, not potential value under more intense land uses; local agricultural zones that exclude land uses incompatible with agriculture; agricultural districts that remove incentives for conversion of farmland while making certain restrictions on farming less stringent; and transfer of development rights where the state purchases the right to develop the land but then chooses to leave it in its agricultural state. *See generally* Pimentel, David, and Susan Pimentel, "Ecological Aspects of Agricultural Policy," 20 Nat. Resources J. 555-585 (1980).

62. Geier, 1980, *supra* note 3, at 659, 671-675. This issue is discussed in more detail in Chapter Three.

63. Buchele, Thomas, C., "State Common Law Action and Federal Pollution Control Statutes: Can They Work Together?," 2 *U. Ill. L. R.* 609 (1986).

64. *See generally* Buchele, 1986, *supra* note 63; Rodgers, William H. Jr., *Environmental Law: Air and Water*, West Publishing Co., St. Paul, Minnesota, 1986, at §§ 1.1, 2.2, 2.4, 2.5, 2.6. William H. Rodgers, Jr., Professor of Law, University of Washington School of Law, December 8, 1988 (personal conversation).

65. Exceptions to this problem include situations where livestock or earthmoving activities are clearly having immediate and acute adverse effects on adjacent property owners.

66. *See generally* Buchele, 1986, *supra* note 63, at 609-644.

67. *Id.*

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PART THREE

Developing a Framework for Comprehensive Control of Poison Runoff

> Water policy, in general, should be formed from the interaction of the legal, political, fiscal, economic, ecological, scientific, and technological forces that converge on particular problem areas. Out of the conflict of these forces there should typically emerge a set of prescriptions which becomes codified in laws and regulations for the responsible agencies.[1]

Part Three discusses how to assemble the program components outlined in Part Two into a coherent, integrated management effort. A state management program should be more than an assemblage of separate programs. It should be a coordinated, integrated effort, ultimately controlled by water quality officials who understand how individual programs can be and have been incorporated into comprehensive state, regional and local

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[1] Rogers, Peter and Alon Rosenthal, "The Imperatives of Nonpoint Source Pollution Policies" (draft), in *Proceedings on the Conference on Political, Institutional and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs*, Marquette University, Milwaukee, Wisconsin, 1987, at 10.

management efforts and driven by compliance with water quality standards.

Key commitments must be made at the federal, state, local and personal level before poison runoff can be controlled. These commitments can involve choices based on economics, ethics, and politics as much as on science and technology. In fact, effective controls may depend more on making political and management choices, than on solving technical problems. And certain unique features of poison runoff render these choices particularly complex.

First, as mentioned in Part One, the sources of poison runoff are ubiquitous, and the pollutants are very diverse. Thus, a far greater number of sources must be controlled than in many other environmental programs: a county full of farms and small condominium developments, rather than one or two factories, for example. Moreover, poison runoff is caused by polluters with widely different socio-economic and cultural characteristics. Government officials need to design innovative policies and programs that confront (not accommodate) these problems and capitalize on (not ignore) these changes at all appropriate levels.

Second, poison runoff stems primarily from land-use activities and patterns.[2] Land-use decisions and associated private property rights, especially those pertaining to agriculture, traditionally have been considered highly personal in nature.[3] The land use activities causing poison runoff have not been subject to extensive government regulation, unlike major industries.

In addition, whereas pollution control is viewed as the responsibility of state and federal government, land use traditionally has been the province of local government. Therefore, state officials must bring local governments into the management arena, to resolve conflicts among them and to oversee their

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[2] Tripp, James, T.B., "The Basic Legal Issues," in *Perspectives on Nonpoint Source Pollution*, U.S. EPA, 1985, at 55.

[3] Batie, Sandra S., "Why Soil Erosion: A Social Science Perspective," in *Conserving Soil - Insights from Socioeconomic Research*, ed., Lovejoy, Steven B., and Ted L. Napier, Soil Conservation Society of America, Ankeny, Iowa, 1986, at 4.

management decisions to ensure that water quality is not sacrificed for the sake of local economic development.

Many of the organizational and institutional issues associated with comprehensive management are analyzed in Chapters Nine and Ten, using examples of actual state and local programs wherever appropriate. Chapter Nine examines the need for poison runoff control programs to be shaped and driven by the achievement of specific water quality objectives in individual watersheds, through a planning process orchestrated by the state water quality management agency. Assembling and organizing the resources and players needed to carry out this planning process is the subject of Chapter Ten.

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The watershed is the only natural and logical geographic unit for the preparation and implementation of many poison runoff controls.

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Chapter Nine

Setting the Framework for Poison Runoff Control Programs: Working Towards Water Quality Objectives

Introduction

Chapter Two of this report identified the fundamental legal requirements of the Clean Water Act in designing and implementing programs to control poison runoff. The CWA requires such programs to be designed to meet water quality standards; at a minimum, programs must achieve "fishable and swimmable" waters.

Much of Part Two focused on using water quality standards to dictate the stringency of specific programs and to justify the need for new BMPs or other control strategies for particular types of activity. For example, we recommend that silvicultural control programs be driven by the need to meet water quality standards in the watershed in question. Similar approaches are urged in designing pollution control programs for agriculture, land use, urban runoff, mining and grazing.

It is extremely rare, however, that an entire watershed will be affected only by one type of polluting land use activity. Watersheds may be affected in some way by the full range of pollutants generated by a variety of diffuse sources. Moreover, as discussed in Chapter Two, the Clean Water Act requires states to address poison runoff on a watershed-by-watershed basis, not by focusing only on an individual category of pollution, such as farming, grazing, or mining.

This chapter discusses two fundamental aspects of controlling poison runoff. First, the dominant characteristic or approach that drives the selection and development of specific programs should be the *achievement of water quality goals* in individual watersheds. The goal of achieving and maintaining state water quality standards should be explicitly spelled out in program plans.

Second, the choice of a lead agency for the management program as a whole is a central decision that will influence a state's overall pollution control effort. *The lead agency should have a strong background in water quality management* to ensure that controls are chosen, developed, implemented and enforced to achieve water quality objectives.

These two issues are discussed separately, along with examples of state programs that reflect these important management components. The chapter concludes with a set of recommendations.

Using Water Quality Standards to Drive Control Programs

Establishing Program Characteristics: A Focus on Water Quality Objectives

Many state poison runoff control programs are influenced significantly by an overriding concern that they remain essentially voluntary in character. In such cases the goal of using voluntary approaches, rather than the goal of protecting or enhancing water quality, can drive every phase of activity, from requesting and targeting funds, to developing and implementing management programs, to evaluating program success. This is not a productive manner in which to design a water quality protection program. No control program should be forced to fit into the arbitrary constraints imposed by the goal of remaining a voluntary program (or any *other* single "implementation policy").[1] Such approaches put the cart before the horse. *The goal of the program should be to attain compliance with water quality standards—whether they be narrative or numerical; or chemical, biological or ecological.*

Under a goals-driven system to control poison runoff, the only *a priori* constraints placed on selecting control strategies are those contained in the CWA and state water quality standards requirements. Such a system will not be biased towards any particular program approach. Advances in modelling pollutant loadings and in understanding BMP effectiveness can be incorporated into such a goals-driven plan[2]. The use of *many* effective management approaches, including regulatory programs, becomes feasible. Choices among strategies can be made in a fair, accurate and unbiased fashion.

As discussed later in this chapter, using compliance with water quality standards as the central focus of nonpoint source control activities guides and shapes the state, regional and local agencies' responsibilities. Simply put, water quality standards provide tangible criteria by which to make decisions and judge their effectiveness at *all* program stages.

Comprehensive control of diffuse pollution sources to meet water quality standards requires a number of basic components. First, states must have in place water quality standards that are

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adequate to address the types of pollution and habitat degradation caused by poison runoff. Second, programs must have a mechanism for cataloging all, or at least all major, sources of poison runoff *in each watershed*, and wherever possible, determining what pollutant load reductions are necessary to meet water quality standards. Next, program officials must use this information to determine what combination of control methods is needed to meet water quality standards in each watershed, and to implement these requirements. In addition, a water quality approach can be used to prevent the degradation of clean watersheds, or further degradation of watersheds that currently do not meet water quality standards. Each of these basic components is discussed below.

Water Quality Standards for Controlling Poison Runoff

Most existing water quality criteria were developed to address point sources of pollution. To date, monitoring and modelling efforts have been oriented for the most part towards point source pollution.[3] Therefore, it has been difficult to determine when poison runoff was contributing to water quality violations, or when control programs were eliminating such violations.[4] As a consequence, today many programs to control poison runoff do not contain a strong, direct link to state water quality standards.[5]

Nevertheless, many existing water quality standards still are applicable to pollution from diffuse sources. This is true particularly where both point sources and dispersed sources contribute to violations of a particular water quality parameter, such as turbidity or criteria for individual metals. As explained below, applying criteria developed for point sources to nonpoint sources may simply require states to redesign their monitoring programs and wasteload allocation process to account properly for pollution contributions from various land use activities.

Poison runoff does pose a number of unique problems that are not addressed adequately by most existing state water quality standards. However, EPA and a number of states are working to develop water quality standards that are more closely related to pollution generated by diffuse sources.[6]

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One major problem is the difficulty of developing instream water quality standards to address nutrients. The adverse effects of excessive nutrient inputs often are not felt in the receiving stream, but in some downstream waterbody, such as a lake or estuary. Nutrients collected in these waterbodies may result in eutrophication. But the relationship between nutrient concentration and eutrophication is not necessarily linear, and is affected by such variables as temperature, the amount of sediment-bound nutrients, and the presence of other pollutants.[7] Therefore, it is difficult to set a single, specific instream concentration for nitrogen and phosphorus that will protect downstream lakes or estuaries.[8]

One rough way to address eutrophication is through standards for dissolved oxygen (DO).[9] Since the effects of eutrophication are felt through reduced dissolved oxygen, excess nutrients are measured indirectly by lowered dissolved oxygen levels.[10] But there are a number of problems with using this approach alone. Given the lag between the time of nutrient enrichment and the onset of adverse effects, dissolved oxygen might not be reduced to levels that violate water quality standards until the damage is already done.[11] Moreover, in lakes and estuaries DO levels will vary diurnally and through the water column.[12] Therefore, it is important for DO measurements to be taken at the correct time of day and at the correct points in the water column. But given these complexities, using DO levels to calculate nutrient levels needed to prevent eutrophication may be extremely difficult.

Some states are using chlorophyll *a* as an indicator of eutrophication.[13] Chlorophyll *a* is a plant pigment used by algae to convert energy from sunlight, along with dissolved carbon dioxide and water, to food energy. As such, chlorophyll *a* is a direct measure of algae growth and can be used to measure eutrophication.[14]

An even more sophisticated approach is to use a combination of measurements, including chlorophyll *a*, turbidity, and nutrient concentrations to calculate a "trophic state index". This type of approach is being used in North Carolina and other states.[15]

Another major problem is that many types of poison runoff, including pesticides and toxic metals, are often bound to relatively heavy sediment particles.[16] These particles tend to be

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deposited in the sediment rather than dissolved in the water column. Thus, water quality criteria that measure pollutant concentrations in water may not adequately address these pollutants since they may accumulate in benthic organisms or be taken up through the food chain.

The obvious solution to this limitation is the development of sediment quality criteria.[17] While most states currently do not have sediment quality criteria, EPA is working on the development of guidance for sediment contamination,[18] and state plans to control poison runoff should consider the future adoption of such standards.

Finally, pollutant-specific water quality criteria alone do not adequately address damage caused by poison runoff. To address this limitation, as well as similar limitations of using numerical criteria alone to address point source pollution, EPA and various states are developing ways to measure the overall biological health of rivers, lakes and coastal waters.[19] Programs to manage diffuse sources of water pollution should use these biological criteria to identify problems, develop appropriate controls and measure program success.

Identifying and Allocating Nonpoint Source Pollutant Loads in Individual Watersheds

The critical steps in a water quality-driven nonpoint source program are: (1) to identify the sources of a particular type of poison runoff (or diffuse groundwater contaminant) in a watershed, (2) to allocate existing loadings from each pollutant, and (3) to determine the reductions from each source or category of sources needed to achieve water quality standards. Because it may be cheaper or easier to control loadings from some sources than others, this watershed-wide approach allows states to consider economic efficiency and equity while still developing a plan designed to meet water quality goals.

It is important that quantitative and measurable water quality goals be utilized, both in the general state control program and in determining suitable implementation projects for individual waterbodies.[20] If compliance with water quality standards is the overriding goal, *all* nonpoint and point source control needs must be combined into a comprehensive "watershed plan" that describes initially what controls are necessary within a given watershed to achieve and maintain beneficial uses.[21]

This concept is perhaps best explained by an example. Assume that a given watershed is violating water quality standards for total suspended solids. Some of the excess pollutants may come from point sources. But these sources already are meeting stringent control requirements, and the best available controls will not come close to meeting water quality standards.

In fact, assume that 60% of the total sediment load to the watershed is from a diverse range of nonpoint sources. Some of this sediment load comes from poorly controlled construction sites; some derives from agricultural erosion, mining, silviculture and urban runoff. A watershed-based plan to control poison runoff should identify each source or source category; *estimate* current loadings, and estimate additional load reductions that can be achieved through improved implementation of BMPs or other controls for each category of sources. The control methods for each source can be chosen based on any number of factors, including technological feasibility, cost, equity, and enforceability, so long as the *total* estimated load reductions are designed to meet water quality standards, with an adequate margin of safety.

To be sure, this process is neither easy nor precise. Depending on the type and intensity of controls, changes in ambient water quality from program efforts may not take effect for a number of years.[22] Using water quality standards to direct the control of poison runoff can be expensive and complex; and it differs significantly from the established activities of many state water quality management agencies.

These difficulties vary with the source category. For instance, because natural water quality in forested watersheds often is pristine, and significant water quality problems are caused by sediment and herbicide loadings (the major silvicultural pollutants), it can be relatively easy to determine what activities are responsible for beneficial use impairments.[23]

Determining whether violations of water quality standards are due to urban pollution loadings, and to what degree, may be more difficult due to various external pollution sources from outside (and within) the watershed under consideration. Variable storm intensities and frequencies, which can cause significant

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temporary changes in water quality, also make the task more complicated.[24] These problems are even greater in agricultural settings.[25]

But despite these difficulties, it is possible to make estimates of *relative* point and nonpoint loadings and to impose treatment requirements on different sources necessary to attain or maintain a given beneficial use.[26] While this process will not be precise, it need not be precise to be effective. And given both the compelling need and the Congressional directive to develop comprehensive, watershed-by-watershed management plans to control poison runoff, complete precision should not be the enemy of an available strategy that makes significant progress towards meeting water quality standards.

The strategy outlined here has a number of clear benefits. Within the watershed, water quality standards provide a concrete goal to work towards because they define what level of pollution reduction is needed to protect beneficial uses.[27] This improves the selection and implementation of control strategies for the range and number of sources that must be managed.[28]

Moreover, unlike a strategy designed to implement a fixed, arbitrary number and type of BMPs, a water-quality driven strategy is not biased towards any given control method or implementation approach. Rather, the correct tools can be chosen for each source or each source category, and can vary among watersheds depending on need.[29] For example, the necessary calculated load reductions from agricultural sources may be achievable in a particular watershed solely with the use of voluntary cost-share programs, if adequate funding is available. In another watershed or another state, agricultural loads may be so great, or cost sharing funds so limited, that regulatory controls may be needed either across-the-board, in critically-affected watersheds, or on farms that contribute the greatest loadings.

Water Quality Standards, Land Use, and Antidegradation

It is easier to conceptualize the use of water quality standards to direct the selection and implementation of BMPs, as explained above, than it is to envision how water quality standards can be used to affect land use planning. Yet in Chapter 5, we

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recommended a strong link between water quality and land use planning and control.

Some types of land use controls are in fact closely analogous (or identical) to BMPs. Land use controls can consist of conditions placed on development, such as prescribed drainage controls, maximum percent impermeable surfaces, or buffer strips between construction and waterbodies. Methods exist to *estimate* the amount of pollution reduction that such methods will produce. With adequate knowledge of existing conditions in a region's surface waters, these controls can be imposed as needed to protect water quality on existing *or* new development.

Perhaps more important, estimates of the pollution loads that will result from new developments, in combination with other existing or proposed developments, can be used for purposes of *siting* facilities or determining desirable land use patterns. High impact facilities that will generate significant loads can be sited where they will have the least impact on surface waters. Open space or buffer strips can be planned where existing pollutant loads already are stressing a particular system. In extreme cases, a permit for a facility can be denied where water quality standards will be violated despite the best efforts to site and design the facility properly.

A special but extremely important case of applying water quality standards to proposed new activities is antidegradation. Under the Clean Water Act and EPA implementing regulations, all states must include in their water quality standards an adequate antidegradation regulation, and policies and procedures to implement that regulation.[30] Essentially, the antidegradation requirement prevents existing clean waters, *i.e.*, waters that are cleaner and healthier than necessary to protect and maintain designated water uses, from being degraded.

There are three "tiers" to EPA's antidegradation regulation.[31] Under the first tier, all existing water uses, and the water quality necessary to protect those uses, must be maintained and protected in all cases.[32] Under the second tier, where existing water quality is better than required by state water quality standards, that level of water quality must be maintained and protected unless it is determined that "allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located."[33] This determination can be made only after adequate opportunity for public participation.[34] Moreover, lower water quality may not be allowed unless the state requires the strictest applicable technology-based controls for point sources in the watershed, and "all cost-effective and reasonable best management practices for nonpoint source control."[35]

Finally, under the strictest third tier of the antidegradation regulation, high quality waters that constitute "outstanding National resources, such as waters of National and state parks and wildlife refuges and waters of exceptional recreational or ecological significance," must be maintained and protected at their existing high levels under all circumstances.[36] This is essentially a zero degradation requirement.

EPA's antidegradation regulation applies equally to water quality degradation from point and nonpoint sources. This regulation, therefore, presents a powerful tool for states and localities to impose strict BMPs, siting requirements, and other controls on any new developments that would otherwise lower existing high water quality.

Specifically, in no case can pollution loadings from a new development push a waterbody over the top, bringing a surface water that barely meets water quality standards out of compliance. Where existing water quality is better than required by water quality standards, any additional development is subject to strict controls or siting requirements to ensure that no detectable water quality degradation occurs, unless the narrow tier 2 exceptions described above are met.

Picking the Right Lead Agency

Using water quality standards to determine the adequacy of programs leads to other important strategic questions. What agency should be the leader in a state program to protect water quality from poison runoff, and how should this agency approach general management issues? While the ultimate responsibility for a state program rests with the state government, it is not so obvious *which* state agency should exercise leadership and oversight. The choice of a lead management agency will influence the character of and emphasis placed on programs designed

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to address water pollution resulting from *all* types of pollution generated by diffuse sources, including urban and silvicultural land uses.[37] How well one kind of nonpoint source is controlled often determines how well other sources (both point and nonpoint sources) need to be controlled.[38]

As a general rule, historically states that consider agricultural pollution problems the most significant have relied upon agriculture and soil and water conservation agencies to develop and administer their overall nonpoint source programs.[39] Today much of these states' programs to control poison runoff are still little more than elaborations of past voluntary soil and water conservation activities. As a result, the "new" programs rely on the same institutional, management and financial framework as did their older, non-water quality-based ancestors.[40] In contrast, states that address vigorously a mix of urban, agricultural, forestry and other water quality impacts usually have programs in which the state water quality management agency takes the lead.[41]

A state agriculture agency is an important institutional resource in an overall management program. However, even in states with large agricultural pollution impacts, water quality management agencies are better suited to serve as lead agencies in such programs for several reasons.[42]

First, as detailed elsewhere in this report, soil and water conservation programs do not achieve optimal water quality results because of their bottom-up voluntary approach and their lack of contact with water quality management activities grounded in the CWA. The non-regulatory SCS-style tradition can bias programs away from a water quality goals-oriented approach. State water quality agencies have greater resources and expertise to evaluate water quality protection needs, and actual program effectiveness.[43]

Second, since nonpoint pollution occurs within distinct hydrologic units while SWCDs usually conform to political (county) boundaries,[44] organizing program activities around the traditional agriculture agencies risks uneven and unsuccessful program implementation. Control efforts should ensure that the state and the localities within watersheds equitably and efficiently share program responsibilities so that nonparticipation by a few

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critical localities or landowners does not negate program benefits.[45]

A state-level program grounded in an agriculture agency will tend to concentrate on using the traditional network of SWCDs and the Cooperative Extension Service. Such a program may under-utilize other entities that could be significant forces for controlling nonpoint pollution as well as for data collection, implementation, enforcement, and evaluation efforts. Local governments, regional planning and water quality management agencies, and drainage districts, to name a few, all have important pollution abatement roles. In sum, the SCWDs are both too specialized and too committed to one approach to serve as *the* dominant vehicles for broad-based control programs. Table 9-1 lists the main advantages of a water quality agency-controlled program over a program administered by a state soil conservation agency.

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Table 9-1
Advantages of Water Quality Management Agency-Administered versus Soil Conservation-Administered Program

Water Quality Agency	Soil Conservation Agency
focuses on complying with water quality goals	tends to focus on non-water quality goals based on "delivery mechanism" (*e.g.*, cost-share dollars, farmers reached, BMPs implemented); must also balance water quality protection with traditional farm productivity and income support goals
possesses expertise and resources for water quality monitoring and modelling as well as enforcement and program evaluation	often lacks expertise in these water-quality management areas
can utilize regional water management and planning agencies and local governments in comprehensive watershed-wide programs	concentrates on existing agriculture services network (*e.g.*, Cooperative Extension and SWCDs) to carry out activities in a fragmented system not based on hydrologic boundaries; traditional "assistance" relationships with clients can inhibit recognizing the need to impose strict controls and the implementation of appropriate programs
not biased towards voluntary implementation policies	tends to rely on traditional, voluntary costsharing framework
not biased towards agricultural pollution problems	tends to focus efforts on most familiar problems (*i.e.*, agriculture pollution)

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Examples of State Programs Linking Planning to Water Quality

Different states and localities have linked water quality standards to nonpoint source programs in various ways. Here are some promising examples:

Florida. Florida is an example of a state whose water quality management agency has assumed a strong role in the development of its *general* management plan for controlling poison runoff as well as in *individual* control programs. As an illustration, Florida's CWA 319 Management Plan describes the role of the state Department of Environmental Regulation (DER):

> With respect to the NPS management, the department [DER] is the primary lead agency with major responsibility for establishing minimum treatment standards to assure that NPS discharges do not cause or contribute to water quality standards violations. Another major department role is to oversee and coordinate the implementation of NPS management programs delegated to other agencies to assure consistency in the application of regulations.[46]

Florida has begun to use water quality standards to develop controls in a number of ways. Compliance with water quality standards not only drives many individual programs in the state but also is an explicit goal in the proposed Florida Nonpoint Source Management Plan.[47]

A good example of a program driven by water quality goals (rather than by a preconceived notion of how it should be implemented) is Florida's SWIM program. This program incorporates both point and nonpoint controls to achieve compliance with state water quality standards.

In 1987, the Florida State legislature enacted the Surface Water Improvement and Management Act (SWIM).[48] This law requires Florida's five regional water management districts (WMDs) to prioritize waterbodies of regional or statewide significance, and to design and implement surface water improvement and management (SWIM) plans.[49] These plans encompass voluntary and regulatory programs that address both point and nonpoint sources. They include participation by local and regional governments and review by the state Department of

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Environmental Regulation (DER).[50] Compliance with state water quality standards and protection of beneficial uses in particular waterbodies is the goal that determines the content of each plan.[51] Water quality criteria and ***holistic habitat and biological parameters*** are used to evaluate the adequacy of proposed programs.[52] Plans are developed for each prioritized waterbody, and address the minimum requirements of the Act:

1. Site description, history, hydrology;
2. Adjacent land use, pollution sources, permitted discharges;
3. Owners of point and non-point sources, and compliance timetables;
4. List of governmental units within one mile;
5. Description of potential restoration strategies to restore water to Class Three (water quality standards) or better;
6. Bibliography of relevant past and current studies;
7. Description of research and feasibility studies to determine restoration strategies, and a list and current status of active restoration and conservation projects;
8. Description of maintenance and management measures needed following restoration;
9. Schedule for restoration and management of waterbody; and
10. Estimated funding needed for restoration.[53]

Similarly, achieving compliance with water quality standards is also used in Florida as a criterion to issue and review urban stormwater permits.[54] All stormwater permits are issued with the proviso that if a discharge is contributing to a violation of water quality standards the Department of Environmental Regulation

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is authorized to strengthen permit requirements as needed.[55] Also, local land use and development plans are reviewed for their anticipated impact on water quality, and plans can be disapproved or modified if violations of state water quality standards are anticipated.[56]

As modelling efforts improve, and as more resources become available, the specific water quality impacts of local land use goals and policies will be more carefully scrutinized.[57] Often, biological and habitat parameters are used if attainment of chemical water quality cannot be determined, or if applicable standards do not exist for particular pollution problems, especially in agricultural areas.[58]

Management and Storage of Surface Waters (MSSW) permits are used in both agricultural and nonagricultural situations that involve diversion, consumption and routing of water, such as highway projects, urban development, golf course maintenance, and agricultural operations.[59] One of the purposes of the MSSW permit is to control poison runoff. In the South Florida Water Management District, specific provisions of each permit are included in order to protect the beneficial uses of state waters through compliance with water quality standards.[60]

In order to fill gaps in standards and criteria, a recent review of water management district rules led the St. Johns River Water Management District to recommend developing special basin criteria for district waterbodies and sub-basins.[61] These criteria will provide additional protection to especially sensitive areas. The review also supported the development of a numerical, water quality-based nutrient standard for waters within the district.[62]

While overall, Florida (like many states) still lacks significant control over some agricultural surface and groundwater contaminants,[63] Florida has established an effective *means* to evaluate the water quality effects of point and nonpoint source problems both systematically and simultaneously. This evaluation is used to develop a comprehensive and scientifically defensible set of cleanup and protection proposals that are custom-designed for a particular waterbody.

San Francisco. In the southern part of the San Francisco Bay area, localities are working with each other, and with the area's Regional Water Quality Control Board and EPA, to determine the most effective methods to meet water quality standards for a variety of toxics coming from widespread point and nonpoint sources.[64] Based on data from a program of continuous monitoring of toxics loadings, permits for specific *nonpoint* sources may be required in the next 2-3 years.[65] These permits, like water-quality based NPDES permits, would be designed to achieve state water quality standards and would seek to distribute control responsibilities equitably among particular localities based on the results of the research currently underway.[66]

The recent Water Quality Control Plan for the San Francisco Bay Region lists water quality objectives that describe the level of water quality for each beneficial water use in the basin.[67] All "controllable water quality factors" are subject to the requirements of the plan if they contribute to adverse impacts on beneficial uses.[68] For each beneficial use, relevant objectives for poison runoff control include those pertaining to: taste and odor; suspended material; settleable material; biostimulatory substances (nutrients); sediment; turbidity; dissolved oxygen; bacteria; salinity; and toxicity (defined using chemical *and* biological parameters).[69] These objectives are used to shape the nonpoint source programs carried out at the state and local level, including the requirement that certain localities address particular urban runoff problems.[70]

Wisconsin. The Wisconsin Department of Natural Resources is responsible for developing the state's Nonpoint Source Pollution Assessment and Management Program under CWA § 319.[71] The Wisconsin approach to controlling diffuse sources of water pollution illustrates the advantages of a program with significant input by a water quality management agency that can address all forms of poison runoff and involve many levels of government.[72] The DNR administers the state Nonpoint Source Pollution Abatement Program,[73] and the soil and water conservation programs administered separately by the Department of Agriculture, Trade and Consumer Protection (DATC) are integrated with those of DNR.[74]

Wisconsin's Nonpoint Source Water Pollution Abatement Program focuses on identifying the generators of all nonpoint source water pollution within a given hydrologic unit and involving all of the local governmental entities in the unit to achieve specific water quality goals based on state water quality standards.[75] This is accomplished by picking priority watersheds and priority management areas, which then become the sites for pollution control projects.[76] These projects are selected through a formal process based on six criteria, presented below in Table 9-2:

Table 9-2
Process and Criteria Used in Selecting Priority Watersheds in Wisconsin*

Selection Process	Selection Criteria
1. numerical ranking of watersheds after technical evaluation of water quality and pollution potential by DNR	1. the severity of water quality problems
2. review and recommendations by regional committees	2. magnitude of pollutant load and potential for reduction
3. further refinement of priority list by a committee with interest group and state agency representation	3. landowners' willingness to participate
4. final selection of projects by DNR	4. willingness and capability of local agencies to carry out their roles
	5. willingness and capability of localities and other local units of government to control other sources of pollution, *e.g.*, erosion and sediment control programs
	6. potential public use and benefits that will result from the proposed watershed project

* Source: Bergquist, Susan, ed., *Nonpoint source pollution: Where to go with the flow*, Wisconsin Department of Natural Resources, January-February, 1986, at 20-24.

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1. numerical ranking of watersheds after technical evaluation of water quality and pollution potential by DNR	1. the severity of water quality problems
2. review and recommendations by regional committees	2. magnitude of pollutant load and potential for reduction
3. further refinement of priority list by a committee with interest group and state agency representation	3. landowners' willingness to participate
4. final selection of projects by DNR	4. willingness and capability of local agencies to carry out their roles
	5. willingness and capability of localities and other local units of government to control other sources of pollution, *e.g.*, erosion and sediment control programs
	6. potential public use and benefits that will result from the proposed watershed project

* Source: Bergquist, Susan, ed., *Nonpoint source pollution: Where to go with the flow*, Wisconsin Department of Natural Resources, January-February, 1986, at 20-24.

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After the selection process, an 8-10 year planning and implementation process begins. Approximately one year is used to assess and to inventory critical-source areas, develop specific water quality objectives, and prepare an implementation plan.[77] Using a variety of models and other data collection activities, DNR staff, with input by DATC, develop a technical assessment to:

1. identify water quality problems and determine specific water quality objectives;

2. identify significant nonpoint sources in relation to point sources and septic systems;

3. identify water quality improvements that can be achieved through various types of controls; and

4. identify the general management needs to achieve water quality improvements.[78]

The rest of the watershed strategy, termed the implementation strategy, is developed by state and local agencies and identifies:

1. the tasks necessary to address the needs identified in the technical assessment;

2. the agencies responsible for these different tasks;

3. the time for accomplishing each task;

4. the estimated hours of staff time needed to carry-out the project; and

5. the approximate costs of implementing the recommended controls.[79]

The Wisconsin program is run with strong input by the state water quality agency. It has an objective planning and implementation process that allows many governmental units to work together toward agreed-on water quality goals within a given watershed. In addition to its value as an organizational structure, the Wisconsin program also highlights the important cause-and-effect relationships between land use and water quality.

In Wisconsin, a central component of each priority watershed project[80] is the set of water quality objectives identified for the watershed's lakes and streams.[81] Use impairments are treated as more significant than violations of chemical parameters in designing control programs, since many affected waterbodies are trout streams with degraded habitat caused by the sedimentation of the stream bottom which may not necessarily be reflected in water column numerical concentration violations.[82] Consequently, biological indicators are often part of water quality objectives for individual lakes and streams.[83]

The Nonpoint Source Pollution Control Plan for Wisconsin's Sevenmile-Silver Creek Priority Watershed illustrates this use of water quality data to design specific programs. Five tools were used in assessing the water resources within each subwatershed and in developing water quality objectives. These include:

1. *Beneficial Uses and Use Impairment;*

2. *Physical Data* - considered when addressing water resource conditions and beneficial uses;

3. *Biotic Index* - the Hilsenoff Biotic Index (HBI) was used to classify water quality conditions according to insect populations;

4. *Stream Fishery Habitat Assessment* - using a variety of physical, chemical and biological indicators, an inventory was developed to determine present and future fisheries uses (with and without various control scenarios); and

5. *Lake Trophic Status* - phosphorous concentrations, chlorophyll-a levels, and secchi disc measurements (a turbidity measure) were taken to evaluate the trophic

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levels of lakes in the watershed with and without various control scenarios).[84]

After pollution loads have been estimated, a management plan can be developed that achieves water quality objectives by calculating necessary load reductions and identifying how and where these reductions can be achieved.[85]

Silviculture and Mining: Different "Watershed" Planning Approaches

To address silvicultural and mining impacts, EPA has conducted a study of using sediment quality criteria as a basis for the protecting of certain kinds of fish habitats.[86] The researchers concluded that, although it is difficult to use stream variables that can *quantify* the effects of sediment on fish and macroinvertebrates, threshold values for dissolved oxygen can and should be used in some circumstances as cut-off points beyond which serious damages to fisheries would occur.[87] In many other instances, given uncertainty and risk, EPA recommended the adoption of water quality standards allowing for *no* incremental increases in sediment fines until more is understood about the relationship between sedimentation and habitat degradation.[88] The study also concluded that "real and detectable relationships appear to exist between disturbances such as stream crossing" and sediment fines.[89]

California. In California, efforts are under way to include habitat conditions as part of the water quality standards that private timber operations must maintain.[90] Because of past difficulties in enforcing water quality standards, the California Board of Forestry is currently supporting the development of two kinds of monitoring in timber operations: compliance and enforcement monitoring to determine if the required BMPs have been implemented properly; and surveillance monitoring to determine if the BMPs, when properly carried out, are *in fact* protecting the relevant water quality conditions.[91] In order to link water quality standards with the preparation of Timber Harvesting Plans, the California Forest Practices Rule Assessment Team has recommended that performance standards be written in an enforceable manner so that the definition of a particular BMP is whatever action (or non-action) supports water quality protection goals.[92] Presumably this could preclude harvesting timber using certain methods or in certain areas.

Conclusions and Recommendations

State programs to control poison runoff must be carefully planned. They must be driven by water quality goals, and be flexible enough to implement innovative solutions that address all significant sources of contaminated runoff (and groundwater) through every useful channel. With this approach established, specific programs can be developed, implemented and evaluated with the confidence that all reasonable control options will be considered objectively. To summarize, the following general program needs must be addressed in order to ensure that state efforts to control poison runoff are shaped by such an approach:

1. State water quality management agencies should be given a lead role in designing, coordinating, and evaluating individual projects to control poison runoff as well as the overall state management program—especially in ensuring that these programs are geared towards compliance with state water quality standards.

2. Programs should set specific quantitative and measurable water quality goals and objectives based on achieving compliance with water quality standards. They should use monitoring and modelling techniques to verify and enforce compliance.

3. Programs should address specific problem waterbodies through a coordinated state, regional, and local approach, with a single state-level agency responsible for overall program administration.

4. Water quality standards should be used to determine the site-specific load reductions needed for targeting, program implementation and funding policies, and to justify the use of non-voluntary programs.

5. Physical, biological and habitat criteria should be used to determine when narrative water quality standards are being met if specific, numerical chemical criteria are not available or feasible.

6. Problem assessments and individual plans should be developed separately for each affected waterbody or group of waterbodies. Wherever possible, programs should apply water quality goals on a watershed- or waterbody-specific basis.

Notes - Chapter Nine

1. As discussed in several places in the report, a voluntary program alone often is not adequate to solve poison runoff problems.

2. Dale Phillips, Virginia Water Control Board, April 5, 1988 (personal conversation); See Chapter Six for a more detailed discussion of the use of data in a nonpoint source management program.

3. U.S. EPA, *Surface Water Monitoring: A Framework for Change*, September, 1987, at 6 (hereinafter cited as *Surface Water Monitoring*).

4. *See* U.S. EPA, *Nonpoint Sources: Agenda for the Future* (proposal for discussion), October, 1988, at 21-22; *see generally* Duda, Alfred M., *et al.*, "Numeric Standards for Managing Lake and Reservoir Water Quality," in *Lake and Reservoir Management - An International Journal, Volume III*, North American Lake Management Society, Washington, DC, 1987, at 1-27; Ron Gregory, Virginia Water Control Board, February 12, 1988 (personal conversation).

5. *See* U.S. EPA, October, 1988, *supra* note 4, at 21-22.

6. *See, e.g.*, U.S. EPA, *Nitrogen-Ammonia/Nitrate/Nitrite – Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria*, September, 1988; North Carolina Department of Natural Resources and Community Development, *Water Quality Progress in North Carolina - 1986-1987 305(b) Report*, July, 1988, at 20.

7. *See* U.S. EPA, *Chesapeake Bay Program Technical Studies: A Synthesis*, September, 1982, at 36-261.

8. *See* Duda *et al.*, 1988, *supra* note 4, at 8; Curran, Sidney J., Jr., John W. Wilkenson and Nicholas L. Clesceri, "Predictions of Quantiles in Distributions of Chlorophyll *a* Concentrations," in *Lake and Reservoir Management: An International Journal, Volume III*, North American Lake Management Society, Washington, D.C., 1987, at 202-212..

9. *See* U.S. EPA, September, 1982, *supra* note 7, at 37, 60.

10. *Id.*

11. For instance, tributary-delivered nutrient inputs to the Chesapeake Bay occur largely in winter and spring but because of various environmental factors, the worst episodes of oxygen depletion and increased algal growth occur in the summer. *Id.* at 245; *see* Chesapeake Executive Council, *Chesapeake Bay Restoration and Protection Plan*, September, 1985, at I.p.2.

12. *See* U.S. EPA, *The Lake and Reservoir Restoration Guidance Manual - First Edition*, February, 1988, at 3-17 - 3-18.

13. *See* Duda *et al.*, 1988, *supra* note 4, at 12; N.C. Admin. Code Title 15, Chapter 2, Subchapter 2B .0211(b)(3)(A).

14. A more complete explanation of this measurement technique is given in Chapter Six.

15. North Carolina Department of Natural Resources and Community Development, 1988, *supra* note 6, at 20.

16. *See generally* U.S. EPA, *Regulatory Applications of Sediment Criteria*, June 24, 1987.

17. This step is desirable to address sediment contamination by both point and nonpoint sources. *See* U.S. EPA, October, 1988, *supra* note 4, at 21-22; Duda *et al.*, 1988, *supra* note 4, at 8; *see generally* U.S. EPA, June 24, 1987, *supra* note 16.

18. EPA publishes guidance for state water quality standards under section 304(a) of the Clean Water Act. 33 U.S.C. § 1314(a).

19. These states include Ohio, Maine, Arkansas, Nebraska and Oregon. *See* U.S. EPA, October, 1988, *supra* note 4, at 21-22; Duda *et al.*, 1988, *supra* note 4, at 8. See Chapter Six and discussion provided in this chapter.

20. U.S. EPA, *Setting Priorities: The Key to Nonpoint Source Control*, July, 1987, at i-ii, 23-25 (hereinafter cited as *Setting Priorities*); *see generally* Davenport, Thomas E., "Nonpoint Source Regulation—A Watershed Approach," paper presented at the 24th Annual Conference and Symposia, American Water Resources Association, Milwaukee, Wisconsin, November 6-11, 1988.

21. *See generally* Davenport, 1988, *supra* note 20.

22. North Carolina Agricultural Extension Service, *Guidelines for Evaluation of Agricultural Nonpoint Source Water Quality Project*, North Carolina State University, 1982, at 3 (hereinafter cited as *Guidelines*).

23. Debora Calden, U.S. EPA Region IX, March 29, 1988 (personal conversation); Gaylon Lee, California Regional Water Resources Control Board, March 2, 1988 (personal conversation). The use of standard chemical water quality standards alone may not suffice in assessing silvicultural water quality impacts because sediment deposition is more likely to affect habitat and biologic parameters than ambient water quality. States are beginning to develop other types of standards to fill the gap. California, for example, is currently working towards the development of new methods to enforce water quality standards on private and federal forested land based on biological criteria and specific habitat conditions as standards against which it can measure whether beneficial uses are being protected. See Chapter Five.

24. *Setting Priorities*, 1987, *supra* note 20, at 25; Jim Cox, Virginia Division of Soil and Water Conservation, February 29, 1988 (personal conversation); *see generally* U.S. EPA, *Results of the National Urban Runoff Program (Volume I - Final Report)*, December, 1983.

25. *Setting Priorities*, 1987, *supra* note 20, at 23-25.

26. This process is discussed in Chapter Six of this report, concerning data utilization. *See generally* U.S. EPA, *Nonpoint Source Monitoring and Evaluation*

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Guide (draft), February 26, 1988; U.S. Fish and Wildlife Service, *Nutrient Dynamics in the Choptank River Watershed, A Comparative Analysis of Subwatershed Exports*, Annapolis, Maryland, April, 1988; *see generally* Davenport, 1988, *supra* note 18.

27. *See Setting Priorities*, 1987, *supra* note 20, at i-ii, 23-24.

28. *See Setting Priorities*, 1987, *supra* note 20, at 23-25. Of course, the most effective type of water quality standard (*e.g.*, chemical, physical, biological) will vary with the circumstances.

29. For reasons of efficiency, a given state program may choose certain preferred, relatively uniform approaches.

30. *See* 40 CFR 131.12.

31. 40 CFR 131.12.

32. *Id.* at 131.12(a)(1).

33. *Id.* at 131.12(a)(2).

34. *Id.*

35. *Id.*

36. *Id.* at 131.12(a)(3).

37. For instance, Virginia's urban and silviculture poison runoff programs are largely controlled by the State Department of Conservation and Historic Resources, and like the agriculture program, are primarily voluntary in nature.

38. Gianessi, Leonard P., *et al.*, "Nonpoint-source Pollution - Are Cropland Controls the Answer?," 41 *JSWC* 217 (1986).

39. *See generally* U.S. EPA, *Report to Congress: Nonpoint Source Pollution in the U.S.*, January, 1984, at 3-1 - 3-15; *see, e.g.*, Virginia Division of Soil and Water Conservation, *Virginia Nonpoint Source Pollution Management Plan*, August 4, 1988, at i; Maryland State Soil Conservation Committee, *Maryland Agricultural Water Quality Management Program*, 1987.

40. *See generally* Virginia Division of Soil and Water Conservation, 1988, *supra* note 39; Maryland State Soil Conservation Committee, 1987, *supra* note 39.

41. For example, Florida and Wisconsin address a wide variety of pollution impacts, and both primarily manage NPS pollution through state and regional water quality and water resources management agencies. Eric Livingston, Environmental Administrator, Florida Department of Environmental Regulation, March 21, 1988 (personal conversation); *see generally* Florida Department of Environmental Regulation, *Florida Nonpoint Source Management Plan* (draft), August, 1988; Bergquist, Susan, ed., *Nonpoint source pollution: Where to go with the flow*, Wisconsin Department of Natural Resources, January-February, 1986.

42. *See generally* Davenport, 1988, *supra* note 20.

43. Konrad, John G., Baumann and Bergquist, "Nonpoint Pollution Control: The Wisconsin Experience," 40 *JSWC* 55-58 (1985). This expertise includes the ability to develop and use watershed pollution and water quality models.

44. Schloesser, Lynn, "Agricultural Non-Point Source Water Pollution Control Under Sections 208 and 303 of the Clean Water Act: Has Forty Years of Experience Taught Us Anything?," 54 *NDLR* 599 (1977-1978).

45. The following chapter discusses intergovernmental coordination in more detail.

46. Florida Department of Environmental Regulation, 1988, *supra* note 41, at 8-1.

47. *Id.*

48. 1987 Fla. Laws Ch. 87-97.

49. *Id.*; Florida Department of Environmental Regulation, 1988, *supra* note 41, at 8-5.

50. Gail Hankinson, St. Johns River Water Management District, Florida, March 23, 1988 (personal conversation); Florida Department of Environmental Regulation, 1988, *supra* note 41, at 8-6.

51. Hankinson, 1988, *supra* note 50; *see generally* 1987 Fla. Laws Ch. 87-97; Florida Department of Environmental Regulation, 1988, *supra* note 41, at 8-5.

52. Hankinson, 1988, *supra* note 50.

53. *See generally* 1987 Fla. Laws Ch. 87-97; *see, e.g.,* St. Johns River Water Management District, *Interim SWIM Plan for Lake Apopka,* February, 1988, at 2.

54. Florida Department of Environmental Regulation, 1988, *supra*, note 41, at 8-2; *see* Fla. Admin. Code 17-25.025 (1987). It should be noted that stormwater, once contained in discrete conveyances such as storm sewers, is considered a *point* source under current law. See Chapter Four.

55. Florida Department of Environmental Regulation, 1988, *supra*, note 41, at 8-2.

56. Lee McNight, Florida Department of Environmental Regulations, March 21, 1988 (personal conversation). This authority would ostensibly derive from regulations requiring agencies' (including Water Management Districts and the Department of Environmental Regulation) reviews of comprehensive plans to "relate to statutory responsibilities", which could include assuring that water quality standards are maintained or restored. Fla. Admin. Code 9J-11.008(5)(a) (1987).

57. McNight, 1988, *supra* note 56.

58. Gail Hankinson, St. Johns River Water Management District, March 22, 1988 (personal communication).

59. *See generally* South Florida Water Management District, *Management and Storage of Surface Waters Permit Information Manual – Volume IV,* (revision 01), Chapter 40E-40, December, 1987.

60. "Basis of Review for Surface Water Management Permit Applications Within the South Florida Water Management District," § 3.2.2.1 (attachment in South Florida Water Management District, 1987, *supra* note 59, at B-15).

61. St. Johns River Water Management District, *Interim SWIM Plan for the Lower St. Johns River Basin* (Appendices), March, 1988, at Appendix F.

62. *Id.*

63. Jeff Ellige, St. Johns River Water Management District, April 5, 1988 (personal conversation); *see* Jurgens, J.A., "Agricultural Nonpoint Source Pollution: A Proposed Strategy to Regulate Adverse Impacts," 2 *J. Land Use & Envtl. L.* 195 (1986).

64. Dick Witsel, San Francisco Bay Regional Water Quality Control Board, March 23, 1988 (personal communication).

65. *Id.*

66. *Id.*

67. San Francisco Bay Regional Water Quality Control Board, *Water Quality Control Plan, San Francisco Bay Basin (2),* December, 1986, at 3-1.

68. *Id.*

69. *Id.* at 3-3 - 3-16.

70. *Id.* at 4-61.

71. Michael T. Llewelyn, Wisconsin Bureau of Water Resources Management, Department of Natural Resources, letter to Tom Davenport, U.S. EPA Region V, October 29, 1987; Wisconsin Department of Natural Resources, *Wisconsin Nonpoint Source Assessment Report (draft),* April 1, 1988.

72. Konrad, Bauman and Bergquist, 1985, *supra* note 43, at 55-56; Bergquist, Susan, 1986, *supra* note 41, at 20.

73. *See* Wis. Stat. § 144.25 *et seq.* (1984); Wis. Admin. Code § 120 *et seq.* NR (1986).

74. The soil and water conservation programs administered by the DATC are authorized under Wis. Stat. § 92 (1986); Wis. Admin. Code § 160 *et seq.* (1986). The consolidation and sharing of authority between these two agencies is still evolving, but DNR will retain a prominent role in the final organizational framework. *See generally* Wisconsin Department of Agriculture, Trade and Consumer Protection and Wisconsin Department of Natural Resources, *Nonpoint Source Pollution Abatement and Soil and Water Resource Management – Implementing Changes to Chapters 92 and 144, Wisconsin Statutes – Transition Workplan for the Period July 1, 1987 to December 31, 1988* (no date).

75. *See generally* Bergquist, 1986, *supra* note 41; Wis. Admin. Code § 120 *et seq.* NR (1986).

76. Konrad, Bauman and Bergquist, 1985, *supra* note 43, at 56; Bergquist, 1986, *supra* note 41, at 22.

77. Konrad, Bauman and Bergquist, 1985, *supra* note 43, at 56.

78. *Id.* at 57.

79. *Id.* The Wisconsin Nonpoint Source program may still be compromised because of its dependence on the voluntary cooperation of localities and landowners. Since voluntary programs are frequently used to address the two most significant sources of NPS pollutants (agriculture and urban runoff), it is important that state programs recognize and utilize their authority to *require* individuals and municipalities to reduce poison runoff. Regulatory programs for the control of agricultural and urban runoff are addressed in Chapters Three and Four of this report.

80. The organization of the Wisconsin Nonpoint Source program is described later in this chapter as well as in chapter Ten.

81. Konrad, Bauman and Bergquist, 1985, *supra* note 43, at 57-58.

82. Konrad, Bauman, and Bergquist, 1985, *supra* note 43, at 58; *see* Bergquist, 1986, *supra* note 41, at 25.

83. Konrad, Bauman, and Bergquist, 1985, *supra* note 43, at 58.

84. Wisconsin Department of Natural Resources, *Nonpoint Source Pollution Control Plan for the Sevenmile-Silver Creek Priority Watershed*, February, 1987, at 7-9.

85. *Id.* at 10.

86. *See generally* U.S. EPA Region X, *Development of Criteria for Fine Sediment in the Northern Rockies Ecoregion*, April, 1987.

87. *Id.* at 239-240.

88. *Id.*

89. *Id.* Also, instead of a system driven by Best Management Practices (which the researchers felt often meant economical practices), the researchers called for the use of informed judgment by the land manager to develop protective measures that prevent increased soil erosion by, among other things, accounting for the possibility of unforeseen impacts (including cumulative impacts). *Id.* at 247. See Chapter Five.

90. Gaylon Lee, California Water Resources Control Board, March 2, 1988, (personal conversation). See Chapter Five for a discussion of silvicultural water pollution control programs and the California Forest Practices Act.

91. *Id.*; *see Final Report of the Forest Practice Rules Assessment Team to the [California] State Water Resources Control Board*, April 24, 1987, at 12-4 - 12-6 (hereinafter cited as the *Final Report on the Forest Practice Rules*).

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92. *Final Report of the Forest Practice Rules*, 1987, *supra* note 91, at 12-7.

Integrating the various components of a poison runoff control program across a state or region requires the participation of many government officials and interested citizens.

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Chapter Ten

Putting the Pieces Together: Comprehensive Program Implementation

Introduction

Designing a program to control poison runoff that is driven by water quality goals is only half of the battle. The planning elements described in this report must be incorporated into a cohesive strategy, which then must be implemented effectively by a large number of actors. The path to success may be strewn with a number of political and managerial obstacles; overcoming these obstacles is as critical to the success of a control program as overcoming technical limitations.[1] Successful control of poison runoff requires a skillful allocation of responsibilities among the many actors who can enhance—or doom—control efforts.

Managing diffuse pollution sources is by nature more complex than many other environmental protection enterprises. For example, point source programs often are administered by a single state-level agency or, at most, a central agency and a group of regional offices that collect data, monitor compliance, investigate complaints and enforce permit provisions. But this approach may not be feasible in the case of poison runoff, where more agencies and levels of government are involved in the control of more sources of pollution. Moreover, unlike point sources, federal laws today do not establish uniform requirements that dictate how poison runoff control should be accomplished.

This chapter describes how to allocate and organize institutional resources efficiently and effectively into an overall program structure for restoring and maintaining water quality. The chapter first discusses general principles of allocating program resources, and then describes innovative approaches being used in Florida, Minnesota, and other areas.

Institutional and Organizational Needs

Centralized state program control is needed to ensure that conflicts between government levels can be resolved and gaps or redundancies in coverage do not waste precious resources.[2] Within state government, many agencies are involved in programs affecting water quality. These agencies are responsible for such areas as:

1. water resources planning;
2. water quality management;
3. natural resource protection;
4. land use and economic planning;
5. agriculture, mining, and highway construction; and
6. health and welfare.

The interstate (and international) nature of poison runoff often creates a need for a mechanism to develop, implement, monitor and enforce specific management commitments at the river basin level.

The Roles and Responsibilities of Program Officials

The state water quality management agency (usually the best lead agency for program management)[3] or any other agency charged with coordinating state efforts must provide a formal mechanism to coordinate the roles of all relevant agencies, ranging from regional planning agencies to SWCDs and county health departments.[4]

State land use organizations and regional units of state water quality management agencies are two important state governmental entities in controlling poison runoff. State land use agencies can develop water quality protection requirements for local Comprehensive Plans, prepare model ordinances and other guidance for localities, and provide data on regional and state shifts in growth patterns. Regional water quality management agencies can provide a focal point for implementing, monitoring and enforcing state-level programs within a given area. They also have additional resources and expertise with which to assist in program evaluation.

Since local governments cannot control activities outside their boundaries, regional planning organizations need to coordinate multi-level programs (many of which are not traditional water quality protection programs), disseminate technical information and foster cooperation among local jurisdictions. Within a state, regional solutions can be developed using regional planning boards or commissions, or similar entities. Multi-state planning obviously should come under the control of the involved state governments with guidance from the federal level. Since existing regional planning institutions usually do not conform to hydrologic boundaries and often lack substantial legal authority, state laws should *mandate* cooperative arrangements both within and among regional bodies. Otherwise, any voluntary compromise could sacrifice water quality for economic and development considerations.

Finally, local jurisdictions and the general public must take part in any poison runoff control program. Local jurisdictions are often primary (and essential) actors in the preparation and implementation of control programs.[5] Local citizens contribute substantially to the pollution problem, and must be a basic part of any effective solution. Methods must be devised not only to gain the input of localities and the public, but also to resolve conflicts[6] and, if necessary, to modify programs to reflect local and public concerns. A strong state role is needed to ensure that state water quality goals are maintained in any negotiated compromises within or between localities.

Coordination Among Different Agencies and Levels of Government

These various poison runoff control players should be viewed in terms of the *functions* that they perform. Generally, each function within a state program to control poison runoff should fall within one of the following types of activity:

1. Strategic Planning - setting broad goals and policies;

2. Management Planning - translating goals and policies into concrete objectives and creating the necessary organizations and the allocation of resources; and

3. Operations - the actual execution of programs and projects.

States should assign roles, responsibilities and relationships based on the functions each agency is best suited to perform. Figure 1 provides a simplified schematic diagram indicating one way to direct the flow of responsibility in a state control program. As the source of program authority, the state water quality management agency should assign responsibilities to other state agencies; to regional organizations; and, finally, to local governments.[7] Feedback and program accountability are provided generally by lower levels of government and from state agencies other than the water quality management agency.[8]

Figure 2 describes how the roles and responsibilities of a few of the different program actors can be conceptualized. For each step in the planning process (*e.g.*, data collection, developing and selecting plans, implementing control activities and evaluating successes) this design can be broken down into the specific tasks of each management entity. As the diagram indicates, each

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Figure 1
Generalized Flow of Authority and Accountability in a State Poison Runoff Source Management Program

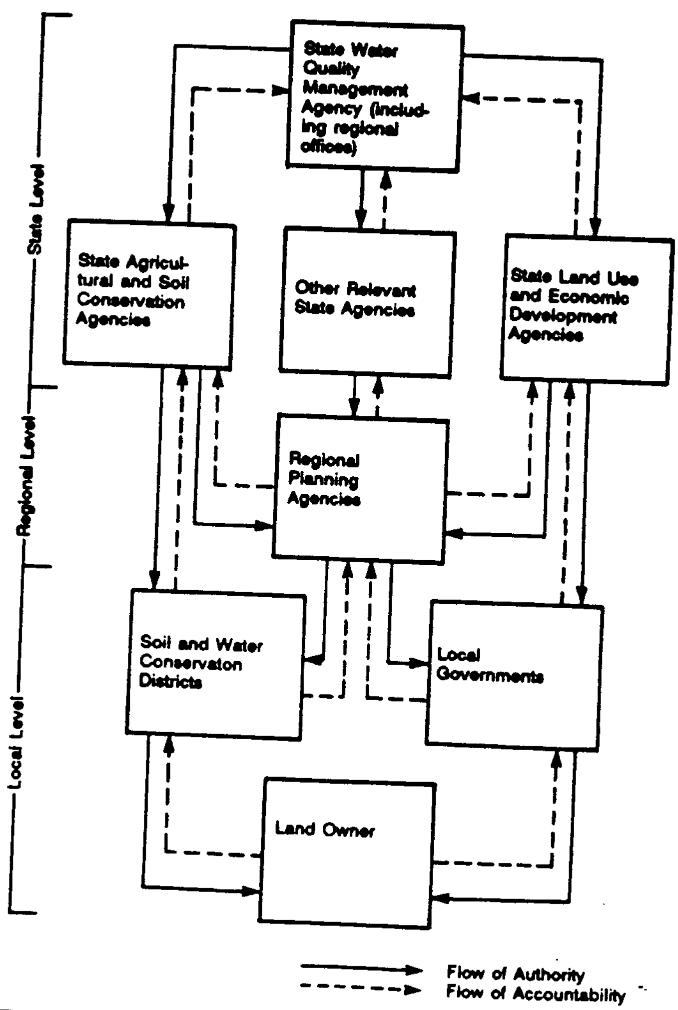

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Figure 2
Generalized Agency Responsibilities in Poison Runoff Management Program

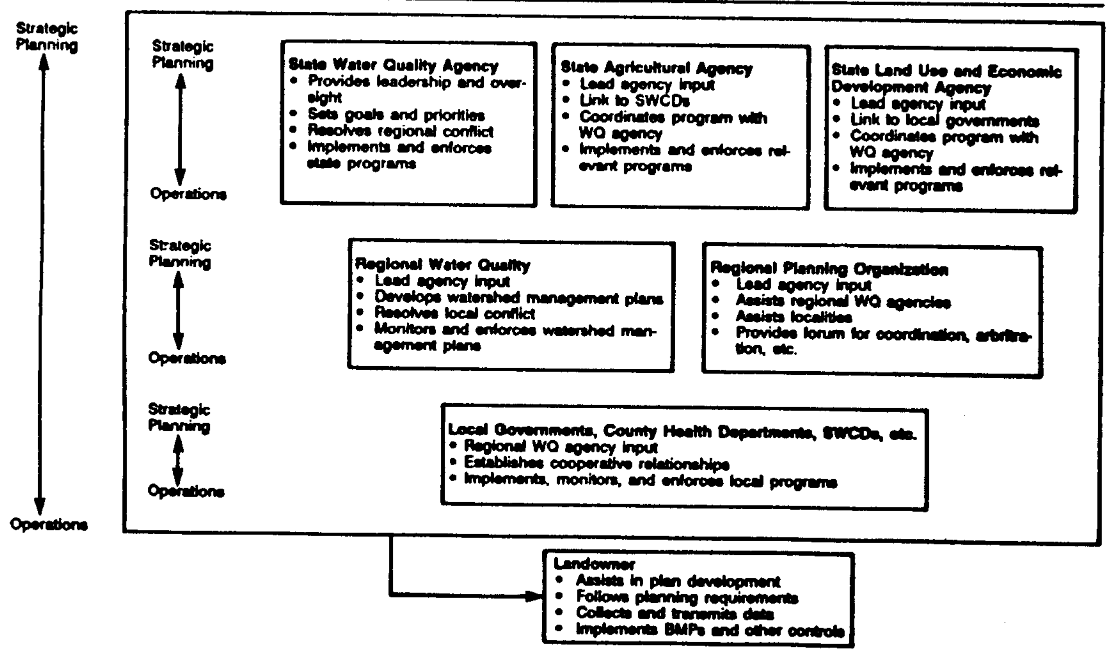

Figure 3
Example of Generic Agency Collections

Agency Connection	Planning Functions: Strategic	Management	Operations
Legislative/ Regulatory Connection	Requires state, regional or local entities to develop common goals and policies	Requires various program components (*e.g.*, enforcement) to be developed collectively	Requires programs to be executed and evaluated using common procedures or multiple agencies
Interagency Review Team	Identifies and solves potential problems within or between government levels	Allows the collective development or analyses of particular program proposals	Allows outside assessment of program successes and failures
Joint Work Plan	Clarifies issues and concerns early in the program development process	Formally establishes working relationships between agencies or government levels	Coordinates on-the-ground implementation activities

level of government is involved in a host of activities falling along the spectrum between strategic planning and operations, while the entire process also is organized according to this scheme.

Developing effective *connections* among state, regional and local governmental units is a pivotal requirement in a state management program and one that is only partially addressed by defining roles and relationships. Figure 3 provides a generic description of some of the agency connections that can be established, and how they can help to coordinate program activities.

What Works: Some Examples of Effective Approaches

Allocating and coordinating program resources will always depend upon the particular institutions and institutional relationships already in place in a state, as well as the poison runoff problems peculiar to that state. Nevertheless, an effective model in one state can be very useful to others seeking to learn from past successes (and mistakes). Examples of state and local programs with innovative institutional and organizational approaches to controlling poison runoff are set forth below. These approaches address particular problems differently, but they share the common trait of taking action to address an important (and difficult) institutional issue. While none of these examples individually incorporates *all* of the institutional and organizational needs identified in this chapter, each one illustrates innovative and effective mechanisms for addressing particular problems.

Florida: A Mandatory Process for Integrated State, Regional and Local Water Quality Protection

Regional Water Quality Management: A Coordinated Process Providing for Aggressive State Leadership and Oversight. Florida is a good example of how particular organizational and management tools can be used to coordinate the many levels of government that are involved in poison runoff control. The end product is site-specific action to achieve water quality objectives.

The development and organization of regional programs in Florida parallels the Surface Water Improvement and Management (SWIM) legislation.[9] Under this Act, the Department of Environmental Regulation (DER), Department of Natural Resources (DNR) and Game and Fresh Water Fish Commission (GFWFC) cooperate with Florida water management districts, each of which is required to develop a prioritized list of "surface waters of regional or statewide significance which require restoration or conservation."[10] Surface Water Improvement and Management (SWIM) plans must be developed for water bodies included on these priority lists.[11]

The SWIM Act provides a detailed set of criteria to be used in preparing the priority list of waters needing attention (Table 10-1), and this list is used as the basis for the involvement of all of the actors within the watershed that assist in the development of the SWIM plan. These criteria provide the means by which state and regional water quality management authorities can scrutinize and influence the contents of the plan, and the actions of public and private interests that affect the priority water bodies. The governing board of each district must hold public hearings and workshops before finalizing restoration strategies for particular water bodies, and must forward copies of the strategies and plans to the DER, other state agencies and appropriate local governmental units for review and comment.[12]

Yearly funding proposals, developed by the water management districts in cooperation with the DER, specify proposed activities and funding requirements.[13] Governing boards also are encouraged to appoint advisory committees to help develop and evaluate strategies and to increase public awareness and intergovernmental cooperation.[14]

Each of the key statewide agencies[15] is required to review each SWIM plan and to suggest modifications based on the criteria established in the legislation for that agency.[16] Several state agencies, along with the water management districts, are also required to review and strengthen their respective rules and enforcement programs to improve water quality protection.[17]

Funding for SWIM planning and implementation is provided by the SWIM Trust Fund, which is administered by the DER.[18] Money from the Fund cannot be dispersed unless the governing board of a water management district adopts a resolution that certifies the money is needed for planning and implementing SWIM plans.[19] A water management district must provide at least 20 percent of the amount of money needed for its SWIM program.[20] The SWIM Act authorizes water management districts to raise funds to develop and implement SWIM plans by levying *ad valorem* taxes at specified rates on property within the district.[21]

Table 10-1
Criteria for Developing SWIM Priority Lists Provided in the Florida Surface Water Improvement and Management Act*

1. The degree to which state water quality standards are violated. In reviewing this criterion, each District shall consider the following factors:
   a. The status and trends of water quality in the waterbody, including the nature and extent of pollution loading from point and nonpoint sources and the extent to which uses are impaired;
   b. Whether the waterbody can reasonably be expected to meet or maintain water quality standards without action to control point or nonpoint sources; and
   c. The nature and extent of sources of point and nonpoint pollution which contribute to the waters not meeting standards.
2. An evaluation of the nature and extent of conditions that adversely affect the waterbody, including, but not limited to:
   a. Nutrient balance of the waterbody;
   b. Trophic state of the waterbody;
   c. Existence or need for continuous aquatic weed control;
   d. Biological condition;
   e. Physical condition; and
   f. Reduced fish and wildlife values.
3. Threats to water supplies, especially agricultural and urban supplies, and recreational opportunities. In reviewing this criterion, each District shall consider the following factors:
   a. Whether uses of the waterbody are impaired, including whether the waterbody does not meet quality standards or requires control programs to maintain compliance with standards; and
   b. Whether conditions intermittently or frequently prevent a beneficial use.
4. Threats to or need for long-term protection of those exceptional or outstanding waterbodies which are currently in good condition.
5. The extent to which the plans, ordinances, and policies of local governmental units with jurisdiction over a waterbody are consistent with a District's efforts to restore or conserve a waterbody.
6. The feasibility of monitoring the success of restoration or conservation efforts in the waterbody.
7. The economic and environmental feasibility of accomplishments or restoration or conservation goals.

* Source: Quoted from Fla. Admin. Code 17-43.030 (1987).

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Local Planning for Water Quality Protection. Recent Florida legislation focuses on local government planning to (among other things) reduce poison runoff. Local governments in Florida are developing new Comprehensive Plans under the requirements of this legislation.[22] This planning process involves regional and state review of *local* Comprehensive Plans for conformance with *regional and state* plans, and with legislatively mandated local planning requirements.[23]

Localities whose plans are not approved at the state level become ineligible for certain funds, grants and revenue sharing.[24] Substantially affected local parties, including other local governments, also have the right to bring civil suits when local actions do not conform to requirements called for in local Comprehensive Plans.[25] While the state, regional and local planning process goes beyond water quality issues, several of Florida's planning requirements either directly or indirectly affect the way in which pollution is controlled at the local level. The minimum criteria for review of local plans are provided in Appendix A. Table 10-2 lists the components of local plans reviewed by the state agencies.

In addition to its substantive provisions, Florida's new Comprehensive Plan review process also includes important organizational and enforcement provisions. For example, Comprehensive Plans must be made internally consistent and must be coordinated with regional and state agencies.[26] Localities must identify and determine the effectiveness of all existing coordination mechanisms, including the subject areas covered, the nature of the relationships and the responsible offices.[27] Means for providing effective intergovernmental coordination must be identified.[28] Proposed growth and development in areas of concern must be identified and compared to comprehensive regional plans[29] to determine the needs for additional coordination.[30]

Comprehensive Plans must account for the impacts of a locality's proposed development upon other localities, the region and the state.[31] They must allow for "resolving conflicts with other local governments through the regional planning council's informal mediation process" and the "consistent and coordinated management" of multijurisdictional bays, estuaries and harbors.[32]

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Table 10-2
Minimum Components of Local Government Comprehensive Plans
Reviewed by Florida Department of Community Affairs*

- Future Land Use Element
- Traffic Circulation
- Mass Transit Element
- Port, Aviation, and Related Facilities Element
- Housing Element
- Sanitary Sewer, Solid Waste, Drainage, Potable Water, and Natural Groundwater Aquifer Recharge Element
- Coastal Management Element
- Conservation Element
- Recreation and Open Space Element
- Intergovernmental Coordination Element
- Capital Improvements Elements
- Optional Elements

* Source: Fla. Admin. Code 9J-5 (1986).

State and Regional Review of the Water Quality Implications of Local Plans: A Multi-Agency Task. The state Department of Community Affairs is responsible for assuring that local plans comply with general planning requirements, regional plans as well as the state comprehensive plan (SCP).[33] Also, relevant state agencies must assist the Department of Community Affairs in reviewing local plans for compliance with both general planning requirements and specific agency plans.[34] This can be a resource-intensive task. For instance, the Department of Environmental Regulation has approximately 12 full-time equivalent positions devoted to evaluating just the water quality implications of each local Comprehensive Plan.[35] Currently, these reviews are based only on general review criteria, and rely heavily on personal knowledge and judgment.[36] However, as resources, expertise and information increase, plans will be reviewed in more detail for their possible impacts on water quality in general and water quality standards in particular.[37]

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Summary. Florida's planning process is new and largely untested, and significant organizational problems still exist. Conflicts are caused because political boundaries do not conform to hydrologic ones,[38] and because water management districts sometimes do not coordinate activities with Regional Planning Councils and the DER.[39] It is too early to determine how these problems will be addressed.[40] But efforts are underway to improve coordination between the DER and the water management districts and to give DER an even stronger leadership and oversight role in water quality planning.[41]

But despite the unanswered questions and the problems associated with Florida's program, important progress already has been made. The tools have been established for comprehensive control of poison runoff, including local involvement in stormwater and groundwater management and environmental protection through land use planning, as well as regional and state coordination, oversight and leadership.

Minnesota: Local Water Quality Management Planning and Conflict Resolution

While Minnesota does not have a *mandatory* local, regional and state water quality planning process like Florida's, it does have a voluntary program that allows county governments to address poison runoff comprehensively and to enlist the participation of localities—all with a mechanism for effective oversight by the state.[42] Many counties (over 50) have undertaken this planning process, grouped into 6 regional areas for purposes of coordination within watersheds.[43] Under the Comprehensive Local Water Management Act (Minnesota Statutes, Chapter 110B) and its implementing regulations, Minnesota's planning process is administered and coordinated at the state level by the Board of Water and Soil Resources (BWSR).[44] The Board also has responsibility for conflict resolution, plan review and technical assistance.[45]

Local Water Quality Planning: A Method for Local Participation in Statewide Water Quality Protection. Each county that chooses to participate in the planning process must agree to meet the legal requirements of the act and review water and

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related land resources plans for consistency with the comprehensive county water plans.[46] County governments must agree to exercise the authority needed to implement the plan.[47] Counties may enter into formal agreements with other counties to prepare comprehensive water plans under a joint powers agreement (Minnesota Statutes 471.59) and may delegate all or part of their authority to prepare the plan to a local unit of government, a regional development commission or resource conservation and development committee.[48]

A county, after adopting a resolution requiring the development of a plan, must inform all of the relevant governmental entities of its decision. Relevant entities include contiguous counties (and local subunits); watershed districts and watershed management organizations that have overlapping jurisdictions; the regional development commission, if any; and the state Board of Water and Soil Resources).[49]

A comprehensive water plan must meet several requirements defined in the law. Specifically, it must:

1. cover the entire county;
2. consider the entire watershed and principal groundwater systems;
3. be based on established economic and environmental principles;
4. be consistent with other water plans in the watershed and groundwater system; and
5. apply at least through 1995, and be updated routinely.[50]

Plans must describe eight specific areas. The scope of a local water plan is given in Table 10-3.

In addition to these substantive requirements, local water plans also must take into account surrounding localities and the efficient allocation of human and financial resources. These minimum requirements are provided in Table 10-4.

Table 10-3
Scope of the Minnesota Comprehensive Local Water Plan[1]

1. The physical environment and expected changes to it
2. Information about water and related land resources and their expected changes[2]
3. Objectives and actions to achieve these objectives
4. Desired changes in state programs
5. Conflicts with local governments
6. Conflicts with other countries
7. Plan implementation
8. An amendment procedure

[1] Source: Minnesota State Planning Agency, *The Handbook for Local Comprehensive Local Water Planning*, November, 1987, at 16.

[2] To provide consistency, data must meet the collection and identification guidelines of the Minnesota State Planning Agency (including map scales) and data of value to the state or other localities must be integrated into state land management information systems. Minn. Code Agency R. Ch. 9300.0040 (1987).

The Minnesota Comprehensive Local Water Management Act establishes a valuable planning process by which counties can address water pollution from diffuse sources. Perhaps the Minnesota Act's most significant progressive feature is the legal *authority* it grants to counties. Counties, municipalities and townships have the authority to raise taxes to pay for the development and implementation of comprehensive water plans.[51] The availability of a funding source greatly increases the prospects for success. Also significant is the Minnesota law's formal coordination and conflict resolution process covering the state, regional and local governments. Finally, the law requires that public participation be ensured during plan *development* as well as *implementation.*[52]

Table 10-4
Implementation Program for Minnesota Comprehensive Local Water Plans*

1. The plan must state how and when it will be implemented to meet the required objectives.
2. The implementation program may include data collection programs, educational programs, capital improvement projects, project feasibility studies, enforcement strategies, amendments to existing official controls and adoption of new official controls. If no action is to be taken to address identified problems or opportunities, the plan must explain why actions are not needed.
3. Staff and financial resources needed to carry out the plan must be identified.
4. The plan must state the time in which each of the actions contained in the implementation program will be taken.
5. If a county has made an agreement for the implementation of the plan (or portions of the plan) by a local unit of government within the county, that local unit must be specified, the responsibility indicated, and a description included of how and when the implementation will happen.
6. If capital improvement projects are proposed to implement the comprehensive water plans, the projects must be described in the plan. This description must include the following information:
   a. the physical components of the project, including their approximate size, configuration and location;
   b. the purposes of the project and their relationship to the objectives of the comprehensive plan;
   c. the proposed schedule for project construction;
   d. expected federal, state and local costs;
   e. the types of financing proposed, such as special assessments, ad valorem taxes, and grants; and
   f. the sources of local financing proposed for the project, such as subcounty, countywide, or multicounty.

* Source: Minnesota State Planning Agency, *The Handbook for Local Comprehensive Local Water Planning*, November, 1987, at 77-81 (paraphrased).

Plan Approval and Implementation: The Local Authority Needed to Address Poison Runoff. The BWSR will distribute copies of the plan to relevant state agencies and will determine if the plan is consistent with the requirements of state

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law as well as with other comprehensive water plans wholly or partially within affected watershed units or groundwater systems.[53] After a plan is approved, local units of government must amend existing water and land use plans accordingly, using the recommendations of the county board.[54]

When the county begins to implement its water plan, it has additional authority to carry out the plan. This includes the authority to:

1. regulate water and land use in municipalities (independent cities) under certain circumstances;

2. acquire real and personal property needed to implement the plan and assess the costs of projects upon benefitted property within the county;

3. establish user charges for projects conducted under the auspices of the plan; and

4. establish special taxing districts within the county and issue bonds for the purpose of financing capital improvements.[55]

Informal and formal procedures are created by the Minnesota law to identify and to resolve any conflicts between the county water plan and local units of government within the county preparing the water plan; contiguous counties; and water management organizations, watershed districts, and joint powers boards sharing jurisdiction over watershed units and groundwater systems affected by the plan.[56] The law provides for an initial conflict resolution meeting, with the chair of the BWSR in attendance to resolve disputes informally. If a conflict cannot be resolved informally, then formal, binding conflicts resolution, with the BWSR acting as the final arbiter, is available.[57] Statutory conflict resolution procedures are in place to adjudicate any disagreements that may arise *after* the plan has been approved and adopted.[58]

After the plan is completed, it must be submitted to a host of governmental entities for review, comment, and in some cases, approval. These include:

1. all local units of government wholly or partly within the county;

2. all applicable regional development commissions;

3. contiguous counties and water management organizations; and

4. other counties, watershed districts, intercounty joint powers boards, and watershed management organizations that are within the same watershed unit or groundwater system as the county preparing the plan, and that may be affected by the plan.[39]

A public hearing must be held before the plan is submitted for state review (along with comments and associated changes to the proposed plan).[40]

Summary. Local water planning in Minnesota has been greatly enhanced by the comprehensive Local Water Management Act. A framework for state and regional participation and technical and financial assistance in local efforts to improve water quality is firmly in place. However, since very little money has been appropriated to encourage local water planning, the program's voluntary nature could discourage participation and result in a poor application of the planning requirements if citizens or public officials refused to raise funds through local taxation.[41] This problem could be overcome by increased state funding or by making the local planning effort a mandatory process, as it is in Florida.

Other Examples of Effective Institutional and Organizational Structures

Puget Sound: An Intra-State Regional Approach Providing for Oversight and Local Government Involvement. The Puget Sound Basin, in western Washington State, is a complex ecoregion consisting of a large fjord-like estuary, numerous bays, sub-basins and straits connecting the estuary to the Pacific

Ocean.[62] The basin has 2000 miles of inland marine shores, is drained by over 10,000 rivers and streams, and contains over 2.9 million people.[63] Recognizing the serious increases in pathogenic, toxic and sediment and nutrient-related water pollution in the Sound, the state legislature established the Puget Sound Water Quality Authority (PSWQA) to develop a plan to improve the management of the aquatic resource.[64] Nonpoint source control is an important component of this plan.

The most innovative aspects of the controls in the Puget Sound area are proposed in the Puget Sound Water Quality Management Plan.[65] The PSWQA recognized that existing programs for controlling particular poison runoff problems (agricultural, urban, etc.) were inadequate because they were voluntary, underfunded, poorly coordinated and not applicable to the full range of sources.[66] In response, the PSWQA established a cooperative local watershed planning process that uses existing and new *state* programs to address problems that require *statewide* control.[67]

The Plan calls for priority watersheds to be chosen by the State Department of Ecology (DE) based on nominations made by local governments, state agencies, environmental, public interest and agricultural organizations and others.[68] Using guidelines developed by the PSWQA, counties then identify and rank all watersheds for the development of future watershed action plans and submit the results of those rankings to the Department of Ecology.[69] The general public and affected individuals must be involved in this process through a separate citizen advisory committee, or by direct inclusion on the committee prioritizing the watersheds.[70] The committee must submit maps showing "watershed boundaries, identification of probable nonpoint sources, identification of all local jurisdictions and special purpose districts with territory within the boundary of each watershed, and identification of all affected tribes."[71] Objective criteria are used by county committees in selecting priority watersheds.[72]

PSWQA, with direct assistance from relevant state agencies, must prepare guidelines for use by watershed management committees in developing watershed action plans.[73] The county or counties within the priority watershed must convene a watershed management committee consisting of all affected political jurisdictions and special purpose districts.[74] Planning and implementation agencies for each pollution source within the watershed must be selected based on the territory governed, legal authority, and expertise.[75] If a lead agency cannot be agreed to internally, then DE, in consultation with the watershed ranking committee, can choose one.[76] The lead agency is responsible for:

1. convening meetings;

2. coordinating activities among local jurisdictions and other agencies;

3. assisting planning and implementation agencies in plan preparation;

4. compiling and publishing the plan; and

5. submitting the plan to DE for approval.[77]

Various programs provide grant funds and technical assistance for the development and implementation of the watershed plans.[78]

PSWQA encourages localities to strengthen the enforcement of water quality law by providing matching funds to counties, cities and local health agencies to improve investigations and prosecutions.[79] Localities are encouraged to use existing legal authority (*e.g.*, police power, health authority) to adopt ordinances or regulations that address farm practices, on-site septic systems or other local nonpoint sources.[80] State guidelines have been provided for controlling agricultural (mainly animal confinement and grazing), urban (including on-site septic systems and stormwater), and silvicultural pollution sources.[81]

An important aspect of the watershed action plan is its essentially mandatory nature. If local governments refuse to prepare plans, then the lead state agency either will prepare and implement the plans itself or will use its regulatory authority to direct localities to undertake the planning process.[82] This is an important feature since it is estimated that as much as half of the cost of implementing water quality improvement activities will be borne by local governments.[83]

Colorado: A Regulatory Framework for Regional Point-Nonpoint Pollution Trade-Offs. Colorado has devised an innovative planning framework to protect a drinking water reservoir from the threats of phosphorous contamination and eutrophication. Through the direction of the Northwest Council of Governments, local governments have developed a mechanism for allocating inputs of phosphorous to the Dillon Reservoir from point and nonpoint sources, instead of increasing phosphorus loads by competing for permits to increase sewage discharges.[84] Colorado allows a program trade-off or exchange of additional point source loadings if offset with reductions in loadings of poison runoff while still meeting target load reductions.[85]

The strategy was developed through modeling efforts that indicated the level of controls needed to meet a phosphorus standard of 7.4 micrograms/liter.[86] State officials maintain point source controls on POTWs, while local governments, bound together in an organization called the Summit Water Quality Committee, control existing poison runoff under the land use and zoning authority of the member localities. All new development must maintain stringent controls.[87] The general program structure is established in regulations by the State Water Quality Control Commission:

1. a wasteload allocation distributes phosphorus loading among point source dischargers based on annual loadings and a water quality standard of 7.4 micrograms/l;

2. point source dischargers are limited in terms of allowable concentration;

3. the state water management agency implements the point/nonpoint trading system through the NPDES permit program–for every 2 kilograms of nonpoint source phosphorus removed, 1 kilogram of phosphorus credit is

added to the point source annual limit (the 2:1 ratio serves as a safety margin).

4. NPDES permits must contain, at a minimum, the following provisions:
   a. a record of the point source credit amount;
   b. construction requirements for the point source control devices;
   c. monitoring and reporting requirements; and
   d. operation and maintenance requirements for the nonpoint source controls.

5. the credit program is not allowed to begin until regulations for controlling phosphorus from new nonpoint sources are implemented; and

6. both point source discharges and nonpoint source controls are mandatory parts of NPDES permits.[88]

As part of the process, the Summit Water Quality Committee:

1. identifies sites for nonpoint source control devices;

2. distributes phosphorus credits gained from the nonpoint source controls;

3. monitors streams, lakes, the nonpoint source controls, and point source discharges;

4. develops septic tank control programs; and

5. collects, from member jurisdictions, the revenues needed to operate the committee, to monitor the program and to construct, operate, and maintain nonpoint source controls.[89]

This program allows growth while providing an institutionalized, multijurisdictional system to establish and enforce the controls needed to maintain water quality standards.[90]

The Denver Regional Council of Governments developed a similar plan to halt the accelerated eutrophication of Cherry Creek Reservoir.[91] The Council used modeling to determine the phosphorus standard needed to reverse eutrophication in the lake.[92] It then developed a management plan based specifically on controls needed to achieve this standard. Because increased urbanization without adequate control of poison runoff would lead to a violation of the standard, a master plan was developed that required a basinwide reduction of at least 50% of yearly phosphorus loads.[93]

Similar to the Dillon Reservoir Program, the phosphorus management program is implemented by a Basin Authority created by an intergovernmental agreement that consists of counties, municipalities, and the water and sanitation districts that operate the wastewater treatment plant.[94] The Authority is responsible for constructing, financing and operating the nonpoint source controls. Under the program, local governments are required to adopt BMPs, which include erosion control ordinances, uniform drainage criteria, and septic system performance standards.[95] Detention, retention and filtration methods also will be used to accomplish a minimum goal of 50% reduction in diffuse phosphorus loadings.[96] After this goal is met, point-nonpoint trading, similar to that described above, can take place.[97]

The point-nonpoint pollution tradeoff programs developed to protect these two reservoirs in Colorado illustrate the technical innovation, program efficiency and funding sources that come from state leadership and cooperation between localities. These programs demonstrate that local governments and groups with competing interests (*i.e.*, point versus nonpoint polluters) can work together to address common water quality problems.

U.S.-Canada Great Lakes Water Quality Agreement. Contamination problems from nonpoint sources respect neither state nor international boundaries. While poison runoff must be controlled by individual states, localities and landowners, a framework for approaching interstate or international problems is essential. States have the authority to compel localities to act, but interstate and international lines of authority are far less clear cut.

It is important, therefore, that international and interstate water quality agreements be developed that provide mechanisms to hold member states and countries accountable for the commitments each has made. Otherwise, good intentions and will not be translated into tangible results.

The 1987 WQA provides a mechanism for convening interstate conferences to address interstate nonpoint source pollution impacts,[98] although it does not indicate how agreements between states should be structured. Recent (1987) amendments to the U.S.-Canada Great Lakes Water Quality Agreement illustrate how leadership, oversight and control can be established at either the multi-state or multi-national level.

Article VIII of the 1987 amendments establishes the responsibility of the United States and Canada, in cooperation with their respective state and provincial governments, to designate specific geographic Areas of Concern. For each Area of Concern, Remedial Action Plans (RAPs) must be developed that define the environmental problems to be addressed, including the beneficial uses that are impaired, and the degree and geographic extent of impairment.[99] The Agreement defines the terms "Areas of Concern" and "Impairment of Beneficial Use(s)."[100] The Plans must employ a "systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern or in open lake waters."[101] In addition, RAPs must also include:

1. a definition of the causes of the use impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources;

2. an evaluation of remedial measures in place;

3. an evaluation of alternative additional measures to restore beneficial uses;

4. a selection of additional remedial measures to restore beneficial uses and a schedule for their implementation;

5. an identification of the persons or agencies responsible for implementation of remedial measures;

6. a process for evaluating remedial measure implementation and effectiveness; and

7. a description of monitoring activities to track program effectiveness.[102]

The International Joint Commission (IJC), the quasi-judicial body charged by the United States and Canada with monitoring progress under the Agreement, reviews and comments on RAPs at three different stages: when the problem is defined; when remedial and regulatory measures are selected; and when monitoring indicates that beneficial uses have been restored.[103]

In addition to specific Areas of Concern and associated RAPs, Lakewide Management Plans for specified critical pollutants must be prepared.[104] The Agreement also establishes minimum contents for the plans and gives the IJC the responsibility to review and comment on them.[105]

A separate section on nonpoint source pollution was added to the agreement in 1987 (Annex 13). This section requires the identification of "land-based activities contributing to water quality problems described in Remedial Action Plans for Areas of Concern, or in Lakewide Management Plans...."[106] In addition, watershed management plans must be developed and implemented. The United States and Canada (in conjunction with State and Provincial Governments) must:

> develop and implement watershed management plans, consistent with the objectives and schedules for individual Remedial Action Plans or Lakewide Management Plans, on priority hydrologic units to reduce non-point source inputs. Such watershed plans shall include a description of priority areas, intergovernmental agreements, implementation schedules, and programs and other measures to fulfill the purpose of this Annex ... Such measures shall include provisions for regulation of non-point sources of pollution.[107]

Annex 13 also calls for "programs and projects" designed to estimate diffuse loadings to rivers and to the boundary waters of the Great Lakes; the changes in land uses and land use management practices from control programs; and the resulting reductions in pollution loadings.[108]

Annex 16 requires the identification of existing and potential sources of contaminated groundwater entering the Great Lakes and the hydrogeologic conditions near the sources of contamination.[109] Standard sampling and analysis procedures must be developed to assess the degree and extent of contamination, and to estimate the loadings of groundwater contaminants to the Lakes.[110] When the problem has been identified, the sources of contamination must be controlled.[111]

The U.S.-Canada Great Lakes Water Quality Agreement establishes the consistency, coordination and oversight mechanisms that are essential in environmental management efforts of such size and technical and political complexity. Of course, the success of particular management efforts cannot be assured by such a framework since actual field level control mechanisms are not dictated by the Agreement. Still, the GLA is an important example of multi-national and multi-state planning through which the state and local approaches discussed previously could be implemented.

Conclusions and Recommendations

While none of the individual examples described above incorporates *all* of the institutional and organizational needs identified in this chapter, each one illustrates innovative and effective mechanisms for addressing particular problems. Taken together with the program aspects discussed in Chapter Ten, these examples can be used as the basis for developing state nonpoint source programs with the essential institutions, management capacity, and organizational relationships.

For instance, Minnesota provides an elaborate (although voluntary) local planning procedure for water quality protection. The Minnesota Planning Procedure could be incorporated into a mandatory state, regional and local planning process like the one in Florida. The Puget Sound mandatory watershed planning process also could be a model for local planning requirements. The Minnesota conflict resolution methods could be used to

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address the inevitable local disagreements that would arise from such a mandatory program.

The regional water quality planning offered through the U.S.-Canada Great Lakes Water Quality Agreement, Florida's SWIM program and Wisconsin's Nonpoint Source Pollution Abatement program provide the regional context (both inter- and intrastate) needed to ensure state leadership and expertise, as well as consistency, in the development of control programs. The technical and financial assistance authorized through the programs in Minnesota, Wisconsin and Puget Sound provide the motivation and opportunity for localities to prepare effective and innovative plans. Of course, the attainment or maintenance of water quality standards should be incorporated into all of these state programs.

The important institutional and organizational aspects of a program to control poison runoff can be summarized as follows:

1. All jurisdictions that contribute poison runoff to waters should be *required* to participate in control efforts if water quality standards are not being met.

2. Localities should be required to address water quality problems within their own jurisdictions through their comprehensive plans, but this should be a subset of a coordinated watershed-wide effort.

3. Local control programs should constitute the major field-level activity, with regional and state levels providing criteria and requirements for program development, technical assistance, funding, conflict resolution, evaluation, and program approval or disapproval.

4. All involved local governmental units and affected local interests (*e.g.*, agriculture, environmental) should develop a single plan to be reviewed and approved at the regional or state level.

5. Binding conflict resolution mechanisms that base decisions on the objectives of the water quality plan (and adverse

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economic and social impacts) must exist at the state or regional level.

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1. Potter, Harry, "Inter-Organizational Relations, Constituencies and Nonpoint Pollution Policy," Proceedings of the Conference on Political, Institutional and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987, at 12; Viessman, Warren, Jr., "Regional Options for Managing and Regulating Nonpoint Pollution," Proceedings of the Conference on Political, Institutional and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987, at 1.

2. *See* Veissman, 1987, *supra* note 1, at 2-4.

3. See Chapter Nine for a discussion of the best lead agency for effective poison runoff control.

4. For example, some of these functions include data collection and analysis by regional water management agencies; design of management approaches; evaluation of the economic and social impacts of particular poison runoff control programs by SWCDs, and review of local Comprehensive Plans by state agriculture agencies. *See, e.g., Virginia Groundwater Protection Strategy Steering Committee, Final Report*, 1987; Puget Sound Water Quality Authority, *Puget Sound Water Quality Management Plan*, 1987. One tried-and-true approach to statewide coordination is to establish a Standing Advisory Committee of representatives from relevant state agencies. This has been done in the past to achieve effective groundwater protection planning at the state level, and some states already have used such committees for nonpoint source management programs. These Standing Committees should include a balance of state, regional and local officials, academicians, and environmental, industrial and other interested parties.

5. However, state and federal oversight is vital in encouraging and requiring effective local controls. Rogers, Peter and Alon Rosenthal, "The Imperatives of Nonpoint Source Pollution Policies," Proceedings of the Conference on the Political, Institutional, and Fiscal Alternatives to Accelerate Nonpoint Pollution Programs, Milwaukee, Wisconsin, December 7-9, 1987, at 28-32

6. *Id.*; Veissman, 1987, *supra* note 1, at 3.

7. For the purposes of this diagram SWCDs are considered local governments, even though technically they are usually units of state government.

8. Regional offices of the state WQM agency may need to be interposed between the statewide agency and other state-level agencies, since these regional water quality managers represent the central state WQM agency within particular geographic areas.

9. The use of general planning and water quality standards in Florida poison runoff control programs is also described in Chapter Nine.

10. Fla. Admin. Code 17-43.030 (1988).

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11. 1987 Fla. Laws Ch. 87-97 §§ 2(1), 2(2); *see, e.g.*, South Florida Water Management District, *Draft Interim Surface Water Improvement and Management (SWIM) Plan for Lake Okeechobee*, October 10, 1988.

12. 1987 Fla. Laws Ch. 87-97 § 2(3).

13. 1987 Fla. Laws Ch. 87-97 § 2(3).

14. 1987 Fla. Laws Ch. 87-97 § 2(4). Representatives on advisory committees include the Game and Fresh Water Fish Commission (GFWFC), Department of Natural Resources (DNR), Department of Agriculture and Consumer Services (DACS), appropriate local governments, federal agencies, existing advisory councils for the subject waterbody, and representatives of the public who use the waterbody. In implementing the SWIM plans, water management districts also may contract with local, regional or state agencies to perform certain tasks.

15. The DER - Department of Environmental Regulation; the DNR -Department of Natural Resources; the GFWFC - Game and Fresh Water Fish Commission; and the DACS - Department of Agriculture and Consumer Services are all required to participate in the Florida SWIM Program.

16. 1987 Fla. Laws Ch. 87-97 §§ 3(1) - 3(5).

17. 1987 Fla. Laws Ch. 87-97 § 3(6); *see, e.g.*, St. Johns River Water Management District, *A Review of District Rules Relating to Water Quality, Compliance Programs and Proposed Strengthening Measures*, March 1, 1988.

18. 1987 Fla. Laws Ch. 87-97 §§ 4(1), 4(2), 5(1). The SWIM Act provides for $15,000,000 to be available for programs designed for specific water bodies listed in the Act. See Chapter Seven for a more detailed discussion of funding poison runoff control efforts.

19. 1987 Fla. Laws Ch. 87-97 §§ 5(1) - 5(2).

20. 1987 Fla. Laws Ch. 87-97 § 5(3) (1987).

21. 1987 Fla. Laws Ch. 87-97 § 10(3)(a); Ellen Slater, Florida Department of Environmental Regulation, March 21, 1988 (personal conversation).

22. *See* Fla. Stat. § 163.3184(8)(a) (1985).

23. *See generally* Fla. Admin. Code 9J-5 (1986); Fla. Admin. Code 9J-11 (1987); Fla. Stat. § 186 *et seq.* (1985); Fla. Stat. § 187 *et seq.* (1985).

24. Fla. Stat. § 163.3184(8)(a) (1985).

25. Fla. Stat. § 163.3215 (1985).

26. Fla. Admin. Code 9J-5.015 (1986). This applies to a given locality's relationship with all adjacent and associated counties, municipalities, independent special districts, regional planning districts, water management districts and state agencies with land use or environmental regulatory authority. *See* Fla. Admin. Code 27E-4.003 (1986); Fla. Admin. Code 9J-5.001 (1986).

27. Fla. Admin. Code 9J-5.005 and 9J-5.015(2) (1986).

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28. Fla. Admin. Code 9J-5.015 (1986). These methods include intergovernmental agreements, joint planning and review agreements, special legislation and joint meetings or work groups. Fla. Admin. Code 9J-5.015(3) (1986).

29. *See* Fla. Stat. § 186.507 (1985). Florida law also requires the development of 11 comprehensive regional plans. *See generally* Fla. Stat. §§ 186.507-508 (1985); Fla. Admin. Code 27E-1 - 27E-4 (1986). The Comprehensive Regional Policy Plans (CRPPs):

> play a pivotal role or link between the State Plan and the Local Government Comprehensive Plans because local plans are required to be consistent with the [State Comprehensive Plan] and the appropriate CRPP. The CRPPs represent a further step in implementing the SCP, as well as a compiling and balancing the needs of local jurisdictions. It is this juxtaposition between the top down planning and the bottom up planning that makes these plans unique and essential. The CRPPs must implement the State Plan by reflecting and furthering its goals and policies from a regional perspective. The CRPPs are to be plans for the region; *i.e.*, a regional approach toward implementing the [State Comprehensive Plan].

Florida Department of Community Affairs, *Comprehensive Regional Policy Plans (CRPPs)—State Agency Review and Evaluation Guidelines*, November, 1986, at 2.

30. *See generally* Florida Department of Community Affairs, November, 1986, *supra* note 29; Fla. Admin. Code 9J-5.015(3) (1986).

31. Fla. Admin. Code 9J-5.015 (1986).

32. Fla. Admin. Code 9J-5.015(3)(c)(2) (1986).

33. *See* Fla. Admin. Code 9J-11.004(2), 9J-11.010, 9J-11.012 (1987).

34. Keith McKaren, Florida Department of Community Affairs, April 20, 1988 (personal conversation); *see* Fla. Stat. §§ 186.021-.022 (1985); Fla. Admin. Code 9J-11.008(3), 9J-11.012(2) (1987).

35. Lee McKnight, Florida Department of Environmental Regulation, March 22, 1988 (personal conversation).

36. *Id.*

37. *Id.* Florida's eleven Regional Planning Councils are also developing Comprehensive Plans and will review local plans for conformance. Regional Planning Councils, chaired by officials from representative localities, have substantial authority (formal and informal) to assist in local conflict resolution, review and modify developments with regional impact, and bring local plans into conformance with regional ones. This authority includes the right of councils to prepare the missing elements of local comprehensive Plans. *See generally* McKnight, 1988, *supra* note 35; Fla. Stat. § 163 *et seq.* (1985); Fla. Stat. § 186 *et seq.* (1985); Fla. Stat. § 163.3167(4) (1987); Fla. Admin. Code 9J-11 (1987); Fla. Admin. Code 27E-1 - 27E-4 (1986).

38. In fact, Fla. Stat. Ch. § 163 *et seq.* (1987) creates a study commission on the issue of substate district boundaries.

39. McKnight, 1988, *supra* note 35; Ellen Slater, Florida Department of Environmental Regulation, March 23, 1988 (personal conversation).

40. McKnight, 1988, *supra* note 35.

41. Slater, 1988, *supra* note 39.

42. Marilyn Lundberg, Minnesota State Planning Agency, March 29, 1988 (personal conversation).

43. Minnesota Environmental Quality Board, *LCMR Pilot Comprehensive Water Planning Projects* (Map Key) (no date) .

44. Minn. Stat. § 110B.10 Subd.1 (1986).

45. Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes Chapter 110B*, November, 1987, at 2-3 (hereinafter cited as *Minnesota Handbook*).

46. *Id.* at 1-4.

47. *Id.*

48. *Id.*

49. Minn. Code Agency R. § 9300.0030, Subp.3 (1987).

50. Minn. Stat. § 110B.04, Subd.4 (1986).

51. *Minnesota Handbook*, 1987, *supra* note 45, at 9; Minn. Stat. § 110B.20 (1986).

52. *Minnesota Handbook*, 1987, *supra* note 45, at 11. The county preparing the plan must, during plan preparation and implementation, conduct meetings with local units of government that have authority over water and related land resources within the county. The planning processes must be coordinated with contiguous counties and joint meetings with other county boards are encouraged. Minn. Stat. § 110B.04, Subd.3 (1986); Minn. Code Agency R. § 9300.0030, Subp.6 (1987).

53. Minn. Stat. § 110B.08, Subd.5 (1986); Minn. Code Agency R. § 9300.0170 (1987).

54. Minn. Stat. § 110B.12, Subd.1-2 (1986); Minn. Code Agency R. § 9300.0180 (1987).

55. Minn. Stat. § 110B.15 (1986); Minn. Stat. § 110B.20 (1986).

56. *Minnesota Handbook*, 1987, *supra* note 45, at 86, 94-96; Minn. Stat. §§ 110B.04, 110B.25 (1986); Minn Code Agency R. §§ 9300.0140, 9300.0200, 9300.0210 (1987).

57. Minn. Code Agency R. § 9300.0210 (1987).

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58. Minn. Stat. § 110B.25, Subd.2-5 (1986); Minn. Code Agency R. § 9300.0210 (1987). The process (called petitioning for a contested case hearing) involves disagreements between the county board and a local unit or other government concerning the interpretation and implementation of the plan; the apportionment of the costs of a portion of the plan; or the recommendations for changes in local programs made by the county board. The actual hearing is conducted by the state office of administrative hearings and the BWSR is responsible for making a final decision based on the findings of the hearing. *Minnesota Handbook*, 1987, *supra* note 45, at 94-96.

59. Minn. Stat. § 110B.08 (1986).

60. Minn. Stat. § 110B.08, Subd.4 (1986).

61. Lundberg, 1988, *supra* note 42.

62. Puget Sound Water Quality Authority, *1987 Puget Sound Water Quality Management Plan*, at 2-1, 1987 (hereinafter cited as *Puget Sound Plan*); *see also* Puget Sound Water Quality Authority, *1989 Puget Sound Water Quality Management Plan*, adopted October 19, 1988.

63. *See Puget Sound Plan*, 1987, *supra* note 62, at 1-1 - 2-6.

64. *See* Wash. Rev. Code § 90.70 (1985).

65. The PSWQA is working with state and local agencies to address the problem of NPS pollution in the Sound. The Washington State Urban Stormwater Management Plan encourages localities to establish stormwater utilities and charge rates for stormwater services or to require and review drainage plans as part of the approval process for building permits. Washington law also requires county comprehensive plans to provide guidelines for the reduction of pollutants entering the Puget Sound, including NPS pollution from urban and agricultural areas. *See Puget Sound Plan*, 1987, *supra* note 62, at Chapter 5.

66. *Id.* at 5-4 - 5-5.

67. *Id.* at 5-6; *see generally* Wash. Admin. Code R. § 400-12 (1988).

68. Wash. Admin. Code R. § 400-12(Part 3) and (Part 5) (1988).

69. Wash. Admin. Code R. § 400-12(Part 4) (1988).

70. *Id.*

71. *Puget Sound Plan*, 1987, *supra* note 62, at 5-8; Wash. Admin. Code R. § 400-12(Part 5) (1988). This planning process is similar to that provided in CWA §§ 303(d) and (e), 33 U.S.C. § 1251 (1977).

72. *Puget Sound Plan*, 1987, *supra* note 62, at 5-8; Wash. Admin. Code R. § 400-12-310 (1988); *see also* USDA Soil Conservation Service, *Watershed Rating Criteria for Non-Point Sources of Pollution*, Seattle, Washington, January, 1988.

73. *Puget Sound Plan*, 1987, *supra* note 62, at 5-9; Wash. Admin. Code R. § 400-12(Part 5) (1988).

74. Wash. Admin. Code R. § 400-12-400(1) (1988).

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75. Wash. Admin. Code R. § 400-12(Part 5) (1988).

76. *Puget Sound Plan*, 1987, *supra* note 62, at 5-7.

77. *See* Wash. Admin. Code R. § 400-12(Part 4) (1988).

78. *Puget Sound Plan*, 1987, *supra* note 62, at 5-12.

79. *Id.* at 5-4 - 5-21.

80. *Id.*

81. *Id.* at 5-9 - 5-10.

82. Wash. Admin. Code R. § 400-12-700 (1988).

83. *Puget Sound Plan*, 1987, *supra* note 62, at 5-23.

84. *See* Mast, Gary and Bruce Zander, "Application of Innovative Pollutant Trading for Reservoir Water Quality Management in Colorado," *Lake and Reservoir Management - Vol. III*, North American Lake Management Society, Washington, DC, 1987, at 138-145; *see also* Kashamian, Richard, *et al.*, "Beyond Categorical Limits: The Case for Pollution Reduction Through Trading," paper presented at the 59th Annual Water Pollution Control Federation Conference, Los Angeles, California, October 6-9, 1986.

85. Mast and Zander, 1987, *supra* note 84, at 138-141.

86. *Id.* at 140.

87. *Id.* at 139-140.

88. *Id.* at 140-141.

89. *Id.* at 140; Greg Parsons, Colorado Tri County Health Department, Bellvue, Colorado, October 25, 1988 (personal conversation).

90. Mast and Zander, 1987, *supra* note 84, at 141.

91. *Id.*; Parsons, 1988, *supra* note 89. The data collection activities of this program are also discussed in Chapter Six.

92. Mast and Zander, 1987, *supra* note 84, at 142-144; Colorado Water Quality Control Commission, *Regulations for Control of Water Quality in Cherry Creek Reservoir*, November, 1985, at § 4.2.3. These regulations were developed pursuant to the provisions of Colo. Rev. Stat. § 24-4-103(5), § 24-4-103(11)(a) (1973).

93. Mast and Zander, 1987, *supra* note 84, at 143; Water Quality Control Commission, 1985, *supra* note 92, at § 4.2.6.

94. Mast and Zander, 1987, *supra* note 84, at 143; Parsons, 1988, *supra* note 89.

95. Mast and Zander, 1987, *supra* note 84, at 143; Parsons, 1988, *supra* note 89.

96. Mast and Zander, 1987, *supra* note 84, at 143; Parsons, 1988, *supra* note 89.

97. Mast and Zander, 1987, *supra* note 84, at 143-144.

98. CWA § 319(g), 33 U.S.C.A. § 1329(g) (1987). The process is described in Chapter Two.

99. *Protocol Amending the 1978 Agreement Between the United States of America and Canada on Great Lakes Water Quality, As Amended On October 18, 1983*, at Annex 2(1).

100. *Id.*

101. *Id.* at Annex 2(2)(a).

102. *Id.* at Annex 2(4)(a)(ii-viii).

103. *Id.* at Annex 2(4)(d).

104. *Id.* at Annex 2(6)(a).

105. *Id.* at Annex 2(6)(a)(i)-(x), Annex 2(6)(c).

106. *Id.* at Annex 13(2)(a).

107. *Id.* at Annex 13(2)(b).

108. *Id.* at Annex 13(4).

109. *Id.* at Annex 16(1).

110. *Id.*

111. *Id.*

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SUMMARY

Criteria for Evaluating Programs to Control Poison Runoff

This report described ways for states and localities to control poison runoff from cities, farms, mines, logging operations, and a range of other sources. In most cases, the report draws on actual programs that are being implemented today by state and local governments around the country.

The ultimate goal of any state or local water pollution control program is to achieve compliance with water quality standards – to make rivers, lakes, and coastal waters safe for fishing, swimming, drinking and other uses. By combining the best examples of program elements discussed above into a comprehensive management effort, state and local governments *can* develop a good set of tools to address poison runoff. And proper implementation and enforcement of such a program should result in the attainment of water quality goals.

None of the examples cited in the report, *taken alone*, will suffice to achieve water quality goals. Nor are the examples given the *only* viable options to control poison runoff. Indeed,

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we hope that these successful examples are just the beginning—that newer and even more effective options will be developed as state and local governments attack poison runoff with more vigor. And specific program components necessarily will differ according to physical, political and economic differences in various regions of the country.

However, the basic principles demonstrated by these examples define the minimum, essential elements of an effective poison runoff control program. Even if the specific examples are rejected or modified, any control program that follows the basic principles discussed in this report, along with vigorous implementation and enforcement, should go a long way to address the complex and ubiquitous problem of poison runoff.

The specific recommendations in this report were divided into two main sections. First, we described the key *components* of good programs: ways to control specific types of pollution from agriculture, contaminated urban runoff and other land uses effects, silviculture, mining and grazing; and ways to implement these controls through adequate data collection and use, funding, and use of legal tools. Next, we described how to combine the building blocks into an effective, comprehensive program.

The following summary distills these specific recommendations into a checklist of criteria for programs to control poison runoff. These recommendations establish basic program goals. But they allow flexibility for states and localities to address specific problems in different ways.

This checklist can be used by various entities in different ways. State and local officials, both legislative and executive, can use them to develop and implement effective programs. State and federal officials can use them to evaluate the completeness and efficacy of local and state programs, respectively. Citizens can use them to evaluate the effectiveness of existing and proposed programs to control poison runoff, and to participate effectively when opportunities are provided for public comment.

Following the format of the report, first we outline basic principles applicable to the individual components of a good program. Next, we summarize the key principles that govern the assembly of the components into an effective overall program to control poison runoff.

Components of an Effective Program*

Agricultural Issues

1. If the state relies primarily on cost sharing in agricultural pollution control, is farmer participation (and funding) sufficient to ensure compliance with water quality standards?

2. Where voluntary programs alone do not suffice to meet water quality standards, are other controls, such as design standards and design taxes, used significantly to address agricultural pollution?

3. Is pollution from agricultural chemicals (including fertilizer and pesticides) addressed independent of programs designed primarily to reduce soil erosion? Do programs reduce agricultural chemical pollution by:
   a. controlling the amount and manner of chemical use; and
   b. requiring forested riparian buffers?

4. Do controls on livestock agriculture:
   a. apply regardless of size?
   b. preserve riparian areas?
   c. limit land application of collected manure and urine?
   d. provide for enforcement of livestock controls based on mandatory inspections and penalties rather than relying on citizen complaints?

5. Is pollution from irrigation water addressed by programs designed to decrease water use through rules developed by a comprehensive irrigation district or similar entity?

* Obviously, some specific recommendations may not apply to every program in every area. While these criteria define the basic elements of good programs to control poison runoff, a complete analysis of a particular program should be based on the more detailed criteria provided in the body of the report.

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6. Do state programs to control poison runoff exploit state and regional agricultural trends and use economic development policies to encourage less polluting or more easily controlled operations (*e.g.*, marketing assistance for hobby farmers, fruit growers and specialty crops; economic assistance in developing regional facilities for manure marketing)?

7. Is a comprehensive farmland preservation program available at the state level?
   a. Does the program require that landowners in the program address agricultural pollution adequately (cross-compliance)?

Land Use and Urban Issues

8. Is water quality a mandatory consideration in the development of local land use plans and controls?

9. Do local governments have the authority to develop controls more stringent than those required at the state level where conditions warrant?

10. Is state review of urban pollution control programs required in areas contributing to the nonattainment of beneficial uses to determine if load reduction needs in particular watersheds will be achieved?

11. Does the state require that polluted urban runoff be controlled through local ordinances (or other means) that are designed to address all urban contaminants, including toxics?
    a. Are stormwater controls administered through a utility or similar entity that conforms to hydrologically defined boundaries?
    b. Is state review of local stormwater ordinances and enforcement of minimum regulatory requirements mandatory?

12. Is an effective erosion and sediment control ordinance required at the local level?
    a. Is the state required to review the adequacy of local programs based on clear and appropriate criteria, and does the state retain the right to administer those local programs not meeting minimum state requirements?

13. Are coastal zone management programs integrated fully with the specific goals and requirements of the state nonpoint source management program?
    a. Are local development proposals reviewed and approved, denied or modified based on their impacts on state water quality standards, considering the cumulative effects of development within the coastal region?

Silvicultural, Mining and Rangeland Issues

14. Are effective state regulatory mechanisms available to control the water quality impacts of silviculture, including enforceable requirements to implement prescribed BMPs and to comply with state water quality standards?

15. Are individual timber proposals reviewed for compliance with the state program within the context of a long range planning effort?
    a. Does the plan ensure that water quality standards will be met given the cumulative effects of timber harvesting within individual watersheds?
    b. Do state officials coordinate the state forest practices program with U.S. Forest Service regulation of silviculture in National Forests?

16. Does the state Forest Practices Act require adequate inspection and enforcement, by multi-disciplinary teams of silvicultural, water quality and fish and wildlife experts, to ensure that minimum state standards are met?

17. Do programs to control poison runoff from mining specify compliance with particular design and performance standards to divert runoff, stabilize and reclaim land during

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and after mining operations, and collect and treat contaminated runoff? Are these standards designed specifically to meet water quality standards?

18. Do mining regulations ensure compliance through regular, detailed inspections, compliance and stop work orders, fines and performance bonds?

19. Is an abandoned mine fund available for reclamation purposes; used only in cases where responsible parties cannot be located; and operated according to a specified environmental priority list?

20. Are the program officials who control poison runoff from private mines also involved in overseeing the activities of Bureau of Land Management and Forest Service regulators to control mining on federal lands?

21. Are programs to control the water quality impacts of grazing integrated with similar efforts for federal lands into a comprehensive set of plans to achieve water quality standards within individual rangeland watersheds?

22. Do these grazing plans protect water quality and riparian habitat by controlling livestock densities, location and access to riparian areas? Do the plans ensure adequate upland forage and ground cover, and diverse native plant species?

Data Collection and Use

23. Do monitoring activities provide adequate trends data to measure changes in the long term impacts of poison runoff?

24. Within hydrologic units, are data used to identify problems, set priorities, establish pollutant load reduction goals, justify program intervention and develop controls based on their ability to achieve those load reduction goals?

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Funding

25. Are significant funding sources other than general revenues available for control of poison runoff?

26. Is the polluter expected to bear some or all of the costs of any cleanup or protection program, through such mechanisms as permit fees, resource extraction or use taxes, or design taxes?

27. Are funding mechanisms combined with financial incentives to modify or to eliminate practices that cause water pollution?

Legal Tools

28. Does the state have explicit statutory authority to require local governments and citizens to participate in control programs as an ongoing part of state efforts to achieve compliance with water quality standards?

29. Does state law require effective stormwater and erosion and sediment control programs that provide for mandatory state review and approval of any locally adopted programs?

30. Does state law provide that:
    a. noncompliance with the requirements of a nonpoint source program constitutes unreasonable conduct for purposes of nuisance suits?
    b. violations of water quality standards presumptively harm downstream uses?

Developing a Comprehensive, Coordinated Program

Driving Programs With Water Quality Standards

31. Are state water quality standards in place for all of the important pollutants associated with poison runoff?

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32. Are programs to control poison runoff designed explicitly to comply with water quality standards and to achieve specific pollution reduction goals?

33. Does the state water quality management agency play a lead role in ensuring that water quality standards are used in developing and enforcing nonpoint source programs in specific watersheds?

Comprehensive Planning and Management

34. Are specific plans to control each source of poison runoff integrated and carried out within a single "watershed plan" tailored to individual, well-defined hydrologic units (watersheds) of reasonable size?

35. Is there a comprehensive institutional mechanism to ensure coordination among local, regional, state and interstate efforts to control poison runoff?

36. Does the state exercise oversight and leadership, through enforceable conflict resolution measures, to ensure that local politics do not compromise control needs?

37. Are state water quality goals (*i.e.*, attainment of water quality standards) required elements of regional and local pollution control programs and economic development programs?

These principles can be applied to any state or local program to control poison runoff. Application of these principles can identify program strengths, weaknesses, and gaps, and can lead to specific recommendations for improvement. The following case study applies these principles to the Nonpoint Source Management Program submitted to EPA by the Commonwealth of Virginia under section 319 of the Clean Water Act.

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PART FOUR

A Case Study in Poison Runoff Control

Pollution from Virginia contributes significantly to the decline of the Chesapeake Bay and other waters. Significant water quality problems in the Bay from nutrient and toxic pollutants are attributed to land management practices in Virginia.[1] According to state figures, poison runoff in Virginia impairs, or threatens to impair, the beneficial uses of 4294 miles of freshwater rivers and streams and almost 500 square miles of estuarine waters.[2]

In recent years Virginia has increased its focus on efforts to combat this poison runoff. Recently Virginia has established an office of the Secretary of Natural Resources and a Department of Waste Management. Increased funding is now being devoted to this effort: The Appropriations Act for 1988 provided budgets of $5.6 million for FY 1989 and $5.3 million in FY 1990 to address poison runoff from construction sites, agriculture, urban

[1] U.S. EPA, *Chesapeake Bay: A Framework for Action*, September, 1983, at 60-66. 109-110.

[2] Virginia Department of Conservation and Historic Resources, *Virginia Nonpoint Source Assessment Report*, April 1, 1988, at i-ii.

areas and other sources.[3] This figure is substantially higher than in previous appropriations.[4] And Virginia has participated in the highly visible Chesapeake Bay Program—a coordinated regional effort to clean up the nation's most productive estuary.

Because of the pervasive nature of poison runoff—and the complexity of solutions—establishing and running effective control programs will test the mettle of Virginia's politicians, agency officials and citizens. Virginia citizens and public officials accepted this major challenge with the submission of Virginia's § 319 Nonpoint Source Management Plan. They signified their belief that it is possible for state, regional and local government, as well as the general public, to band together to control poison runoff, to revive and maintain the health of Virginia's rivers, lakes and estuaries, and to do Virginia's part to restore the health and productivity of the Chesapeake Bay.

Given this belief and commitment, it is logical that the state choose those strategies and methods that will lead to an effective control program. This case study evaluates the efficacy of Virginia's CWA § 319 Nonpoint Source Management Plan in light of the principles and examples provided in the preceding report.

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[3] 1988 Va. Acts Chapter 800 (Item 488).

[4] Ron Jordon, Virginia Appropriations Committee, December 8, 1988 (personal communication).

A Case Study: Virginia Nonpoint Source Management at the Crossroads

Introduction

This case study evaluates the Virginia proposed Nonpoint Source Management Plan[1] using the questions and basic principles provided in the preceding report. Wherever appropriate, Virginia's unique environmental, political and other circumstances and conditions are taken into account.

This case study is divided into two main sections. The first section summarizes[2] the existing and proposed state program for addressing poison runoff. The second section evaluates this program based on material specific to Virginia and by applying the general criteria and recommendations discussed earlier. Some aspects of Virginia's program also may serve as additional models for other state programs. These notable aspects of Virginia's program will be highlighted where appropriate.

Nonpoint Source Management in Virginia

For purposes of simplicity, Virginia's programs to control poison runoff are described using the structure provided in the state CWA § 319 Nonpoint Source Pollution Management Plan (§ 319 Plan)[3] submitted to EPA in August, 1988. After a brief introductory section, the plan addresses each specific source category of poison runoff: agriculture, forestry, construction, urban, resource extraction, land treatment and disposal (*e.g.*, hazardous waste management, septic tank permits, sewage sludge disposal) and hydrologic modification.

Virginia's Division of Soil and Water Conservation (DSWC), within the Department of Conservation and Historic Resources, developed the management plan and has "overall statewide responsibility for implementing" the plan and coordinating the activities of other agencies.[4] The overriding purpose of the program, established under the authority of the state Soil Conservation Districts Law,[5] is the "attainment of beneficial uses as measured by water quality standards compliance."[6] Priority is given to the Chesapeake Bay drainage basin in controlling both point and nonpoint sources of pollutants.

The Agricultural Pollution Management Subplan

The Virginia NPS Management Plan emphasizes the control of pollution by agriculture, which is the most significant overall source of poison runoff in the state.[7] The state General Assembly appropriated over $830,000 in FY 1984-85 and almost $1.2 million in FY 1985-86 for the state agricultural pollution control program.[8] Funds are used for a variety of purposes, including cost sharing, education, technical assistance, research and general administration. Because of the importance of the Chesapeake Bay, federal funds are provided to supplement the state effort in the Bay watershed.

The Virginia agricultural BMP cost sharing program is the centerpiece of the state's agricultural pollution control effort. Funds are allocated to state Soil and Water Conservation Districts (SWCDs) based on factors that can contribute to water quality problems (*e.g.*, intensive cropland cultivation, erosive soil conditions, and livestock numbers).[9] Within the Chesapeake Bay watershed, where most of the funds are allocated, funds to SWCDs are allocated according to their location in one of three regions classified as: intensive cropland agriculture (this area receives 50% of state Chesapeake Bay cost sharing funds); intensive livestock production (this area receives 30% of available cost sharing funds); and the general program area (this area receives the remaining 20% of funds).[10]

Through the SWCDs, farmers are encouraged to enter voluntarily into contracts with the district to implement one (or more) of the 20 state-authorized BMPs in exchange for a prescribed payment (usually a percentage of the cost of implementation or a flat rate). Program participation is induced largely through a variety of technical assistance and education activities.

State guidelines constrain SWCDs in how they implement the cost sharing program in several ways. In the Chesapeake Bay drainage area, location in the three different regions mentioned above restricts how much funding can be provided for certain types of BMPs. Districts within the cropland priority area must use at least 70% of their allocations on soil erosion BMPs while those in the animal waste priority areas must use at least 85% of their allocations for animal waste controls.[11] In districts where applications from farmers exceed available funds (a common occurrence), a cost-effectiveness formula is used to estimate which applications prevent a given amount of sediment loading to the nearest stream at the lowest cost.[12] Contracts cannot exceed $3,500 for cropland controls and $7,500 for animal waste controls.[13]

Virginia provided over $1.5 million in cost sharing funds from 1984 to 1986. During this period, in the critical Chesapeake Bay drainage, 1651 farmers enrolled over 66,000 acres in the program, reducing sediment delivery by 75,000 tons and phosphorus by 84,500 pounds. In Fiscal Year 1987-1988, $1.27 million dollars in cost sharing funds were dispersed in the Virginia program, and in Fiscal Year 1988-89, $1.23 million is available.[14] Outside the Chesapeake Bay drainage area, control efforts have focused on technical rather than financial assistance.[15] However, in Fiscal Year 1988-89, between $350,000 and $500,000 in cost sharing funds should be available for non-Chesapeake Bay drainage farms.[16]

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An important part of Virginia's effort to control agricultural pollution is the ongoing development of the "Virginia Geographic Information System" (VirGIS), which assists in the identification of lands with a high potential for sediment-related pollution. VirGIS is a computerized mapping system that incorporates data on soil, watershed, elevation, land use and ground cover, and uses equations designed to estimate the potential for sediment loadings from 1 hectare (2.47 acre) cells.[17]

Because of the inherent flexibility of geographic information systems, VirGIS has the potential to be useful in controlling poison runoff in a variety of ways. For example, it might assist in farm-level comparison of the water quality value of different BMPs.[18] But at present, Virginia uses VirGis only for state- and district-level personnel to target education and outreach programs more effectively.[19]

DSWC also provides various forms of technical assistance to SWCDs to improve the evaluation of cost sharing applications, to help farmers plan and implement BMPs, and to monitor program effectiveness.[20] DSWC and the Virginia Cooperative Extension Service (VCES) provide educational services directly to farmers in order to encourage those who normally might not participate in conservation programs to become involved in the state program to control erosion and water pollution. In 1986, for example, over 2,600 farmers who usually do not participate in government-sponsored conservation programs had personal contact with VCES personnel who discussed various aspects of the nonpoint source program.[21] In 1985, a nutrient management program was established to provide education and technical services as the primary state vehicle for addressing nitrogen pollution.[22]

The state has undertaken many demonstration and research projects. A rainfall simulator was developed to demonstrate the effectiveness of various kinds of BMPs and to collect data.[23] Over 600 people attended simulator demonstrations in 1986.[24] In 1986, a series of innovative BMPs were implemented at various sites to try out new approaches to controlling erosion and nutrient runoff.[25] Two demonstration watersheds have been selected to assess the impacts on groundwater and downstream surface water quality of implementing cropland and livestock

BMPs at all feasible sites throughout the watershed.[26] If these demonstrations prove successful, Virginia hopes to apply this approach to other watersheds in the state.[27]

Virginia's § 319 Plan contains descriptions of these and other activities to control poison runoff. A major goal of the § 319 Plan is a 40 percent reduction in the nutrient loadings to the Chesapeake Bay. This goal is derived from a commitment Virginia made, along with three other political jurisdictions, in the recently renewed Chesapeake Bay Agreement.[28] Other goals in the § 319 Plan are: reduction of erosion on all lands eroding at greater than soil loss tolerance (T) levels[29] by the year 2000; development of effective modeling and other tools to track agricultural nonpoint source loadings and to prioritize areas within the state for controls; and the provision of "effective educational and technical assistance programs which optimize voluntary implementation of best management practices."[30]

In the § 319 Plan the DSWC makes a general commitment to expand the role of VirGIS, the scope of demonstration programs and the use of educational efforts to promote the use of BMPs. The DSWC also commits to seek increases in staff and funding to provide additional assistance to SWCDs and to improve monitoring, modeling and BMP tracking capabilities.

The DSWC also pledges in the State's § 319 Plan to increase the involvement of various local, state and federal agencies in controlling poison runoff, including:

1. SCS (to develop a master statewide hydrologic subunit designation);

2. Virginia Department of Taxation (to require land enrolled under the state Use Value Assessment Law to have implemented a conservation plan to reduce erosion to below "T" values); and

3. USDA (DSWC will attempt to obtain state funds to increase per acre bids for lands to be entered into the federal Conservation Reserve Program (CRP) and to investigate the possibility of a state CRP).

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Other activities proposed for DSWC include: investigating the establishment of a state revolving loan fund to provide low interest loans for animal waste management facilities;[31] establishing an Alternative Use Task Force to promote innovative uses of animal manure; and developing a pesticide user certification program for all DSWC and SWCD field personnel.[32]

In addition to DSWC, other state agencies are involved in the agricultural subplan. The Virginia Department of Agriculture and Consumer Services (VDACS) is responsible for coordinating the proper use, handling, storage and disposal of pesticides and pesticide containers. In the § 319 Plan Virginia commits to strengthening and expanding the concepts of Integrated Pest Management in its educational and pesticide certification programs. Also, the Virginia Cooperative Extension Service plans to increase a variety of informational and educational services for handling animal waste and using commercial and manure fertilizer nutrients.

The main federal agencies involved in the agricultural subplan are the Federal Department of Agriculture's Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCS). In addition to SCS's own duties under federal programs such as the Agricultural Conservation Program (ACP) and the conservation provisions of the Food Security Act,[33] SCS will assist DSWC in developing VirGIS and using it to track BMP implementation within individual watersheds. After 1995, it will begin to "redirect existing staff priorities to efforts targeted strictly to water quality initiatives after 1995."[34]

In addition, SCS will seek to increase participation of Virginia farmers in the Conservation Reserve Program, with a target of enrolling 100,000 acres by 1990. The SCS commits to developing ten new watershed demonstration projects by the year 2000, including five that demonstrate animal waste management. The agency also commits to revising SCS field manuals and conservation standards and specifications to include various water quality considerations and to develop new BMPs "as necessary to achieve water quality improvements."[35]

ASCS also will undertake additional activities beyond those required under the federal ACP and the conservation provisions of the Food Security Act of 1985.[36] It will analyze and modify

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existing procedures for the ACP to address water quality problems and coordinate efforts with DSWC to provide joint or complementary cost sharing programs.

The Plan establishes a number of milestones to indicate the progress made in controlling agricultural pollution. Milestones include: nutrient analysis of 500 manure samples a year; statewide completion of the VirGIS system by 2000; statewide completion of the hydrologic unit submap by 1991; enrollment of 100,000 acres of land in the CRP by 1990; installation of 50 animal waste units and 500 nutrient management plans per year; and implementation of BMPs on 400,000 new acres of land per year.

The Urban Nonpoint Source Management Subplan

In the past, Virginia's urban program to control poison runoff focused on demonstration of urban stormwater management and erosion and sediment control BMPs to encourage their voluntary use by land developers and local government officials.[37] The CWA § 319 Urban Nonpoint Source Control Plan adds significantly to this earlier effort. Goals of the urban plan include: development of comprehensive stormwater management legislation and regulations; revision of urban BMPs to reflect innovative technologies, and their promotion through education and training programs; targeting of resources to priority urban areas, and promotion of the development of local Comprehensive Plans and zoning ordinances (and the incorporation of BMPs into land development ordinances) that provide water pollution control.

DSWC also will develop a system for estimating pollution loadings generated in urban areas and use these loadings to identify "urban priority areas." Localities will be encouraged to address poison runoff in Comprehensive Plans, to adopt BMPs in land development regulations, and to sign Memoranda of Understanding with DSWC to address these concerns.

The recently-enacted Chesapeake Bay Preservation Act[38] creates a new agency called the Chesapeake Bay Local Assistance Department (governed by an appointed Board) that must:

> promulgate regulations which establish criteria for use by local governments [in Tidewater Virginia][39] to determine the ecological and geographic extent of Chesapeake Bay Preservation Areas ... [and] ... in

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granting, denying or modifying requests to rezone, subdivide or to use and develop land in these areas.[40]

Protection of high quality waters, prevention of increases in pollution and reduction of existing pollution are among the purposes of the criteria to be developed. Regulations must be promulgated by July 1, 1989 and Chesapeake Bay Preservation Areas must be established by July 1, 1990.

Also, recent legislation amended Virginia law specifically to allow localities to protect surface and groundwater resources with the comprehensive planning and zoning process.[41] Another amendment states that surveys and studies of groundwater and surface water and geologic factors must be part of local comprehensive plans.[42] Virginia law now states that groundwater protection areas may be designated for application of "reasonable groundwater protection measures."[43]

Besides DSWC and local governments, other actors are involved in controlling poison runoff in urban areas. Planning District Commissions (PDCs)[44] can provide technical assistance and education to localities that seek to control pollution through comprehensive planning and zoning. PDCs can become involved in coordinating or preparing "interjurisdictional watershed plans" and plans for urban priority areas (described earlier) to address poison runoff with the consent of the involved localities.

The Virginia Department of Transportation will cooperate with the DSWC to study the feasibility of using highway rights-of-way for the construction of BMPs such as detention basins. SWCDs and the SCS will provide training and education to technical staff within the agencies as well as to landowners and local officials. The Virginia Department of Health (along with local health departments) operates programs pertaining to the proper use of sewage treatment systems, the regulation of sewage at marinas and the condemnation of shellfish areas when contaminated by fecal bacteria. The state Council on the Environment is charged with the operation of the state's Coastal Resources Management Program.

Like the agricultural subplan, the state's urban subplan establishes milestones of progress against which to measure the fulfillment of these general goals. In addition to the control requirements established in recent legislation,[45] these milestones include dates for developing a proposal for stormwater management legislation, designating urban priority areas, updating the Urban BMP handbook and promoting the signing of Memoranda of Understanding between DSWC and localities in urban priority areas.[46] A variety of milestones also are spelled out for completing training, educational and demonstration activities.[47]

Erosion and Sediment Control (ESC) Subplan

DSWC administers ESC controls pursuant to the Virginia Erosion and Sediment Control Law.[48] This statute requires all counties, cities and incorporated towns to develop and implement a program to control erosion, sediment and stormwater runoff from land disturbing activities. Improving the DSWC's efforts to reduce the water pollution impacts from construction and other large-scale earth moving activities is addressed in Virginia's § 319 Plan. Specific goals in the Plan include: improving the effectiveness of the ESC regulations and controls (including implementation); increasing the knowledge and skill of those involved in the program; and achieving effective control on a minimum of 95% of regulated private construction projects by the year 2000.

DSWC plans to evaluate existing local programs to identify needed improvements, to revise ESC standards and regulations, and to seek revisions in the ESC Law. DSWC will require that state and local officials be certified as possessing minimum levels of knowledge and skill to implement the ESC program. It also will develop an educational program for state and local officials and the general public. Technical assistance will be provided to improve local plan review, inspection and enforcement capabilities. DSWC will be responsible directly for ensuring that state construction projects comply with ESC requirements.

Other state agencies, including the Virginia Department of Transportation, will seek to improve the application of the ESC program to their construction projects to provide a model of effective erosion and sediment control. The State Water Control Board (SWCB) and the Army Corps of Engineers issue permits for the discharge of fill material (often from various construction activities) into waterways under CWA §§ 401 and 404, respectively. The Virginia Marine Resources Commission (VMRC)

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issues permits for activities in state-owned wetlands and development in tidal wetlands, when there is no local wetlands board to assume this responsibility. These permits incorporate ESC practices as necessary. SWCDs and the SCS assist local governments in various aspects of their ESC programs in both official and advisory capacities.

As the central feature of the state ESC program, local governments will be encouraged by DSWC to improve their individual ESC programs in a number of respects. These include better compliance with existing statutory requirements, provision of necessary funding and personnel, improved inspection and enforcement and more extensive training and education.

Virginia expects the actions listed above to accomplish a number of tasks listed in the milestones section of the ESC program. In addition to fulfillment of existing statutory requirements, the § 319 Plan makes specific commitments to provide training seminars and other educational services; to revise the existing ESC standards; and to develop and implement a certification process for ESC officials. The Plan calls for developing a "generalized but reasonable methodology for estimating sediment load reductions" from the ESC program by July 1, 1990. Localities will identify "erosion impact areas"[49] within their jurisdictions and stabilize these areas by July 1, 1992. Finally, by July 1, 1995:

> local governments will achieve effective E&S control (minimal or no violations of law, regulations or standards and specifications) on a minimum of 70 percent of regulated private construction projects, and state agencies and local governments will achieve effective control on at least 95% of their own government-sponsored projects.[50]

Forestry Nonpoint Source Management Subplan

The Virginia Department of Forestry (VDOF) is the lead agency for the forestry portion of the state's § 319 Plan, with DSWC also involved in implementation of the various activities. The Virginia Cooperative Extension Service provides educational services to forest landowners and logging contractors on various water pollution issues. The goals of the § 319 Plan include: initiation of a monitoring and evaluation program to determine silvicultural sediment and nutrient loads to state waters; reduction of erosion from silvicultural activities by use of BMPs on all forested land; use of preharvest plans in 90% of cutting operationss by 1995; and assistance with corrective action in problem areas.

By December, 1989, VDOF plans to undertake a variety of activities to control poison runoff from silvicultural activities. In addition to the training and education programs, VDOF will develop a system for monitoring and reporting annual water quality improvements, inspecting all cutting operations to determine the level of and need for BMP implementation, and making recommendations for BMPs where necessary. Those lands under the direct control of VDOF will be managed using BMPs. Ties with logging associations will be strengthened to promote the use of BMPs, and procedures will be established to register and investigate citizen complaints.

By 1995, payments under the Reforestation of Timber (RT) Program will be conditioned on the use of BMPs.[51] A voluntary system will be developed for timber owners to notify VDOF prior to harvesting operations. Increased personnel and funding will be provided to improve monitoring and training activities and the consideration of poison runoff in recommendations made to landowners seeking advice from VDOF.

Federal agencies, including the Agricultural Stabilization and Conservation Service (ASCS), Soil Conservation Service and the Forest Service also provide some control of poison runoff in Virginia. This includes requiring the use of BMPs in some of the forestry practices that receive cost sharing funds from ASCS through the Agricultural Conservation Program and Forestry Incentives Program[52] or SCS technical assistance and education programs. The USFS includes BMPs in its contracts with commercial logging firms.

Although no specific milestones section is provided, the Virginia forestry plan commits to preparing an annual report. This report will quantify the cost sharing funds expended and the number of acres affected, the numbers of BMPs needed versus the number implemented, and sediment and nutrient load reductions.[53] If interim goals of 10% - 40% sediment reduction are not met between 1991 and the year 2000, the state will "submit appropriate legislation for mandatory Best Management Practices for silvicultural activities" to the legislature.[54]

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Other Nonpoint Source Management Subplans

Other sections of Virginia's § 319 Plan pertain to resource extraction, land treatment and hydrologic modifications. As these programs are less extensive, they are outlined only briefly.

Resource Extraction. The Department of Mines, Minerals and Energy (DMME) is the state agency with primary responsibility for the resource extraction program. DMME requires mining and gas/oil extraction permits, and is responsible for ensuring compliance with permit conditions. It also investigates citizen complaints, requires performance bonds to guarantee reclamation and maintains an inventory and prioritized list of abandoned and unreclaimed mined lands. The goals for Virginia's resource extraction (mining) subplan include reducing erosion and water quality impacts from active and abandoned coal and non-coal sites; considering water quality when setting priorities for reclamation activities; and providing training to the mining industry in nonpoint source control through the year 2000.

DMME will seek funding for the reclamation of 25 abandoned mine sites per year and will include sediment and other pollutant loadings as factors in developing the reclamation list. The agency also will seek regulations to encourage the reclamation of abandoned lands through the participation of active mining operations.

The SCS operates the Rural Abandoned Mine Program in Virginia and is committed to reclaiming 250 acres of land by the year 2000 (4-5 sites per year). The Virginia Cooperative Extension Service (VCES) provides various technical assistance, research and education services to improve the control of mining-related water pollution. The Tennessee Valley Authority provides coordination and financial assistance for reclaiming abandoned non-coal mines created before enactment of state non-coal mineral mining and reclamation laws.[55]

Land Treatment and Disposal. This part of the Virginia § 319 Plan addresses the following sources of water pollution:

1. on-site subsurface disposal (primarily septic tank drain-fields);

2. landfill disposal;

3. lagoons for storing and treating wastes;

4. land treatment of non-hazardous wastes and sludge;

5. management of hazardous waste;[56] and

6. reclamation.[57]

Construction of septic systems is regulated through a permit system operated by county health departments. Before a permit is issued, factors such as soil type, setback distances (from streams or property lines) and topography are considered. The Virginia Department of Health in cooperation with county health departments also undertakes sanitary surveys to determine the need for public sewers, and educational activities or enforcement actions when voluntary compliance is not adequate.

Nonhazardous waste landfills (pollution sources regulated under RCRA Subtitle D) soon will require permits with minimum requirements under proposed rules published by EPA.[58] These requirements include leachate control, groundwater monitoring, and landfill closure and post-closure care.

Most lagoons (sewage, sludge, and industrial and animal waste) are permitted by the State Water Control Board through the Virginia Pollution Abatement Permit (VPA) program which is used, when necessary, to regulate potential sources of pollution that are not strictly characterized as point sources. The Virginia Department of Health (VDOH) conducts the technical review for sewage and septage treatment and sewage sludge storage. Regulations for land treatment of sewage sludge and effluent are currently being revised so that sites suitable for treatment are chosen more carefully. Permits for treatment are to be granted only after public and local government review and regulatory agencies (SWCB and VDOH) are satisfied that ground and surface water quality is not threatened.

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Hydrologic Modifications. Poison runoff that results from the alteration of stream channels (to assure adequate water supplies, improve drainage, control floods, etc.) also is addressed in Virginia's § 319 Plan. The overall purpose of this portion of the Plan is to "minimize the adverse effects of hydrologic modifications on water quality through the use of BMPs."[39]

The SWCB issues a CWA § 401 certifications for discharges of dredge and fill material. Channel management projects are controlled by a SWCB policy stating that such projects should be operated "... to minimize and preferably avoid short and long term adverse environmental impacts."[40]

DSWC is responsible for ensuring that hydrologic and other BMPs are used to protect water quality during the construction of dams. Other agencies also carry out activities under the hydrologic modifications subplan. These agencies include: Virginia Council on the Environment (reviews applications associated with hydroelectric projects and reviews federal actions for consistency with the Virginia Coastal Resources Management Program); Department of Game and Inland Fisheries (reviews state and federal actions for impacts on fish and wildlife); and Soil Conservation Service (commits to use BMPs to minimize sediment loads from hydrologic modifications such as impoundment construction and channel modification).

Analysis of the Virginia § 319 Plan

It is obvious that poison runoff is an important concern in Virginia. The state Nonpoint Source Pollution Management Plan provides a comprehensive list of the programs and actions of many federal, state and local agencies that contribute to the effort to control poison runoff in Virginia.

Some elements of Virginia's § 319 Plan are commendable; and some can be drawn on by other states. However, much of the Virginia plan does not represent the "state of the art" in managing diffuse sources of pollution. More important, in some key respects, the Virginia plan is not consistent with CWA section 319.

Problems with the Virginia § 319 Plan do not arise from a lack of commitment or skill on the part of state officials.

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Instead, they are based on historical trends in nonpoint source control established at the national level, and on state and local political influences that have constrained the range of solutions chosen by decisionmakers.

The following analysis highlights both positive and negative aspects of Virginia's § 319 Plan.[41] Specific recommendations are provided, where appropriate, to improve the plan and to conform Virginia's program with Clean Water Act requirements. While many of these problems could take years to address on a fundamental level, numerous positive steps also can (and must) be taken in the short term to begin the transition to an approach consistent with the CWA.

Virginia's § 319 Plan Represents Significant Improvements Over Past Efforts

A review of Virginia's Nonpoint Source Pollution Management Plan indicates that the state has begun to establish an effective capability to control poison runoff. Recent increases in funding and personnel devoted to controlling poison runoff testify to a significant state commitment to nonpoint source management.

Virginia's § 319 Plan contains several specific commitments with the potential for effective control of poison runoff. The state has developed legislation to address pollution of the Chesapeake Bay region through local land use planning and management. Stormwater legislation has been proposed to control contaminated urban runoff. In addition, the state's erosion and sediment control (ESC) program has been expanded and improved to address more effectively the water pollution problems at construction sites. Improvements also are planned in the federal and state guides that specify the designs of particular BMPs so that ground and surface water quality considerations are taken into account.

In addition, Virginia has undertaken an array of important research projects aimed at improving its knowledge and understanding of the relationship between land use and water quality, and the effectiveness of specific BMPs. This research has, in part, fueled many innovations in traditional approaches to control poison runoff. These innovations include enhancing the cost-effective use of state funds, and the development and use of models that identify lands for priority treatment. The § 319 Plan also establishes a significant level of coordination among many federal, state and local governmental agencies.

However, the Virginia § 319 Plan does contain important weaknesses that must be addressed in both the short and the long term. One of the most pervasive weaknesses of the Plan is its failure to comply with the basic nonpoint source control mandates in the Clean Water Act.

Controlling Poison Runoff Within the Context of CWA Water Quality Management Planning

The Virginia § 319 Plan does not comply with the water quality management process required by the Clean Water Act.[42] In particular, the Virginia plan lacks: a proper emphasis on water quality standards and water quality standards-based controls; a "watershed-by-watershed" management process; adequate direct involvement by the State Water Quality Control Board (SWCB); and appropriate procedures to use water quality information to direct control programs.[43] These issues are discussed below.

A Lack of Dependence on Water Quality Standards. As discussed in Part III of this report, water quality standards, in the form of beneficial water use designations and narrative, numerical, biological and habitat criteria designed to protect those uses, should be the cornerstone of Virginia's nonpoint source control program (Rec. 9-1, 9-4).* Water quality standards provide the authority to develop controls, and should be used to establish the specific pollutant load reduction goals for individual water bodies (Rec. 9-1, 9-3, 9-5).

With few exceptions, it is apparent that state water quality standards will not play a significant role in the development and implementation of controls in Virginia. On the first page of the

* Where appropriate, citations are given to specific recommendations made in the preceding report. For example, Rec. 9-1 refers to Recommendation 1 in Chapter Nine of the report.

proposed plan a general statement is provided regarding water quality standards:

> The attainment of beneficial uses as measured by water quality standards compliance is the overriding purpose of control programs identified herein for nonpoint sources of pollution.[44]

This laudable but vague statement, however, is not supported by the rest of the plan. No details are given on how specific controls will be used to attain beneficial uses in specific water bodies. As a result, it is not clear how (or if) this very fundamental goal can be achieved.

References to the achievement (or even the development or application) of water quality standards essentially are absent from the subplans for individual source categories. For instance, the ultimate goal of the agricultural subplan is not to achieve compliance with water quality standards in specific water bodies. Instead, the goal of the agricultural subplan is a vague balancing of environmental and economic interests:

> to reduce the off-site water quality impacts of agricultural activities to an environmentally non-significant level while still maintaining soil productivity levels and economically feasible farm operations.[45]

Similarly, the stated overall purpose of the urban subplan is:

> to assist local jurisdictions having control over urban areas in meeting the requirements of the 1987 Water Quality Act.[46]

While this goal cannot be criticized *per se*, the urban subplan never translates this general statement into a method for achieving compliance with water quality standards.

Given these loose purposes, none of the more specific goals of the agricultural or urban subplans (or any of the other subplans) even mentions water quality standards. Since water quality standards are rarely *mentioned* in Virginia's plan, whether or not the plan will *achieve* such compliance is not even an issue.

This inadequate focus on water quality standards is exacerbated by the fact that Virginia does not have adequate water quality standards for most pollutants generated by diffuse sources.[67] This deficiency might help to explain the lack of integration of water quality standards with the general and specific aspects of the Virginia § 319 Plan. Virginia's recent work on developing a water quality standard for nutrients (an important nonpoint source pollutant) only affects point source polluters.[68] This approach contrasts sharply with efforts in other areas to reduce the combined discharges of nutrients from point and nonpoint sources to specific levels needed to achieve compliance with water quality standards.[69]

The SWCB reasons that it would be impossible to pinpoint responsible individuals and to enforce controls based on an evaluation of water quality standards violations.[70] As indicated earlier in this report, however, each polluter does not have to be proven individually responsible for a violation of ambient water quality standards in order to justify each additional BMP and control program. When water quality standards are violated due to the cumulative effects of a large number of diffuse pollution sources, the entire responsible community can and should be required to achieve the necessary load reductions to eliminate these violations. Controls can be imposed through the host of permitting systems and regulations discussed in this report.[71]

An Absence of Comprehensive Watershed Planning. It is apparent from a review of Virginia's § 319 Plan and Water Quality Standards regulations that Virginia has not established, as required by the CWA, the explicit authority to carry out and enforce a comprehensive watershed management process designed to achieve compliance with water quality standards in individual watersheds (Rec. 9-5). This authority should be made clear in the State plan as well as the State Water Quality Standards regulations.

The watershed provides the basis for determining what pollution load reductions are needed to achieve compliance with water quality standards for particular water bodies. As discussed in the previous report, a true watershed-by-watershed system develops nonpoint source controls commensurate with the estimated load reductions needed for each individual hydrologic unit, after analyzing all sources of all relevant pollutants. Once the necessary load reductions are determined, the state must

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ensure that farmers, local governments, and other parties responsible for poison runoff achieve the necessary load reductions within a coordinated watershed plan.[72]

A watershed-by-watershed approach should also incorporate nonpoint source controls in a timely manner within the context of existing and projected point and other nonpoint loadings. There is little in the Virginia § 319 Plan to imply that this level of coordination will take place. There is also no way to coordinate control efforts between the source categories (*e.g.*, agriculture versus urban) or between point and nonpoint sources. Each nonpoint source subplan (agriculture, urban, etc.) is presented separately, generally without reference to the need to coordinate actions within watersheds to achieve beneficial water uses. There is an equal paucity of information concerning coordination with point source programs so that in individual watersheds management needs can be analyzed, and long term improvements can be planned, within a given timeframe.

A De-emphasized Role for the State Water Control Board. As explained above, it is essential that programs to control poison runoff be developed, implemented and evaluated based on their ability to achieve the quantitative load reductions that will lead to compliance with water quality standards within individual watersheds. Given this need, state and regional water quality agencies must assume an active, lead role in the state's overall effort to manage diffuse pollution sources (Rec. 9-6).

Without the fundamental involvement of water quality agencies, the state program to control poison runoff is likely to lack an adequate water quality focus. Water quality agencies have the expertise to determine which waters need attention, what pollutants are of concern, and how much of the contaminant level must be reduced to meet water quality standards. These agencies also have both the *authority* and the *responsibility* to take whatever actions are needed to achieve the formal objectives of the state's water quality management plan.

In Virginia, the Division of Soil and Water Conservation within the state Department of Conservation and Historic Resources is given the lead role in overseeing and evaluating the state § 319 Plan and is the chief agency charged with the

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development of the plan itself. Essentially this agency is generally responsible for determining how to address poison runoff in Virginia and how much control is adequate to comply with water quality standards. DSWC's role in controlling poison runoff is extremely important, and must continue. It does not substitute, however, for the functions that must be performed by Virginia's primary water quality management agency.

The SWCB is the Virginia agency responsible for water quality management. Yet the Virginia § 319 Plan apparently reduces the role of the SWCB to that of all the other agencies involved in specific components of the plan. In particular, the SWCB addresses individual types (usually point sources) of pollution covered by the Plan.[73] The only statements discussing the general role of the SWCB (in the introduction) provide SWCB with no formal, direct or comprehensive function in general program management:

> The DSWC will work closely with the SWCB to ensure that the nonpoint source control programs are consistent with programs required to achieve compliance with the state's water quality standards and goals and the requirements of the Clean Water Quality Act of 1987. The SWCB monitoring programs are supportive of DSWC in its evaluation of the overall success of the nonpoint source programs.[74]

These lone references to general SWCB involvement are vague and nonspecific. No provisions describe how SWCB will implement its authority with respect to the specific actions listed in the § 319 Plan. There is no indication how SWCB will ensure consistency of control programs with those required to achieve compliance with water quality standards, or how SWCB monitoring programs will support DSWC efforts to control poison runoff. This vague reference to the SWCB's overall role in program management contrasts sharply with the limited, highly specific roles established for SWCB in the actual substantive parts of the management plan. For example, the § 319 Plan states that SWCB is responsible for regulating animal feeding operations with "case-by-case" determinations and carrying out the NPDES aspects of federal stormwater regulations.[75]

At the most basic level, it appears that SWCB is not perceived, and more important, does not perceive itself as having the authority to undertake general nonpoint source management activities (except in isolated incidents of acute poison runoff events).[36] To be sure, SWCB most likely will undertake actions that can be construed as addressing the commitments listed above. However, the vagueness of these commitments, the paucity of information describing how (and how much) they will be fulfilled, and the degree to which the SWCB's role in nonpoint source management appears to fall short of that required in a successful water quality management plan all point to a significant lack of participation by the state water quality protection agency.

The SWCB should assume the responsibility to determine the water quality needs in particular watersheds, and to monitor and enforce poison runoff reduction requirements needed to attain beneficial uses. Where adequate water quality standards are not available, SWCB must develop and promulgate them. Thereafter, the SWCB (along with available Planning District Commissions) need to establish and carry out a process to communicate the pollution reduction needs in individual watersheds and provide a means to negotiate and enforce a comprehensive watershed plan agreed to by all involved localities and agencies.

If this process is to succeed, significant technical guidance and mandatory conflict resolution mechanisms must be developed and implemented by the parties involved in the watershed management plan. However, there is no mention of the need to develop or implement mandatory conflict resolution in cases where localities refuse to address extra-local problems. Since there is no real strategic role for the SWCB in the Virginia § 319 Plan, there is no process identified to coordinate the nonpoint source management activities of the SWCB and DSWC (either statewide or within individual watersheds). This problem should also be remedied.

The absence of a strong lead role for the SWCB in program development and management foreshadows, or perhaps causes, additional problems with Virginia's § 319 program. One of the most important of these problems is a departure from the use of water quality standards as the basis for establishing and maintaining specific activities to control poison runoff.

The Need for a Load Allocation Process. Virginia's § 319 Plan includes no process to calculate the total load reductions needed to meet water quality standards in each watershed or to allocate those load reductions among the range of diffuse pollution sources in the watershed. This is not to say that Virginia is unconcerned with identifying the hydrologic boundaries of the state's watersheds, since this is one of the activities in the § 319 Plan. However, the purpose of defining watersheds in the Virginia plan appears to be limited to improving the targeting of resources. It does not include estimating load reductions or identifying and implementing the controls needed to achieve those reductions.[7] Virginia "targets" more funds to areas that contribute relatively high levels of poison runoff. This improves the *relative efficiency of resource allocation* but does not provide a basis on which to determine if, for that particular water body, enough poison runoff reduction will occur to restore or maintain beneficial uses.

There is also little in the state plan that indicates how (or if) the SWCB or any other agency will identify watersheds where funds should be targeted based on *nonattainment of beneficial uses*, and what level of funding is needed or how these funds will be spent to achieve those uses. Most of the existing grounds for distributing funds are based on the *potential* for areas to generate sediment-related poison runoff rather than on ambient water quality. This approach fails to consider the types of load reductions needed in a particular area and the relative severity and importance of existing beneficial use impacts throughout the state. For example, erodible soils in a watershed *may* indicate a high *potential* for sediment loads, but nutrients nevertheless may be the most significant pollutant in the watershed. Funds spent to control sediment may not result in the attainment of water quality standards.

Summary of General Water Quality Considerations. Perhaps most fundamentally, the kinds of management problems discussed above stem from the confusion and false perceptions about the authority of the state to require control of poison runoff. For instance, the current nonpoint source management plan is authorized under the state Soil and Water Conservation

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District Law,[78] not under Virginia's water quality management statutes. The relationship of the Division of Soil and Water Conservation (DSWC) to the local SWCDs does not provide a mechanism for mandating that state and federal water quality goals be met, since the SWCDs are operated essentially through local consent. As an illustration, one of the duties of the Board that directs the operations of DSWC is:

> to coordinate the programs of the [soil and water conservation districts] *so far as this may be done by advice and consultation.*[79]

It is difficult to imagine how a state-driven water quality-based approach to controlling poison runoff could ever take place under the auspices of a program that is almost completely within the context of traditional, locally-oriented, voluntary soil and water conservation efforts. For example, since state water quality standards are not mentioned in the state soil and water conservation laws, compliance with these standards hardly can be considered an enforceable responsibility of either DSWC or individual SWCDs.

Also, state water quality management and land use laws do not *require* local governments throughout the state to prevent water pollution from poison runoff. In fact, local governments only recently were given explicit *authority* to address surface water and groundwater contamination in local comprehensive planning; and, even so, such authority still appears to be a discretionary local function.[80] Insofar as localities provide funds to SWCDs to carry out various activities, opportunity exists for coordinated water quality protection at the local level. But so much local autonomy exists that SWCDs will remain the entity most directly responsible for compliance with state water quality standards in many areas.[81]

To be sure, SWCDs are invaluable organizations in any plan to control poison runoff. In the context of their enabling legislation, however, it is not clear how they will be able (or willing) to control poison runoff to the extent needed to achieve compliance with water quality standards—given that controls in many areas may involve the need for significant direct state involvement and may be unpopular locally.

Virginia needs a system of "command and control" designed to ensure that water quality standards are met in individual watersheds. This requires the adoption of water quality standards to address the types of nonpoint source problems prevalent in Virginia, and the application of these standards through monitoring, watershed-by-watershed modeling and implementation of needed controls. The state water quality agency should play a key role in this effort.

Comprehensive Program Implementation

For a watershed-by-watershed approach to be successful, it is critical for a state nonpoint source management program to coordinate the participation of all government entities and affected citizens to ensure that load reduction goals are achieved (Rec. 10-1). Local land use planning is important to effective control of poison runoff and, thus, should be scrutinized by regional and state nonpoint source officials based on detailed planning requirements and review criteria (Rec. 10-2, 10-3). All control programs should be integrated into a single watershed plan, and the state should provide mandatory conflict resolution measures to ensure that agreements for strict controls are not sacrificed (Rec. 10-4, 10-5).

Unfortunately, the Virginia § 319 Plan does not provide for significant and effective coordination. As mentioned previously, Virginia is not proposing a watershed-by-watershed process. It follows, therefore, that the Virginia § 319 Plan does not include a process to coordinate the control programs of all involved parties into a single watershed plan. State criteria for the adequacy of such a plan also are lacking. As discussed below, although increased involvement by some local governments is expected, it is not clear in the § 319 Plan how localities are to be incorporated into a comprehensive watershed plan, or whether the state can review (and approve or disapprove) many proposed local controls. And also as discussed below, binding conflict resolution mechanisms are not proposed to ensure that pollution reduction in one part of a watershed is not offset due to weaker rules in another locality.

Nonpoint Source Pollution Management Subplans

Despite these general problems in the Virginia Nonpoint Source Pollution Management Plan, the individual subplans for each pollution category provide some useful programs and activities for addressing poison runoff. Important research projects and data collection activities are a significant part of most of the plans. Recent legislation (discussed later) has expanded significantly the ability of the state to address poison runoff. Still, the subplans presented in the state § 319 Plan are limited by a number of serious problems. These strengths and weaknesses are discussed below using the criteria set out in the preceding report.

Agriculture. An effective agricultural pollution control effort must recognize that new, regulatory approaches are often realistic solutions to water quality problems caused by sediment and agricultural chemicals and may be necessary to achieve the level of pollution control needed to meet water quality standards (Rec. 3-1, 3-2). Design standards can be used as minimum requirements, while performance standards can ensure that water pollution will be controlled when compliance with design standards is not effective in addressing a particular poison runoff problem (Rec. 3-2). Agricultural chemicals can be controlled by reducing the amount of chemicals available for runoff and leaching, the use of forested buffer zones, and economic development policies that promote an environmentally sound agricultural sector—not primarily through the implementation of erosion-based "conservation plans" (Rec. 3-6, 3-7). Livestock programs can require control of runoff and leaching from confined feeding and storage areas, of the application of manure on porous land, and of the destruction of streambanks and other riparian areas (Rec. 3-8). Finally, a comprehensive farmland protection program can be developed that offers substantial incentives to preserve *prime* farmland as long as poison runoff is effectively controlled (Rec. 3-10, 3-11).

As explained in Chapter Three, this does not mean that each of these controls *must* be used, much less used exclusively, in an adequate state nonpoint source control plan. But neither should such controls be rejected out of hand. More important, the

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combination of agricultural pollution controls selected, whether voluntary, regulatory, or both, must be sufficient to meet water quality goals. Where agricultural pollution is severe, regulatory controls will often be needed as part of the mix of strategies used to meet water quality standards.

Virginia has not explored fully the potential of alternative approaches to cost sharing, using the principles and examples provided in Chapter Three. Virginia's agricultural subplan emphasizes improving the efficiency and effectiveness of *existing* state programs to control poison runoff rather than the development of new approaches. Perhaps the most conspicuous drawback of the subplan is the bias towards keeping its voluntary approach for reasons unrelated to water quality protection. In fact, the plan includes no attempt to demonstrate its sufficiency to meet water quality standards. Virginia, along with Maryland and Pennsylvania, has committed to exploring the "regulatory option" as part of an agreement developed through the Chesapeake Bay Program. In Virginia's § 319 Plan, however, no mention is made of such a study, and the exclusive emphasis on voluntary programs continues. This seems to indicate that the use of regulatory controls in the foreseeable future is not considered a serious alternative. Even the purpose of the agricultural subplan implies a voluntary orientation:

> to establish a direction and framework for agricultural interests (government agencies, industry and private sector) to address nonpoint source pollution loadings attributed to agricultural lands and operations.[82]

Federal documents that discuss Virginia's state agricultural pollution control program often stress its voluntary nature.[83]

The bias towards voluntary controls in agriculture is explained partially by a perceived lack of authority by state officials to use other kinds of controls. The absence of a cause-and-effect linkage between BMP implementation and water quality was an early justification for a voluntary approach to controlling poison runoff.[84] However, from the standpoint of water quality protection, this lack of knowledge will have at least as big an impact on the success of voluntary programs as on regulatory ones.

Partially because of its voluntary nature, it is not clear how the Virginia agricultural plan addresses groundwater and soluble contaminants. In a voluntary program, the BMPs used will be influenced not only by their value in protecting water quality, but also by their popularity among farmers. Most of the BMPs that are eligible for cost sharing funds (except animal waste control facilities) are designed to address sediment or sediment-attached pollutants. For instance, in the Cropland Priority Area (described above) a minimum of 70% of the funds allocated to SWCDs must be spent on soil erosion BMPs.[85]

Some of the BMPs used in Virginia, such as no-till cropping practices, can actually lead to an increase in the level of soluble fertilizers (mainly nitrates) and pesticides that are applied to a field and that become available for groundwater contamination or subsurface transport.[86] Also, controlling phosphorus and not nitrogen could reduce productivity in one area and thus make nitrogen more available downstream, since the two are used in specific ratios.[87] These kinds of concerns are not reflected in Virginia's agricultural subplan, in contrast to the recommendations provided in Chapter Three. In addition, nutrient management is addressed primarily through the provision of technical assistance and education, thereby allowing farmers who do not choose to participate in the state program to continue polluting state waters through the over-application of animal and chemical fertilizers.[88]

The State Water Control Board is not given any responsibility to develop Water Quality Standards for pesticides or to develop a comprehensive assessment of potential contamination (and associated management options) within the state. The Department of Agriculture and Consumer Services (DACS) will undertake several activities to improve the use, handling, storage and disposal of pesticides and their containers though education and technical means.[89] But regulatory efforts are targeted to pesticide storage facilities, and BMP Improvements will focus on improving spill containment and loading/mixing/rinsing sites, not the actual application of pesticides.[90] The agricultural subplan, therefore, does not provide a method to evaluate comprehensively general problems (both geographic and management) associated with pesticide application. Nor does it contain a management strategy (including the development of specific

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pesticide-control BMPs) to *ensure* that pesticide application will not contaminate state waters.

The bias in the state agricultural subplan towards controlling soil erosion as opposed to agricultural chemicals is emphasized by the data used in the cost sharing program. Most information about the effectiveness of the cost sharing considers tons of sediment and pounds of phosphorus (largely a sediment-bound nutrient) retained on the farm and ignores estimates of soluble chemical loadings.[91] The VirGIS data collection system addresses soil erosion and sediment loadings but not soluble (and leachable) nutrient and pesticide losses. Also, funds are allocated based on potential for erosion and sediment-related poison runoff.

This approach contrasts sharply with the findings and recommendations of a recent U.S. Fish and Wildlife Service study of the Choptank River watershed in Maryland.[92] The report found that most nitrogen pollution was in the nitrate form, which is often transported through shallow subsurface flow (baseflow).[93] Perhaps just as important is the conclusion that targeting for both sediment and nutrient (including nitrate) control BMPs is possible not only within watersheds but also within subwatersheds.[94] Even within subwatersheds, individual farms or groups of farms that contribute disproportionate loadings of poison runoff (including nitrate) might potentially be identified.[95] Priority subwatersheds can be established by setting nutrient concentration goals for tributaries at their confluence with the mainstream river based on the needs of the area's aquatic resources.[96] Those subwatersheds exceeding the goals would then be targeted for the appropriate BMP treatments.[97] Although such an approach is still imperfect, the Virginia agricultural subplan does not appear to explore even the potential for developing this kind of management capability.

The agricultural subplan does provide for a revision of the SCS Field Office Technical Guides so that BMPs and conservation plans will reflect water quality considerations.[98] But the subplan still leaves the development and implementation of BMPs mostly to the discretion of the local Soil and Water Conservation Districts (SWCDs). So, while it is admirable that water quality will be addressed more explicitly in the Technical

Guides, there is no real assurance at the state level that the Guides will be followed precisely, given the locally-led, voluntary nature of this program.

The subplan addresses *off-farm* (water quality) impacts more directly than some past nonpoint source programs. However, the plan does not address the possibility that voluntary participation could decline since participation often depends on the farmer perceiving that he will benefit economically (*i.e.*, receive *on-farm* benefits) from BMP implementation. An associated problem is that local SWCDs carry out the state BMP program, but do not operate under any regulatory responsibility (or authority) to achieve compliance with state Water Quality Standards in their respective watersheds.

The development of animal waste BMPs is being promoted through education, technical assistance and cost sharing. Although the final figures are not available, a recent EPA report states that only 51 farmers had participated in the program as of 1986 at a combined federal and state cost of over $500,000.[99] In contrast, there are at least 291 dairy operations in Rockingham County, Virginia alone[100] and up to 700 various livestock facilities (including those for raising chickens) in Rockingham, Page and Shenandoah counties.[101] Applicants for manure management cost sharing are chosen based on costs, manure and urine production, and distance and slope to nearest stream, without any input by the SWCB.[102] Nutrient management plans are required of farmers as part of the BMP, but are much more difficult to enforce because inspectors must visit the farms when the manure or chemical fertilizer actually is being land applied.[103] At any rate, only 5% of the BMPs are randomly "spot-checked" per year, as with the rest of those implemented through the Virginia cost sharing program.[104]

Although SWCB regulations maintain that no animal feeding operations shall maintain a *point source* discharge of "pollutants to state waters except in the case of a 25 year - 24 hour storm events," permits are required only at facilities serving a minimum number of animals and on a "case-by-case" determination made by the state for smaller facilities.[105] For instance, permits for meeting the discharge standard mentioned above (called Virginia Pollution Abatement permits) are required generally only for facilities where more than 300 slaughter and feeder cattle or 200 dairy cattle are confined.[106]

In any case, the regulations only apply to areas where no vegetation is maintained and do not cover the destruction of riparian habitat by cattle and sheep or the application of manure to pasture or cropland.[107] While it is suggested that land application limits be determined and followed, there is no compliance oversight for this process—only enforcement actions taken under the State Water Control Law in response to complaints of acute water contamination.[108]

The state permit program does not address the vast majority of farms (as many as 90%)[109] with fewer than 300 head of cattle. As mentioned in Chapter Three, improper control of small livestock operations can create significant water quality problems.[110] For these numerous operations, the only way that the SWCB determines if water quality problems are resulting from any aspect of the livestock operation is through responses to complaints made by private citizens.[111] Such complaints are a poor substitute for systematic assessment of existing problems and a mandatory program to address *all* of the sources of livestock-related water pollution.

The agricultural subplan does state that legislation will be sought to require all land enrolled under the "use value" tax assessment program to have an approved conservation plan to reduce erosion to below "T" values.[112] Although this is commendable, the plan does not provide an evaluation of other, more comprehensive farmland protection programs similar to those described in Chapter Three. It also does not prevent farmers receiving program benefits from contributing poison runoff not associated with erosion.

Cost sharing, education and technical assistance are all essential aspects of an effective program to control poison runoff. But such program components are only tools and do not provide an adequate framework within which to develop the goals and programs needed to *ensure* the attainment and maintenance of beneficial uses of water within individual watersheds. The innovative solutions to the problems associated with cost sharing that are described in the previous report are not reflected in the agricultural subplan.

Urban Runoff. Urban poison runoff control requires a host of important program components.[113] Localities must take water quality considerations into account when developing zoning and subdivision ordinances and must participate with other localities (and state agencies) in a comprehensive watershed management plan (Rec. 4-1, 4-2, 4-3). Because localities create water quality problems outside their political boundaries, a strong state role is needed to determine water quality protection needs, to negotiate and coordinate local control efforts and to resolve conflicts among and within localities without sacrificing water quality goals (Rec. 4-5). Localities in coastal areas need to cooperate with state agencies to address poison runoff through existing programs designed to enhance and preserve coastal resources (Rec. 4-4). A comprehensive stormwater management program must provide the means to ensure that local governments address the water quality impacts, including toxic contamination, of both new and existing development (Rec. 4-7, 4-8, 4-9, 4-10, 4-11).

In contrast to these needs, Virginia localities outside of the Chesapeake Bay watershed are not required to address water quality issues in their comprehensive planning process. In fact, as a Dillon's Rule state, only in 1988 was local government legally *authorized* (not required), by statute, to use comprehensive planning to protect surface water and groundwater.[114] Moreover, the state has provided no mandatory conflict resolution mechanism to ensure that localities do not sacrifice water quality for political or economic reasons. The urban subplan calls for the signing of Memoranda of Understanding (MOUs) with local governments in "urban priority areas" to incorporate "the most cost-effective BMPs and implementation mechanisms into their local programs."[115] Since there is no clear provision in the urban subplan for the development of watershed-wide plans and associated load reduction goals, the *need* for conflict resolution in the negotiation of these MOUs also is diminished. A MOU with a local government will be based, by definition, on local preferences, so it is understandable—but unsatisfactory—that no mandatory process is provided explicitly to address localities that choose not to address water quality issues.

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Also in contrast with recommendations made in Chapter Four, the urban subplan does not provide any evaluation of current zoning, subdivision or site plan review ordinances or practices or make recommendations as to how they should be improved to address poison runoff and other environmental concerns more effectively. Although some Planning District Commissions (PDCs) have provided technical assistance on nonpoint source management to their members,[116] there is no formal commitment to expand the role of the PDCs (or SWCB) in any particular fashion, especially to the extent of acting in an official arbitration, conflict resolution or coordination role as part of a mandatory watershed planning process.

Controlling poison runoff in urban areas in Virginia has advanced considerably in the past two years. New laws were passed that provide the *potential* for increased control of polluted urban runoff. However, this means that significant work lies ahead in ensuring that the laws passed in 1988 are put to good use.

The Chesapeake Bay Preservation Act (CBPA) added a whole new dimension to the way which the state views local decisions affecting water quality within about half of the Chesapeake Bay portion of the state. The CBPA creates a new Chesapeake Bay Local Assistance Board (CBLAB), which must approve the criteria for development in areas designated by localities (and approved by the Board) as "Chesapeake Preservation Areas." The criteria for selecting these areas and regulating land use within them are of pivotal significance. However, the Act does not require explicitly that one of the *duties* of the CBLAB will be the maintenance and restoration of beneficial uses of water as defined in the State Water Control Law.[117]

The Board "shall be representative of, but not limited to, citizens with an interest in and experience with local government, business, the use and development of land, agriculture, forestry and the protection of water quality."[118] Therefore, in order to ensure that the Board acts fairly and objectively, the state needs to ensure that water quality interests are adequately represented on the Board, and are not outweighed by development interests. Also, in developing criteria, the Board must consider "the economic and social costs and benefits which can

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reasonably be expected to obtain as a result of the adoption or amendment of the criteria."[119] Reliance on attainment of beneficial uses is important because this consideration of economics could cause water quality considerations to be down played in the development of regulations and the review of local plans.

Consistent with the principles established in Chapter Four, care must be taken to ensure that performance standards are used that require localities to protect beneficial uses of waters based on the findings of the SWCB.[120] To do this, the Board should work in conjunction with the SWCB so that the controls required in each local jurisdiction are tailored to achieve specific load reductions in individual watersheds. A simple set of design standards and land use tools provides some desirable consistency in program implementation. But applying these minimum requirements across all regulated jurisdictions cannot ensure compliance with water quality standards, given the site-specific nature of water quality degradation. Additional controls will be needed in specific areas.

Therefore, a strong emphasis should be placed on SWCB and CBLAB *review* of the adequacy of poison runoff controls proposed by individual localities to meet the water quality needs in specific watersheds. Otherwise, a set of inflexible design criteria might allow localities to claim that they are following the regulations even when compliance with water quality standards will not be forthcoming. In addition to the activities of the SWCB, it is also uncertain how (if at all) the CBLAB will coordinate its own goals and requirements with those of the state Coastal Resources Management Program.

Another important issue is the lack of a mandatory conflict resolution procedure in the CBPA and Virginia's § 319 Plan. Without such a mechanism, to be applied by an independent state entity, there is no guarantee that local political factors will not influence environmental considerations. And there is nothing in the § 319 Plan that indicates that mandated conflict resolution processes are being given due consideration elsewhere in the state.

As mentioned previously, the extra-local water quality consequences of many municipal and county decisions makes state-level participation in an urban nonpoint source management plan essential. The CBPA, however, establishes a role for the Commonwealth that is described as "supportive". The ability of the CBLAB to bring about local action is clear. Among the powers and duties of the Board are to:

> [e]nsure that local government comprehensive plans, zoning ordinances and subdivision ordinances are in accordance with the provisions of this chapter; (and)
>
> [t]ake administrative and legal actions to ensure compliance by counties, cities and towns with the provisions of this chapter.[121]

However, besides reference to the provisions of the state Administrative Process Act,[122] there are no special penalties that the state is entitled to use to ensure local compliance with the state criteria.

A final confusing factor is that the CBLAB is given "exclusive authority to institute legal actions to ensure compliance by local governing bodies with this chapter and with any criteria or regulations adopted hereunder."[123] This seems to imply that the program will not be tied to water quality standards because, if it were, the SWCB would require legal authority as well. As worded, the CBPA could be interpreted to mean that the SWCB does not have any authority in local water quality protection beyond the point source programs specifically referenced in the law. As mentioned previously, this limitation is a serious barrier to effective control of poison runoff.

The issues described above regarding the Chesapeake Bay Preservation Act apply generally to any state controls that are developed for the majority of the state that lies outside of the tidewater province. However, there are no similar statutes for local governments outside the tidewater area, making urban nonpoint source management concerns even more fundamental in the rest of the state.

The Virginia urban subplan does not call for the existing state Coastal Resources Management Program (CRMP) to be expanded. Nor does the subplan describe how the CRMP will be integrated with poison runoff controls implemented in the state's coastal areas, or how the CRMP will be used to comply with state water quality standards. In 1986, the state's Coastal

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Resources Management Program (CRMP) proposed "no new state programs, organizations, regulations and laws," finding that none were needed to comply with the minimum requirements of the Coastal Zone Management Act.[124]

In terms of general land use management and planning, the Virginia Coastal Resources Management Program is limited—especially with respect to mandated local involvement.[125] There is no indication in the urban subplan that revision of the CRMP to require specific coastal management programs in local land use planning activities was considered as a means to reduce poison runoff in coastal areas, or specifically to condition coastal development on compliance with water quality standards.

The CRMP describes existing state programs such as the Chesapeake Bay Program and the state efforts to control poison runoff, as well as programs to protect sand dunes and coastal wetlands that are usually administered at the local level.[126] Various programs provide technical assistance to localities and landowners seeking to limit shoreline erosion and federal grant funds to localities and regional planning authorities for waterfront development.

It is not clear, however, how the state CRMP makes existing programs having nonpoint source management benefits more effective by increasing their emphasis or through a more rigorous scrutiny of local actions in coastal areas. In fact, the urban subplan does not provide any indication of how existing activities authorized through the state CRMP have been evaluated to determine opportunities for improved control of poison runoff. Essentially, the state CRMP describes existing activities to control poison runoff as examples of improved coastal resources management while the state § 319 Plan describes existing CRMP activities to show improved nonpoint source management. This "double counting" does not, however, describe how *separate* programs and activities in one area can (or will) be modified or coordinated to enhance or improve the effectiveness of those in the other.

The portion of the urban subplan that addresses contaminated stormwater is equally unsettled. The urban subplan proposes to:

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develop a proposal for enabling legislation for comprehensive storm water management programs combining erosion and sediment control, water quality control and flood control objectives.[127]

Although this proposal is still in its early stages and no design or performance criteria have been establish, draft language has been submitted. The proposal calls for a *voluntary* stormwater management program that localities may adopt as they see fit.[128] Because of the need for strong state leadership to ensure that stormwater ordinances are enforced and coordinated, and that watershed-wide solutions are developed, it is doubtful that a voluntary program will result in stringent, comprehensive local programs. Given the problems that have been identified with the state's *mandatory* erosion and sediment control program[129] and the intense efforts that have been necessary to enforce *mandatory* stormwater controls,[130] it is unlikely that federal and state water quality goals can be attained by a voluntary participation in a stormwater management program.

Without an effective local stormwater ordinance, the only relevant state requirements for controlling stormwater pollution can be found in the erosion and sediment control law and the associated technical handbook, which are designed not to address water quality, but to prevent flooding and channel erosion from excess stormflows. These provisions are vague, often are not enforced at the local level, and generally are inadequate for poison runoff control purposes.[131]

Finally, it is not clear how this new voluntary program will be integrated with the rest of the urban subplan. For instance, the Memoranda of Understanding into which localities will (it is hoped) enter with DSWC are supposed to contain "the most cost-effective BMPs and implementation mechanisms."[132] Although a well-enforced, water quality-based stormwater ordinance may be a very cost-effective "implementation mechanism", it is doubtful that the MOU can require such an ordinance since both the MOU and the stormwater programs are voluntary and are subject to bargaining between the state and consenting localities.

Other Nonpoint Source Management Subplans. The other subplans (forestry, construction, resource extraction, land

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treatment and disposal and hydrologic modifications) are less detailed than those for the urban and agricultural categories. While the poison runoff problems associated with these categories are not necessarily widespread, they still can be important, particularly on a localized basis.[133]

Forestry. Poison runoff related to silvicultural activities must be controlled through coordinated state and federal planning and the application of BMPs implemented as part of an overall timber management plan designed to preserve the beneficial uses of streams and lakes within the watershed (Rec. 5-1, 5-2).[134] Before timber is harvested, an interdisciplinary group of professionals (including officials within the state water quality agency) should review cutting proposals to determine if adequate measures have been taken to preserve and protect water quality (Rec. 5-4). State forestry and water quality officials also need to work together to review federal plans for national forests to ensure that the state's interest in high quality waters is maintained (Rec. 5-2). All of these activities must be carried out through a planning process to identify the areas where significant timber harvesting is likely; to determine potential water quality problems and protection priorities; and to focus resources to improve the management of forestry resources in each indicated area (Rec. 5-2).

Although some progress is provided in the Virginia forestry subplan, there remains significant room for improvement. The state forestry subplan remains voluntary and even the consideration of a regulatory program could be postponed until the year 2000.[135] Logging interests do not even have to notify the state of their intent to cut timber much less use BMPs or protect state waters through compliance with performance standards.[136] Only by 1995 will Virginia have developed even a *voluntary* notification system.[137]

Each county has only one state silviculturalist to observe how well logging operations are carried out and to assist landowners in developing forest management plans (and then only at the landowner's request). It could be difficult for these state personnel to find out about timber operations before they have started,[138] especially if increased concern for water quality must be programmed into current workloads.

There also appears to be no systematic procedure for assessing the potential of private lands to contribute incrementally to poison runoff. The state does not appear to be considering evaluating the adequacy of poison runoff control on the significant amount of land managed by the U.S. Forest Service in Virginia. In addition, there is no indication that a long term planning process will be used to assess threatened areas in the state. Little in the forestry subplan reflects the need for interdisciplinary participation in control of water pollution from timbering. For instance, no mention is made of any involvement in water quality protection on forested lands by either the State Water Control Board or the State Commission on Game and Inland Fisheries.

Erosion and Sediment Control. Sediment generated at construction sites can be a serious pollutant in both rural and urbanized areas. Effective erosion and sediment control requires a strong state role in the development of regulations and guidelines and the review of local program effectiveness (Rec. 5-13). Local ESC officials are challenged to develop programs with sufficient inspections and stringent compliance enforcement (5-13, 5-14).

The Virginia General Assembly recently appropriated funds and passed legislation that allow the DSWC to increase significantly the staff of the state erosion and sediment control program and to improve the implementation and state review of local programs.[139] However, problems still remain. Some significant exemptions are allowed by state legislation, including single family homes and construction sites under 10,000 sq. ft.[140]

The Virginia plan also does not address directly how localities can be ensured of obtaining adequate resources to carry out ESCs. This is especially significant given that studies, carried out before the lofty goals of the CWA § 319 Plan were developed, found that many Virginia localities had inadequate resources to carry out an effective plan.[141] Inadequate resources and enforcement translate into poor inspection and enforcement of local programs.[142] There is also a lack of support in the judiciary to impose substantial fines for violations of local programs.[143] The state can only develop, and not implement, ESC plans when the locality refuses to act.[144]

Virginia's ESC program also lacks a full range of adequate enforcement tools. Administrative fines do exist but only if agreed to by the developer as a means of avoiding a civil or criminal enforcement action.[145] Stop work orders are available but apply only to land disturbing activities, not to other work (like much of the construction of buildings) that might be going on while the erosion or sediment problem remains.[146]

Guidance in several areas is missing. For instance, review of local plans by the state is required, but at an unspecified rate.[147] Inspections of construction sites must be performed by local officials but also on an unspecified basis, making it difficult for state officials to define when local officials are or are not conducting an adequate number of inspections. Many time limits associated with various compliance standards, including the requirement that landowners comply with orders by program officials to correct ESC problems, are not defined. Even the regulations themselves contain a significant variance clause that allows any requirements found in the regulations to be waived as long as local officials consent.[148]

The Virginia subplan for construction provides for improved technical assistance and education by DSWC to local governments to carry out the plan. It also has greatly expanded its capacity to review and evaluate local plans. It remains to be seen, however, if this structure provides systematically for the achievement of the goal of 95% compliance by the year 2000. In evaluating local programs and updating the ESC Handbook, DSWC should capitalize on studies that have been conducted pertaining both to problems with ESC programs in Virginia and effective programs in other areas. In the long run, additional legislation may be needed to make the program more aggressive at the state level and provide necessary local resources.

Resource Extraction, Land Disposal and Hydrologic Modifications. Developing an adequate program to address mining-related pollution requires a coordinated effort by both the state water quality agency and the mining regulatory authority (Rec. 5-6).[149] All forms of mining should be addressed through a process that identifies areas unsuitable for mining, regulates mining through land use controls and the control hierarchy established in SMCRA, and reclaims abandoned lands to prevent further water quality degradation (Rec. 5-7, 5-8, 5-9, 5-11). Adequate inspections and effective enforcement actions are vital; hence, detailed regulations, including performance standards, are needed to provide the minimum criteria that all mining operations must meet (Rec. 5-5).

The other two subplans (land disposal and hydrologic modifications) are not addressed in the proceeding sections of this report. These sources of water pollution often are not considered nonpoint sources or are addressed through specific programs provided for in legislation other than the Clean Water Act (*e.g.*, solid and hazardous waste facilities are regulated under Subtitles C and D of the Resources Conservation and Recovery Act). Problems related to these facilities also can be addressed through siting, zoning and other land use controls discussed in Chapter Four.

The case of nitrate and fecal contamination of surface and ground water by failing septic systems (a significant problem in Virginia) is a possible exception, but this problem also is addressed through land use regulation. For instance, based on an analysis of the cumulative impacts of development, the state or locality can require certain minimum lot sizes, depending on soil and topographic conditions and total allowable contaminant loadings, for individual septic systems.[150] Although no specific guidance has been developed in this study for many of the sources contained in these two subplans, comments are provided where appropriate.

With some exceptions, the subplans for resource extraction (mining), land disposal and hydrologic modifications appear primarily to restate existing program requirements. For example, the resource extraction subplan focuses attention on the environmental protection requirements of existing state regulations

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pertaining to mining. However, there does not appear to be a way to evaluate whether *existing* programs are adequate (or are being implemented adequately).

Current laws and regulations apply to both coal and non-coal mining as well as to oil and gas exploration.[151] However, unlike the legislation and associated regulations described in Chapter Five, much of the Virginia program applicable to non-coal mining is based on statutory and regulatory provisions that provide few details or guidance. Therefore, the success of the program in addressing poison runoff depends on how stringent local officials of the Virginia Department of Mines, Minerals and Energy choose to make permit requirements, inspections, enforcement actions and other program requirements.[152]

For instance, the environmental protection data requirements for permit applications and for permits are very limited compared with those of the Wisconsin program described in Chapter Five.[153] Review and approval procedures provide no details or criteria for evaluative purposes. General criteria for protecting wetlands and other sensitive areas also are lacking. This is especially significant because the SWCB does not appear to have any role in determining where reclamation is needed or influencing how the Department of Mines, Minerals and Energy carries out inspections or develops pollution control requirements for poison runoff.

For non-coal mining operations, the minimum inspection and enforcement provisions are equally vague. Although mine inspectors presently must cover an average of 55 mines,[154] the subplan does not propose expanding or even reviewing personnel needs to improve nonpoint source management. In addition, there does not appear to be a planning process in place to assess poison runoff problems and to determine needed controls within specific watersheds or areas where mining is unsuitable.

Perhaps the most important consideration of the land treatment and disposal subplan is the adequacy of the state program for on-site waste disposal (septic systems). But the subplan itself does not propose to review the adequacy of this program or how well it is being implemented at the county level. Instead it merely summarizes how the existing program works. There do not appear to be *any* new activities proposed for this particular problem, which is a major source of fecal bacteria impairments to state waters. Since bacteriological contamination is the most prevalent type of use impairment in the state, it is apparent that the current system of septic system control is not effective.

Virginia still controls pollution problems from septic systems primarily through requirements for a "perc" (percolation) test to determine if the soils in the area can absorb effectively the effluent from the septic tank, and through an evaluation of individual site characteristics. This process is controlled by county health department officials—not state water quality managers—who are not responsible for ensuring that state water quality objectives are achieved. No provisions seem available at the state level to account for the water quality impacts of the aggregate loading caused by mahy septic systems in one area or the incremental increases in these systems brought on through time by development pressure.

Similarly, the section on hydrologic modifications consists largely of restatements (as opposed to evaluations) of existing programs. Apart from rare exceptions, there do not appear to be any new activities or programs proposed by non-federal entities, which indicates that the state believes this poison runoff category is already being addressed adequately by existing programs.

Data Collection and Use

Critical to the success of a watershed-by-watershed approach in nonpoint source management is the proper use of water quality information.[155] Water quality data not only provide the information needed to establish water quality goals and priority areas within the watershed. They also establish the state's *authority* to require that necessary pollution load reductions be achieved on a watershed-by-watershed basis (Rec. 6-1, 6-4). As mentioned in Chapter Six, using water quality information to develop, implement and monitor controls can be the most challenging part of a program to control poison runoff. While it may not be possible to model precisely the actual and potential impacts of each individual source of diffuse pollution, successful modeling has been demonstrated on a watershed-wide basis, and progress continues to be made.

Unfortunately, Virginia's plan does not describe how ambient water quality information and watershed modeling are to be used to develop nonpoint source management programs for specific hydrologic areas. No references are made to establishing, for example, a procedure to monitor above and below the fall to determine the severity of the nonpoint source problem in a particular watershed. This omission is unfortunate and ironic given Virginia's leadership in demonstrating, by the creation and expansion of the land-based VirGIS information system for targeting resources (described earlier), innovation in the field of data collection and use.

The state § 319 Plan should recognize explicitly the need to use ambient water quality as the primary means of judging the success of nonpoint source controls in individual watersheds (Rec. 6-4). A proposal should be made as soon as possible that describes how water quality monitoring and modeling activities will be modified and used to develop comprehensive watershed plans. As part of these plans, water quality monitoring and modeling should be used to *require* both point and nonpoint source controls in watersheds where beneficial uses of water are not attained.

Funding

Besides general management and the particular plans for each source category, funding is also an important issue in controlling poison runoff.[156] Not only are significant *levels* of funding needed, but money for control programs should also be provided from a variety of sources, including the polluters themselves (Recs. 7-1 through 7-7).

Virginia has substantially increased funding for its nonpoint source programs in the past few years. But it seems unlikely that these levels are sufficient, especially given the approaches currently used. Virginia officials have estimated that $170 million in cost sharing funds would be necessary to install the BMPs that would address only erosion-related pollution problems and only in the Chesapeake Bay drainage.[157] This figure excludes the costs of controlling sediment in the remainder of the state as

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well as the costs of controlling groundwater contamination from soluble fertilizers, pesticides and toxic chemicals from both agricultural and nonagricultural nonpoint sources throughout the entire state. Therefore, the approximately $1.25 million available for cost sharing (mentioned in a preceding section of this case study) in each of the next two years cannot be regarded as adequate.[158]

While the state expenditures for cost sharing described in the previous section are less than adequate, additional problems also can be foreseen based on how those limited funds are used. The majority of funds are used to pay for those popular BMPs that are designed to control erosion and sedimentation. Cropland-related nutrient enrichment is addressed almost entirely through technical assistance and education provided by the state Nutrient Management Program. At the rate at which farmers are brought into the state nonpoint source program using these approaches, it is difficult to discern at what point actual improvements in ambient water quality will be achieved in any particular location.

The agricultural subplan also does not reflect the negative environmental impacts that can result from cost sharing. By paying farmers to implement BMPs that can improve farmer profits and production, the state could be artificially perpetuating poison runoff problems. For purposes of cost sharing, a careful distinction must be made between BMPs that provide short term on-farm benefits and can be implemented by the farmer without any financial assistance, or provide longer term benefits that can be implemented with minimal assistance (or perhaps a low interest loan); and those that must be heavily subsidized because they provide no on-farm benefits. Having both farm prices and practices reflect environmental considerations is essential to the effective control of poison runoff, so cost sharing must be used carefully.

There also is little indication that funding sources within the state other than general revenues will be used to provide resources for the Nonpoint Source Program, or that parties responsible for poison runoff will be required to fund control programs. In fact, most of the discussion of funding in the agricultural section addresses the availability of federal funds,

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which cannot be tailored to Virginia's particular problems as easily or as effectively as state or local funds.

There is no provision in the plan to ensure that local governments contribute to the costs of controlling poison runoff in urban areas by allocating property tax or other revenues for stormwater or other nonpoint source controls. Other entities that could be viable taxing authorities, such as SWCDs and regional water quality control agencies, are not considered in the plan as potential taxing authorities to commit funds for either the general nonpoint source program at the state level or for the development of "watershed plans."

"Pollution control taxes" for polluting farm practices are not considered seriously as a potential source of program funds or pollution prevention. Although there is a possibility that fertilizer tax revenues will be re-allocated to the Nonpoint Source Program, neither this tax nor any other is being used to dissuade groups from undertaking land use activities that generate water pollution.[159] Although the fertilizer tax is a step in the right direction, the Plan does not state whether fertilizers will provide the high levels of funding required to implement through cost sharing all of the agricultural BMPs needed to meet water quality goals. In any case, there is no indication in the subplan that farmers will be required to finance some of the costs associated with controlling poison runoff.[160] Other charges, such as impact fees and other land use-based fees are not provided for in the § 319 Plan.

Legal Considerations

A legal system that is responsive to the need to control poison runoff is the foundation of all control programs. While totally restructuring a state's legal framework is unnecessary, comprehensive "source" control laws are needed to address contamination from stormwater and construction activities (Rec. 8-1, 8-2). Local governments should be required to prevent serious water quality impacts from land use development according to state criteria (Rec. 9-3). The state environmental policy act should be used to review all activities that could affect state waters and to require mitigation where necessary (Rec. 9-

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4). Finally, the exercise of the common law should bolster nonpoint source controls established through statutory programs.

Much of the preceding analysis provides a critique of the laws available in Virginia for controlling poison runoff. While many laws have been passed (or proposed) that improve the management of nonpoint sources, most of these laws, such as those applicable to land use planning, stormwater management and erosion and sediment control, could be improved. Similarly, although restrictions placed on localities because of Dillon's Rule have been eased by recent legislation, it remains to be seen if localities will capitalize on this opportunity by improving water quality protection activities.

Finally, the § 319 Plan does not expand the Council on the Environment's role in the Virginia Environmental Quality Act beyond the review of Environmental Impact Statements (EISs) for projects undertaken by certain state agencies and for comments made to appropriate federal agencies on projects that require an EIS under the National Environmental Policy Act. Therefore, substantial state-level control through VEPA is not available to control the individual or cumulative impacts of most private development.

Conclusion

The art and science of controlling poison runoff is undergoing another stage of growth after the initial activity that peaked in the late 1970s. No state alone has come to represent a model and, in fact, many have not progressed as far as Virginia in recognizing the significance of poison runoff. Nevertheless, there are significant problems with Virginia's plan to address poison runoff.

Some of the problems with Virginia's program can be fixed relatively easily and quickly, through increased resources or fine-tuning of existing programs. Other problems need more fundamental changes in approach. But as this report and case study have shown, none of the problems in Virginia or elsewhere is insurmountable.

We hope that the analysis in this case study, whether based on the detailed criteria set forth in the body of the report or the summary criteria provided immediately before the case study, will

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be of use not only to Virginia, but to all states and localities trying to improve their efforts to control poison runoff, as well as to government officials and citizens who review and comment on those efforts.

Notes - Case Study

1. This plan was submitted on August 4, 1988 to EPA Region III for federal approval.

2. It is not the purpose of this report to describe in detail all of Virginia's poison runoff control activities. The details of the programs outlined below are available in the documents cited.

3. Unless otherwise noted, the remainder of this section is based on - Virginia Department of Conservation and Historic Resources, *Virginia Nonpoint Source Pollution Management Plan*, August 4, 1988 (hereinafter cited as *Virginia NPS Pollution Management Plan*).

4. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at i, 1-1.

5. *See* Va. Code §§ 10.1-500 - 10.1-573 (1988).

6. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 1-1.

7. On a localized basis, especially in urban areas, other diffuse sources may predominate.

8. U.S. EPA, *Chesapeake Bay Nonpoint Source Programs*, January, 1988, at 25 (hereinafter cited as *Chesapeake NPS Programs*).

9. Virginia Department of Conservation and Historic Resources, *1988 Virginia Agricultural BMP Cost-Share Program Manual* (no date), at 5.

10. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 26.

11. *Id.*

12. Virginia Department of Conservation and Historic Resources, *Chesapeake Bay Nonpoint Source Pollution Control Program, Annual Report, July 1, 1985 - June 30, 1986*, November 20, 1986, at 8-9 (hereinafter cited as *Annual Report*). This formula ranks each application using the total estimated cost of installing and maintaining the BMP, the maintenance life of the practice, the Universal Soil Loss Equation and a sediment delivery ratio to determine which applications provide the largest sediment loading reductions per dollar. *Id.*

13. *Id.*

14. Don Wells, Virginia Division of Soil and Water Conservation, October 26, 1988, quoting unpublished program figures (personal conversation).

15. *Id.*; *see Chesapeake NPS Programs*, 1987, *supra* note 8, at 25-26.

16. Don Wells, October 26, 1988, *supra* note 14.

17. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 30; *see generally* Hession, W.C., *et al.*, "The Virginia Geographic Information System for Targeting Non-Point Agricultural Pollution of the Chesapeake Bay," paper

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presented at the 1985 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 17-20, 1985.

18. *See* Hession, *et al.*, 1985, *supra* note 17, at 1-2.

19. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 30; Yagow, E.R., *et al.*, "Use of Geographic Information Systems (GIS) for Soil Conservation and Water Quality Improvement," paper presented at the 85th Annual Meeting of the Southern Association of Agricultural Scientists, New Orleans, Louisiana, January 31-February 3, 1988, at 3-4.

20. *Annual Report*, 1986, *supra* note 12, at 12.

21. *Id.* at 15. This total includes farm visits and education meetings. *Id.*

22. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 32.

23. *Annual Report*, 1986, *supra* note 12, at 17. The simulator demonstrates the impact on runoff of tilled versus no-till cropland. It can also demonstrate the effect of grass filter strips. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 30.

24. *Annual Report*, November 6, 1986, *supra* note 12, at 17.

25. *Id.* at 18.

26. Virginia Department of Conservation and Historic Resources, *Chesapeake Bay Research/Demonstration Project Summaries, July 1, 1984 - June 30, 1987*, December 2, 1987, at 6-7 (hereinafter cited as *Chesapeake Bay Research/Demonstration Project*; *see also* Byler, R.K., *et al.*, "Water Quality Monitoring for Nonpoint Source Pollution Assessment," paper presented at the 1985 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 17-20, 1985.

27. See *Chesapeake Bay Research/Demonstration Project*, 1987, *supra* note 28, at 6-7.

28. The Chesapeake Bay Agreement was signed by the governors of Maryland, Virginia and Pennsylvania, the Mayor of Washington D.C., and the Administrator of EPA as the basis for a coordinated and aggressive effort to restore Chesapeake Bay productivity. One commitment within the agreement was the reduction of phosphorus and nitrogen inputs into the Bay by 40 percent.

29. See Chapter Three for an explanation of T levels.

30. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-2 - 2-3.

31. The DSWC is also considering the allocation of existing fertilizer tax revenues toward poison runoff control.

32. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-4 - 2-6.

33. These provisions include the Conservation Reserve Program, Conservation Compliance, Sodbuster and Swampbuster. See Chapter Three for a brief description of these provisions.

34. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-7.

35. *Id.* at 2-9.

36. *Id.* at 2-12 - 2-14.

37. *Annual Report*, 1986, *supra* note 12, at 21-22.

38. Va. Code §§ 10.1-2100 - 10.1-2115 (1988).

39. Tidewater is defined to include 28 counties and 17 cities. Va. Code § 10.1-2101 (1988).

40. *See Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 5-6; Va. Code § 10.1-2107 (1988).

41. Va. Code § 15.1-489 (1988). The exact wording of the bill is: "Such (zoning) ordinance may also include reasonable provisions, not inconsistent with applicable state water quality standards, to protect surface water and groundwater."

42. Va. Code § 15.1-447 (1988).

43. Va. Code § 15.1-446.1 (1988).

44. Twenty-two PDCs were created through the Virginia Area Development Act. Va. Code §§ 15.1-1400 *et seq.* Planning District Commissions are regional planning organizations with limited authority to implement programs and services. Cox, William E. and Lorraine M. Herson, *Control of Nonpoint Source Pollution in Virginia: An Assessment of the Local Role*, Bulletin 158, Virginia Water Resources Research Center, November, 1987, at 15-16.

45. *See* Va. Code §§ 10.1-2100 - 10.1-2115 (1988).

46. A proposal for stormwater management legislation was to be developed by November 1, 1988. Urban Priority Areas are to be designated by December 31, 1992. The Urban BMP Handbook will be updated by October 1, 1990. Memoranda of Understanding will be promoted by December 31, 1993. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 5-23 - 5-24.

47. *Id.* For example, updated urban poison runoff control educational materials will be distributed throughout the state by June 30, 1991. A training program will be developed by December 31, 1991 to inform local government personnel about revised urban BMPs and their implementation strategies. By July 1, 1990, the DSWC will begin a series of (at least) four urban BMP seminars for a "minimum total attendance of 160." *Id.*

48. Va. Code §§ 10.1-560 - 10.1-571 (1988).

49. Under the Erosion and Sediment Control Law, an "erosion impact area" is defined as "an area of land not associated with current land disturbing activity but subject to persistent soil erosion resulting in the delivery of sediment onto neighboring properties or into state waters." Va. Code § 10.1-560 (1988).

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50. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 4-18. By the year 2000 the figure is supposed to rise to 95% of regulated private construction projects. *Id.*

51. The RT Program offers to pay 50% of the cost of replanting land that has been cut over with pine or other suitable soft woods. *See* Va. Code §§ 10.1-1170 - 10.1-1176 (1988).

52. The Forestry Incentives Program provides landowners financial assistance for site preparation, tree planting and stand improvement practices. *See* 16 U.S.C. § 2103.

53. Sediment and nutrient load reductions will not be calculated until 1990.

54. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 3-5.

55. *See* Virginia Department of Mines, Minerals and Energy, *Minerals Other Than Coal Surface Mining Manual–Law and Regulations* (no date), Va. Code §§ 45.1-180 - 45.1-197.18 (1986).

56. Hazardous wastes are managed in Virginia under EPA authority pursuant to the Resource Conservation and Recovery Act. Since this potential source of groundwater contamination is already governed by federal regulations it is not addressed in this report.

57. This section of the plan refers to the incorporation of sewage sludge in the reclamation of land disturbed by mining. Most aspects of this process would be controlled by the Division of Mined Land Reclamation as part of the state's Coal and Surface Mining Reclamation Program established pursuant to the federal Surface Mining Control and Reclamation Act of 1977.

58. *See* 53. Fed. Reg. 33,114 (Aug 30, 1988). NRDC has sharply criticized the adequacy of these proposed rules. *See Comments of the Natural Resources Defense Council on U.S. Environmental Protection Agency's Proposed Rule for Solid Waste Disposal Facility Criteria*, November 30, 1988.

59. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 8-1. CWA § 401 requires "any applicant for a federal license or permit to conduct any activity ... which may result in any discharge into the navigable waters [to] provide the licensing or permitting agency a certification from the state ... that any such discharge will comply with the applicable provisions of sections 301, 302, 303, 306 and 307 of this act."

60. *Id.* at 8-2.

61. This analysis is based on the criteria and recommendations developed in the preceding report, as well as specific comments submitted by NRDC on Virginia's NPS Plan. *See generally* Thompson, Paul and Robert W. Adler, *Comments of the Natural Resources Defense Council on Virginia's Proposed Nonpoint Source Pollution Management Plan to Fulfill the Requirements of CWA Section 319*, July 28, 1988. This analysis takes into account Virginia's written responses to NRDC's comments. *See* letter and attachment from

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Stuart Wilson, Environmental Program Supervisor, Virginia Division of Soil and Water Conservation to Paul Thompson, Natural Resources Defense Council, September 8, 1988.

62. The requirements of CWA §§ 208, 303 and 319 and 40 CFR Parts 130 and 131 are explained in Chapter Two of the preceding report.

63. These major thematic problems track the NRDC comments (mentioned above) at 1-29. More detailed comments on specific provisions of Virginia's plan, which are too narrowly focused to be of use in this report, are included in Attachment 1 to NRDC's comments.

64. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 1-1.

65. *Id.* at 2-1. Interestingly, the *purpose* of the subplan however, is stated in a far different fashion than the *goal:*

> to establish a direction and framework for agricultural interests (government agencies, industry and private sector) to address nonpoint source pollution loadings attributed to agricultural lands and operations. *Id.* at 2-2.

66. *Id.* at 5-2.

67. Ron Gregory, State Water Control Board (Virginia), February 12, 1988 (personal conversation). For instance, although nutrients from agricultural fertilizers and livestock operations are a significant source of nitrogen and phosphorus enrichment of Virginia waters and the Chesapeake Bay, the water quality standard for "nutrient enriched waters" adopted by the SWCB address only phosphorus discharges by municipal POTWs. The standards do not apply to nonpoint source polluters, and in any case, does not address nitrogen contained in either point source discharges or poison runoff and baseflow. VR 680-14-02 (1988) - Policy for Nutrient Enriched Waters; VR 680-21-07.3 (1988) - Nutrient Enriched Waters.

68. See note 67.

69. See Report Chapter Nine.

70. *See, e.g.*, letter and attachment from Stuart Wilson, Virginia Division of Soil and Water Conservation, September 8, 1988, *supra* note 61, at 4:

> The VWCB can take enforcement action against any polluter, either point or non-point, who can be demonstrated to be causing water quality standards violations. Obviously, it is technically much simpler to place blame with point sources. In the case of non-point sources, we can and have taken enforcement actions. But when non-point sources are truly diffuse, the cause-effect relationship is much harder to establish, especially "beyond a reasonable doubt." To take an extreme example cited in NRDC's report, who would Virginia sue for causing deepwater deoxygenation in the Chesapeake Bay?

See generally Thompson and Adler, July 28, 1988, *supra* note 61.

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71. An interesting analogy to this idea is the creation of a zoning law that restricts all (or some) dwelling to residential use because of traffic, safety and aesthetic considerations. In order to develop and pass that law information must be produced that shows (to some accepted level of certainty) that without the proposed restrictions undesirable conditions will result. Once the law (including its variance procedures) is enacted it applies to everyone equally. The authorities do not have to prove through lawsuit that every single person who proposes a nonconforming land use will bring about those conditions individually. Violations of water quality standards are the conditions that indicate to government officials the need (and authority) to take action.

72. See Report Chapters Nine and Ten.

73. *E.g.*, point source animal waste effluent, land treatment of sewage sludge, discharging of dredged and fill materials.

74. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 1-4. The same section also restates the role of the SWCB:

> The State Water Control Board (SWCB) remains the water quality management agency in Virginia. As such they remain responsible for establishment of water quality standards for surface and groundwater, monitoring of streams to measure compliance with water quality standards, and overall water quality management. These responsibilities remain unchanged. *Id.*

75. *Id.* at 2-19, 5-4 - 5-5.

76. Alan Pollock, State Water Control Board (Virginia), January 5, 1988 (personal conservation); Dale Phillips, State Water Control Board (Virginia), April 5, 1988 (personal conversation); and Bernie Catton, State Water Control Board (Virginia), April 7, 1988 (personal conversation).

77. Targeting improves the efficiency of poison runoff control programs and is therefore a desirable program component. It does not, however, determine necessary load reductions or provide coordination and cooperation within the watershed. Once the watershed planning process has been undertaken, *then* the state can target funds and resources both among and within watersheds.

78. Va. Code §§ 10.1-500 - 10.1-573 (1988).

79. Va. Code §§ 10.1-505(3) (1988) (emphasis added).

80. Va. Code § 15.1-489 (1988).

81. Under the state agricultural pollution control program, SWCDs are described as "lead local management agencies." *Virginia Nonpoint Source Management Plan*, *supra* note 3, at 2-10.

82. *Id.* at 2-2. In addition, one of the goals of the agricultural plan is to:

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> [p]rovide effective educational and technical assistance programs which optimize voluntary implementation of best management practices.

Id. at 2-3.

According to the Plan, the six main functional areas of the DSWC consist of cost sharing, technical/administrative assistance, education, demonstration/research, nutrient management and NPS data base development. *Id.*

83. *See, e.g., Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 22.

84. State Water Control Board, *Best Management Practices Handbook (Management)*, Planning Bulletin 322, 1981, at 1-2.

85. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 26.

86. Madariaga, Bruce, "Assessing Current Cost-Share Programs for Agricultural Best Management Practices Within the Chesapeake Bay Drainage Basin," paper presented at the Conference on the Economics of Chesapeake Bay Management II, Annapolis, Maryland, May 28-29, 1986, at 6-7; Jackson, Gary, *et al.*, *Agricultural Management Practices to Minimize Groundwater Contamination*, University of Wisconsin-Extension, July, 1987, at 61-62.

87. Madariaga, 1986, *supra* note 86, at 5.

88. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-3, 2-25; *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 32.

89. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-11 - 2-12.

90. *Id.*

91. *See, e.g., Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 29; *Annual Report*, 1986, *supra* note 12, at 6-7.

92. *See generally* U.S. Fish and Wildlife Service, *Nutrient Dynamics in the Choptank River Watershed - A Comparative Analysis of Subwatershed Exports*, April, 1988.

93. *Id.* at E-3 and 14 - 21.

94. *Id.* at 60.

95. *Id.* at 61.

96. *Id.* 60.

97. *Id.*

98. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-9 - 2-10.

99. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 29.

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100. Halstead, John M., Sandra S. Batie and Randall A. Kramer, *Agricultural Practices and Environmental Attitudes of Rockingham County, Virginia Dairy Farmers: Results of a Survey*, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, January, 1988, at 2.

101. David Knicely, Shenandoah Valley Soil and Water Conservation District, December 6, 1988 (personal conversation).

102. *Id.*; *Annual Report*, 1986, *supra* note 12, at 12.

103. Knicely, 1988, *supra* note 101; *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 33.

104. Knicely, 1988, *supra* note 101; *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 33.

105. VR 680-14-01 § 6.1(D) (1988).

106. VR 680-14-01 § 6.1(C)(4)(a) (1988).

107. VR 680-14-01 § 6.1(C)(1)(b) (1988).

108. Larry Hough, State Water Control Board (Virginia), Valley Regional Office, December 6, 1988 (personal conversation); Knicely, 1988, *supra* note 101.

109. Knicely, 1988, *supra* note 101.

110. *Id.*

111. *Id.*; Hough, 1988, *supra* note 108.

112. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-4.

113. See Report Chapter Four.

114. Va. Code § 15.1-489 (1988).

115. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 5-24.

116. *See generally* Northern Virginia Planning District Commission, *Guidebook for Screening Urban Nonpoint Pollution Management Strategies*, November, 1979; Hampton Roads Water Quality Agency and the Southeastern Virginia Planning District Commission, *Comprehensive Elizabeth River Water Quality Management Plan*, December, 1986; Northern Virginia Planning District Commission, *Evaluation of Regional Best Management Practices in the Occoquan Basin*, December, 1986; Northern Virginia Planning District Commission, *Profile of Nonpoint Pollution Management Activities in the Occoquan Basin*, December, 1985.

117. The wording of the Act is that the criteria developed by the Chesapeake Bay Local Assistance Board are to "encourage and promote" water quality protection. But the Act does not specifically reference achievement or maintenance of state water quality standards as a necessary goal for local protection efforts. Va. Code § 10.1-2107 (1988).

118. Va. Code § 10.1-2102 (1988).

119. Va. Code § 10.1-2107(C) (1988).

120. The Act states that the state criteria will "operate in conjunction with other state water quality programs." Va. Code § 10.1-2107(B) (1988). The Act also states that "[n]o authority granted to a local government by this chapter shall affect in any way the authority of the State Water Control Board to regulate industrial or sewage discharges under articles 3 or 4 of the State Water Control Law ...." Va. Code § 10.1-2113 (1988).

121. Va. Code §§ 10.1-2103(8), (10) (1988).

122. *See* Va. Code § 9-6.14.1 *et seq.* (1988). Strictly speaking, the CBPA states that determinations of *compliance,* not penalties, will be in accordance of the Administrative Process Act. Va. Code § 10.1-2103(8) (1988).

123. Va. Code § 10.1-2104 (1988).

124. U.S. Department of Commerce, Office of Ocean and Coastal Resource Management, *Commonwealth of Virginia Coastal Resources Management Program and Final Environmental Impact Statement* (Volume 1), July, 1986, at Part 1.

125. *See generally* Memorandum from Keith J. Zuttleman, Virginia Council on the Environment, to William C. Milhouser, U.S. National Oceanic and Atmospheric Administration, *Virginia Coastal Zone Management Program Implementation—Quarterly Report,* July 3, 1988.

126. *See generally* U.S. Department of Commerce, 1986, *supra* note 124, at Part 1; *Virginia Coastal Zone Management Program Implementation,* July, 1988, *supra* note 125.

127. *Virginia NPS Pollution Management Plan,* 1988, *supra* note 3, at 5-3.

128. Marlene Hail, Virginia Division of Soil and Water Conservation, December 2, 1988 (personal conversation); *see* Va. Code §§ 10.1-658 - 10.1-672 (draft legislative amendments, dated November 28, 1988).

129. Virginia Department of Conservation and Historic Resources, *Implementation Effectiveness of the Virginia Erosion and Sediment Control Program* (House Document No. 15), 1988, at 1-35, 54-63 (hereinafter cited as House Document No. 15).

130. See Chapter Four.

131. House Document No. 15, 1988, *supra* note 129, at 47-48.

132. *Virginia NPS Pollution Management Plan,* 1988, *supra* note 3, at 5-24.

133. By undertaking a thorough watershed-by-watershed evaluation, localized NPS problems (and potential solutions tailored to these problems) could be identified more effectively than in a single statewide evaluation.

134. See Report Chapter Five.

135. *Virginia NPS Pollution Management Plan,* 1988, *supra* note 3, at 3-4 - 3-5.

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136. *Id.* at 3-4.

137. *Id.*

138. Sam Austin, Virginia Department of Forestry, October 26, 1988 (personal conversation).

139. *See* 1988 Va. Acts 800 (Item 488 - Nonpoint Source Control); Va. Code §§ 10.1-565 - 10.1-566, 10.1-569 (1988).

140. Va. Code § 10.1-560 (1988).

141. Cox and Herson, 1987, *supra* note 44, at 40-41.

142. *Id.* at 43-44.

143. *Id.* at 44.

144. Va. Code § 10.1-562 (1988).

145. Va. Code § 10.1-569 (1988).

146. Va. Code § 10.1-566(C) (1988).

147. Va. Code § 10.1-561(D) (1988).

148. Soil and Water Conservation Commission, *Virginia Erosion and Sediment Control Handbook*, 1980, at III-A.

149. See Report Chapter Five.

150. Some states have regulations that apply to septic tank location and construction. Delaware is one of the only states that regulates septic tanks according to specific requirements for minimum siting densities and isolation distances, based on estimates of projected cumulative loadings of nitrate to groundwater. *See* Delaware Department of Natural Resources and Environmental Control, *Regulations Governing the Design, Installation and Operation of On-Site Wastewater Treatment and Disposal Systems*, July, 1985, at 85-88. Exemptions to these standards can only be made according to detailed regulations that provide for a geological and hydrogeological evaluation by a Registered Professional Geologist to consider specific issues, including existing groundwater uses and quality and the designated uses of surface water within 1000 feet of a proposed septage disposal area. *Id.* at 87-88. The exemption cannot be granted at the discretion of the state (much less the local county health official), but instead, can occur only after specified site conditions can be demonstrated. *Id.*

151. *See generally* Va. Code §§ 45.1-286 - 45.1-361; Virginia Department of Mines, Minerals and Energy (no date), *supra* note 55; Department of Mines, Minerals and Energy, *Permanent Regulatory Program for Surface Coal Mining and Reclamation Operations* (no date); Va. Code §§ 45.1-226 - 45.1-270.1.

152. A review of Virginia's surface and coal mining program is being conducted by the Environmental Law Institute, under a grant provided by the Virginia Environmental Endowment, which also funded this report and case study.

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153. *See* Va. Code §§ 45.1-180 - 45.1-197.18 (1986); Virginia Department of Mines, Minerals and Energy, (no date), *supra* note 55, at 1-22 (Section II).

154. Catherine Pearsal, Virginia Department of Mines, Minerals and Energy, October 28, 1988 (personal conversation).

155. See Report Chapter Six.

156. See Report Chapter Seven.

157. Yagow, *et al.*, 1988, *supra* note 19, at 2.

158. Controlling erosion alone also does not ensure effective control even of pollutants which can become attached to soil particles. This is because there is not always a perfect correlation between movement of eroded soil and transport of such pollutants to aquatic environments. For instance, in the U.S. Fish and Wildlife study described earlier, phosphorus loss was not found to be strongly related to soil loss within the Choptank river watershed. U.S. Fish and Wildlife Service, 1988, *supra* note 92, at E-3. In another study of tributaries to Lake Erie, Ontario, one researcher concluded that lands should be targeted based on the specific pollutant of concern since, for example, "sources of high nitrate and phosphorus loadings are not usually the same area of high erosion." North Carolina Agricultural Extension Service, *NWQEP Notes*, November 15, 1988, at 3.

159. *Virginia NPS Pollution Management Plan*, 1988, *supra* note 3, at 2-5.

160. Under the existing cost sharing program, depending on the BMP, the state sometimes provides only a percentage of the cost associated with the installation of a BMP. *Chesapeake Bay NPS Programs*, 1988, *supra* note 8, at 28. However, many farmers would not likely volunteer to adopt a BMP unless they felt it provided economic benefits or, at least, did not decrease profitability.

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Appendix

Local governments play a key role in fighting poison runoff by gathering information, developing plans and implementing and evaluating field-level controls. This appendix offers some examples of promising local government programs to attack poison runoff. Two of the examples, in Florida and Minnesota, are parts of statewide land use management efforts designed to protect water quality. The third example is the program of comprehensive land use planning in Long Island, New York. Specific aspects of each program are discussed in the main report; more complete descriptions of these programs are given below.

Florida

Local NPS protection in Florida is mandated by the Local Government Comprehensive Planning and Land Development Regulation Act of 1985 (Comprehensive Planning Act). This land use planning process, described in Chapters Nine and Ten, contains a set of review criteria, embodied in regulations requiring certain "elements" in local planning documents, by which state officials can determine whether or not local comprehensive plans will have unreasonable impacts on state water quality standards. These are described below.[1]

The future land use element requires that existing and planned waterwells and cones of influences,[2] wetlands and surface water resources be identified on a land use map.[3] Objectives must be established that coordinate future land uses with the appropriate topography and soil conditions, ensure the protection of natural resources, and discourage urban sprawl.[4] The future land use element must provide for drainage and stormwater management, and the protection of potable water wellfields and environmentally sensitive lands.[5]

Another mandatory planning element must include policies to protect and conserve natural resources for the development of ports and airports.[6] Localities must collect data that identifies all facilities related to sanitary sewers, solid waste, drainage and potable water, their geographic service areas, the responsible operating entity and the current and projected level of service needs.[7] Land use regulations must provide for the protection of natural drainage features and natural groundwater aquifer recharge areas, and for water conservation and stormwater management.

The conservation element of local comprehensive plans is perhaps more directly related to local NPS pollution control than the other required elements. Table A-1 presents the water quality-related data collection activities required by the conservation element of local comprehensive plans.

Table A-1
Water Quality-Related Data Collection Requirements of the Comprehensive Plan Conservation Element*

Identify and Analyze the Following:

1. Rivers, bays, lakes, and wetlands including estuarine and marine waters, including information on the quality of the resources classified by the Florida Department of Environmental Regulation;
2. Floodplains;
3. Known sources of commercially valuable minerals;
4. Areas known by the local soil and water conservation district to have experienced soil erosion problems;
5. Fisheries, wildlife, marine habitats, and vegetative communities;
6. For each of the above natural resources, the element shall identify existing commercial, recreational or conservation uses, known pollution problems, and the potential for conservation; and
7. Current and projected water needs and sources for the next ten-year period based on the demand for industrial, agricultural, and potable water use and the quality and quantity of water available to meet these needs. The analysis shall consider existing levels of water conservation, use and protection and applicable policies of the regional water management district.

* Source: Fla. Admin. Code Ann. r. 9J-5.013(1) (1986).

The water quality objectives and policies that must be contained in the element are given in Table A-2.

Table A-2
Water Quality-Related Objectives and Policies of the Comprehensive Plan Conservation Element*

Objectives Shall Be Developed Which:

1. Conserve, appropriately use, and protect the quality and quantity of current and projected water resources and waters that flow into estuarine waters or oceanic waters.
2. Conserve, appropriately use, and protect minerals, soils and native vegetative communities including forests; and
3. Conserve, appropriately use, and protect fisheries, wildlife, wildlife habitat and marine habitat.

Policies Shall be Developed for Each Objective Which Address Implementation Activities for the:

1. Protection of water quality by restriction of activities known to adversely affect the quality and quantity of identified water sources including existing cones of influence, water recharge areas, and waterwells;
2. Emergency conservation of water sources in accordance with the plans of the regional water management district;
3. Protection and conservation of the natural functions of existing soils, fisheries, wildlife habitats, rivers, bays, lakes, floodplains, harbors and wetlands (including estuarine marshes and freshwater wetlands);
4. Designation of environmentally sensitive lands for protection based on locally determined criteria which further the goals and objectives of the conservation element; and
5. Management of hazardous wastes to protect natural resources.

* Source: Fla. Admin. Code Ann. r. 9J-5.013(2) (1986).

Programs developed in Florida to protect coastal resources provide a good example of the kinds of controls available to protect water quality in sensitive areas. The Florida program is integrated into the statewide comprehensive planning process,[8] which requires consistency and coordination among all agencies and government levels with local, regional or statewide coastal protection responsibilities, objectives and activities.[9] As described in Chapter Ten, the 1984 Florida State and Regional Planning Act[10] requires the preparation of a State Comprehensive Plan, which is embodied in Chapter 187 of the Florida Statutes. The

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ninth goal of the State Comprehensive Plan refers to coastal and marine resources and is accompanied by 10 policies:

> *Goal:* Florida shall ensure that development and marine resource use and beach access improvements in coastal areas do not endanger public safety or important natural resources. Florida shall, through acquisition and access improvements, make available to the state's population additional beaches and marine environment, consistent with sound environmental planning.

Policies

1. Accelerate public acquisition of coastal and beachfront land where necessary to protect coastal and marine resources or to meet projected public demand.
2. Ensure the public's right to reasonable access to beaches.
3. Avoid the expenditure of state funds that subsidize development in high-hazard coastal areas.
4. Protect coastal resources, marine resources, and dune systems from the adverse effects of development.
5. Develop and implement a comprehensive system of coordinated planning, management, and land acquisition to ensure the integrity and continued attractive image of coastal areas.
6. Encourage land and water uses which are compatible with the protection of sensitive coastal resources.
7. Protect and restore long-term productivity of marine fisheries habitat and other aquatic resources.
8. Avoid the exploration and development of mineral resources which threaten marine, aquatic, and estuarine resources.
9. Prohibit development and other activities which disturb coastal dune systems, and ensure and promote the restoration of coastal dune systems that are damaged.

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10. Give priority in marine development to water-dependent uses over other uses.[11]

State agencies must develop functional plans with objectives and procedures designed to ensure measurable progress towards state goals.[12] Regional Plans, consistent with state goals, must also be developed, reviewed and approved by the state.[13] Regional plans are used in evaluating developments with regional impacts.[14]

The comprehensive plans of coastal localities must contain a coastal management element that includes nonpoint source pollution.[15] In passing the Comprehensive Planning Act, the state legislature intended that "local government comprehensive plans restrict development activities where such activities would damage or destroy coastal resources, and [that such plans] protect human life and limit public expenditures in areas . . . . subject to destruction by natural disaster."[16]

The legislature gave special status to coastal protection by requiring the coastal management element to achieve the following specific objectives:

1. Maintenance, restoration, and enhancement of the overall quality of the coastal zone environment, including, but not limited to, its amenities and aesthetic values.

2. Continued existence of viable populations of wildlife and marine life.

3. The orderly and balanced utilization and preservation, consistent with sound conservation principles, of all living and nonliving coastal resources.

4. Avoidance of irreversible and irretrievable loss of coastal zone resources.

5. Ecological planning principles and assumptions to be used in the determination of suitability and extent of permitted development.

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6. Proposed management and regulatory techniques.

7. Limitation of public expenditures that subsidize development in high-hazard coastal areas.

8. Protection of human life against the effects of natural disasters.

9. The orderly development and use of ports to facilitate deepwater commercial navigation and other related activities.

10. Preservation, including sensitive adaptive use of historic and archeological resources.[17]

The element addressing coastal management requires an inventory and analysis of estuarine pollution problems and actions needed to maintain estuaries.[18] This assessment must include the identification of existing nonpoint source pollution problems and the impacts of development and redevelopment and of facilities proposed in other elements of the comprehensive plan on water quality and the accumulation of contaminants in sediment; a description of how existing pollution problems can be remedied; and the identification of "the state, regional and local regulatory programs which will be used to maintain or improve estuarine environmental quality."[19] Some of the specific water quality-related objectives and policies that are required are given in Table A-3.

Table A-3
Water Quality-Related Objectives and Policies of the Comprehensive Coastal Management Element*

Objectives Shall Be Developed Which:

1. Protect, conserve, or enhance remaining coastal wetlands, living marine resources, coastal barriers, and wildlife habitat; and
2. Maintain or improve estuarine environmental quality.

Policies and the Identification of Regulatory or Management Techniques are Required for:

1. Limiting the specific impacts and cumulative impacts of development and redevelopment upon wetlands, water quality, water quantity, wildlife habitat, living marine resources, and beach and dune systems;
2. Restoration or enhancement of disturbed or degraded natural resources including beaches and dunes, estuaries, wetlands, and drainage systems and programs to mitigate future degradation;
3. Establishing priorities for shoreline land uses, providing for siting water-dependent and water-related uses, establishing performance standards for shoreline development, and establishing criteria for marina siting which address land use compatibility, protection of water, economic needs, and feasibility;
4. Protecting estuaries which are within the jurisdiction of more than one local government, including methods for coordinating with other local governments to ensure adequate sites for water-dependent uses, prevent estuarine pollution, and control surface water runoff; and
5. Demonstrating how the local government will coordinate with existing resource protection plans such as resource planning and management plans, aquatic preserve management plans, and estuarine sanctuary plans.

* Source: Fla. Admin. Code Ann. r. 9J-5.012(3)(b)-(c) (1986).

Besides land use planning activities, Florida has also adopted other programs to protect coastal waters.[20] Under the Save Our Coasts program, Florida has acquired more than 88,000 acres of sensitive coastal land.[21] Lands are chosen for acquisition by a selection committee composed of representatives from relevant state agencies, according to a set of criteria established by the state legislature.[22] Also, state funds cannot be used for constructing bridges or causeways to coastal barrier islands not already

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accessed by such structures, and the state is prohibited from allocating funds to expand local infrastructure unless this expansion is consistent with the coastal management element of the local plan.[23]

The State's Beach and Shore Preservation Act establishes Coastal Construction Control Lines (CCCLs) to prevent erosion and other damage to sandy beaches.[24] The CCCLs are delineated based on the 100-year storm surge. Construction on the seaward side of the line is strictly controlled (not prohibited) in terms of its potential to cause erosion based on tidal action, shoreline stability and other information.[25] Localities can administer the program through zoning and building codes which must be approved for this purpose by the State Department of Natural Resources (DNR), although DNR retains veto authority over exceptions granted by the locality.[26]

Another part of the Beach and Shore Preservation Act (added in a 1985 amendment) essentially prohibits all new construction in what is defined as the thirty-year erosion zone, which is based on the DNR projection of the seasonal high water line at the site thirty years after application of the permit.[27] As a compromise to property owners in this zone and to avoid claims of unconstitutional "takings" of private property, single-family dwellings can be built under certain restrictive conditions.[28] So far, these restrictions have not been challenged.[29]

A final restriction on building in coastal areas was added by the 1985 passage of the Coastal Zone Protection Act which established a coastal building zone where stringent construction standards must be utilized in sensitive coastal areas.[30] This zone is defined as the area from the high water line to a point 1500 feet landward of the CCCL for "high energy beaches" and to boundaries established for federal flood insurance purposes in other areas. Most natural islands can be covered completely by such a coastal zone.[31] Standards for locating, designing and building in these areas are contained in the state building code and the National Flood Insurance Program, and are supposed to be implemented by local governments using the local building code.[32] Because of the technical burden and expense that such an approach places on the local level, significant technical assistance and funding from the state are seen as essential to the

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success of the program.[33] This need, however, has a positive aspect. It brings together the two levels of government so that information on program strengths and weaknesses will be transferred across government levels.

Regulations recently adopted in Franklin County, Florida provide an example of what local governments can do to protect coastal waters. The county recently enacted an ordinance designed to protect coastal water quality by protecting wetlands and by guiding development and land use on adjacent lands to create a protective buffer zone.[34] The ordinance defines a Critical Shoreline District, which includes a Pollution Sensitive Segment (areas to protect important water resources from septic tank pollution) and a Critical Habitat Zone.[35] The district (all lands within 150 feet landward of county wetlands) is established for general purposes by land use maps, and is defined more precisely by the county planner for regulating individual parcels.[36]

Development in this critical area is controlled in a number of ways. The developer must obtain a permit which contains standards described in a development manual provided by the county.[37] In the Critical Habitat Zone, most development is prohibited.[38] Minimum development standards are also provided in the ordinance itself. These pertain to minimizing impervious surfaces, maintaining natural vegetation, locating and properly designing individual waste treatment systems, providing for stormwater management systems, and requiring infiltration BMPs and on-site retention and storage of stormwater.[39]

Inspections are also required for erosion and sediment controls, and the installation of underground storage tanks before they are covered; in addition, there must be a final inspection of all required stormwater management components which must be passed before a "certificate of occupancy" can be issued to allow use of the development.[40] The stormwater system must be maintained by the owner and inspected every year by the county.[41] Easements must be provided to allow the county to perform any necessary work that the owner is unwilling to carry out, in which case the county will place a lien on the property for the costs of the maintenance.[42] Permit applicants are charged a base fee of $100 with additional fees for multifamily or

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commercial development based on the number of dwelling units, square feet of structural development, or numbers of lots.[43]

Minnesota

The local planning process in Minnesota (described in Chapter Ten) requires significant information collection and program development activities before the State Board of Water and Soil Resources will approve the final comprehensive local water plan. The planning and institutional aspects are considered in Chapter Ten, while the following section discusses the substantive requirements for local plan approval.

Each local water plan must be developed using a set of general management guidelines. These are provided in Table A-4.[44]

Table A-4
Management Requirements for Preparation of Comprehensive Local Water Plans Under Minnesota Statutes Chapter 110B*

1. Significant upstream and down-stream effects on surface water, and up-gradient and down-gradient effects on groundwater, should be fully considered;
2. Natural water storage and retention systems should be preserved and used to the maximum extent practical;
3. Water management decisions should be based on sound data and technical analysis;
4. The interrelationship between surface and groundwater, land and water use, and quality and quantity of water should be recognized;
5. Potential variations in precipitation, both short-term and long-term, should be fully considered;
6. Potential cumulative effects of proposed actions should be considered;
7. Prevention of potential water and related land resources problems should be emphasized;
8. The overall quality of the environment should be protected or enhanced;
9. The total benefits of water programs and projects should exceed the total costs;
10. Water management programs should be adequately funded to achieve high-priority objectives;
11. Comprehensive water planning should be coordinated with other related planning programs to fill management gaps and minimize duplication of effort;
12. Comprehensive approaches to identified problems and opportunities should be considered; and
13. Water conservation practices should be used to the maximum extent practicable.

* Source: Minn. Code Agency R. Ch.9300.0170, Subp.4 (1987).

In addition to management requirements, certain steps must be taken in order for the State Board of Soil and Water Resources to approve a plan. Table A-5 indicates the steps that should be followed in developing a water plan.

Table A-5
Steps in Developing
the Minnesota Comprehensive Local Water Plan*

1. Outline Preliminary Issues, Goals, Objectives
   a. Use public input
   b. Assess existing county plans
2. Collect Information
   a. About physical environment
   b. About surface water, groundwater, and related land resources
   c. About conflicts, issues, problems, opportunities
   d. About expected changes
   e. Compile plans and official controls of local units
   f. Gather plans and studies of regional, state, and federal agencies
3. Evaluate Information
   a. Assess resource information
   b. Define issues and opportunities
   c. Consider options
   d. Consider goals and objectives
4. Establish Goals, Objectives, and Actions
   a. Set goals
   b. Establish objectives to meet goals
   c. Develop priorities and action plan

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 15.

Plans must describe eight specific areas. The scope of a local water plan is given in Table A-6.

Table A-6
Scope of the Minnesota Comprehensive Local Water Plan*

1. The physical environment and expected changes to it;
2. Information about water and related land resources and their expected changes;
3. Objectives and actions to achieve these objectives;
4. Desired changes in state programs;
5. Conflicts with local governments;
6. Conflicts with other countries;
7. Plan implementation; and
8. An amendment procedure.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 16.

A great deal of specific information and a number of activities are necessary in order to prepare a water plan under the statute. For each specific requirement, the state planning agency has offered guidance as to the purpose of the requirement as well as specific names and phone numbers of individuals and agencies who can assist in obtaining or preparing the necessary information or plan component. The information required is given in Tables A-7 through A-11. In addition to the extensive information gathering requirements, the plan also must contain elements addressing problems and opportunities, goals, objectives and actions, as well as the plan's implementation program. These elements describe what the county wants to achieve and how it will accomplish these goals and objectives. Tables A-12 and A-13 indicate the major features of these planning elements.

Table A-7
Specific Contents of Minnesota Local Comprehensive Water Plan: Physical Environment, Land Use, and Development*

Precipitation:
1. A map or list of the location of precipitation gauging stations in the county;
2. A map showing isolines of normal annual total precipitation in inches;
3. A map showing isolines of normal total precipitation in inches for the period May through September.

Geology and Water Resources:
1. A map or description of important aquifer systems, confining layers, and flow characteristics to the extent known;
2. A description of ground and surface water interconnections, such as recharge and discharge areas, where they are known;
3. A map of boundaries and flow directions of watershed units and minor watershed units;
4. A map of state protected waters and public drainage ditches, including the location of any existing dams and control structure.

Soils:
1. A general soils map and description of soils infiltration characteristics; and
2. A map of erosion-prone soils.

A Map of Original Vegetation:

A Description of General Topographic Relief of Watershed Units Based on USGS Topographic Maps:

Land Use and Public Utility Services:
1. A general map of existing land uses;
2. A map showing the areas served by storm sewers, sanitary sewers, and public water systems; and
3. A map or list by geographic indicator showing the location of community public water supply intakes and wells.

Land Ownership:
1. A map showing the ownership of local, state, federal, and Indian tribal lands; and

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2. A map showing lands with easements that relate to water resources, where that information is available.

Identification of Expected Changes to Land Use and Cover, Public Utility Services, and Other Changes Potentially Affecting Water Resources.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 23-34.

Table A-8
Water Quantity*

Surface Water Quantity:

1. A description of high, mean, and low flows on streams;
2. A list of lakes where the state has established ordinary high water marks;
3. A list of permanent withdrawals from lakes and streams, including the location by geographic indicator, source, use and amounts withdrawn;
4. A list of lakes and streams in the county for which state protected levels or flows have been established;
5. A description of known water use conflicts, including those caused by groundwater pumping that affects surface water; and
6. The implications of surface water quantity.

Groundwater Quantity:

1. A list of wells covered by state appropriation permits, including the location by geographic indicator, amounts of water appropriated, type of uses, and aquifer source;
2. A description of known well interference problems and water use conflicts;
3. A list of state observation wells located in the county including geographic indicator, unique well number, aquifers measured, years of record and average monthly levels; and
4. The implications of groundwater quantity information for present and future water and land uses and an assessment of those implications.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 37-69.0

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Table A-9
Water Quality*

Surface Water Quality:

1. A map or list of the state water quality management classifications for each stream and lake;
2. A summary of available lake and stream water quality monitoring data (examples include);
   a. Bacteriological contamination indicators,
   b. Inorganic chemicals,
   c. Organic chemicals,
   d. Sedimentation,
   e. Dissolved oxygen, and
   f. Excessive growth or deficiency of aquatic plants;
3. A summary of information from informal sources relating to surface water quality, such as fish kills; and
4. The implications of surface water quality information for present and future water and land use, and an assessment of those implications.

Groundwater Quality:

1. Summary of available water quality data, including routinely monitored sites; and
2. The implications of groundwater quality information for present and future water and land uses with emphasis on those with potential health-related impacts and an assessment of those implications (where possible, the information required in this item should be presented by aquifer system and geographic area).

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 37-69.

Table A-10
Special Land Uses and Conditions*

Eroding Lands:

1. A description or map by watershed unit of areas where eroding lands are causing sedimentation problems;
2. Water quality and quantity implications for watercourses, water basins, ditches, and wetlands of sedimentation and an assessment of those implications; and

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3. An assessment by watershed unit of the effects of land use and cover on quantity and quality of runoff.

Irrigation:

1. A map or list by geographic indicator of irrigated acreage; and
2. For any county containing more than 1,000 acres of irrigated land in any one township, the implications of irrigation for present and future lands and water use and an assessment of those implications.

Drainage:

1. A table listing the public drainage systems in the county and the amounts expended, by year, for repair work on each system;
2. An assessment of any significant water quality and quantity effects due to public or private ditch systems; and
3. A summary of any known water quality and quantity information from engineering reports and modelling efforts on ditches in the county.

Pollution Sources:

1. A map or list by geographic indicator of known closed and operating sanitary landfills, closed and operating open dumps, and Minnesota Superfund hazardous waste sites and a summary of available water quality information relating to these sites;
2. A map or list by geographic indicator of feedlots, abandoned wells not sealed in accordance with state statutes and rules, underground storage tank sites, and permitted wastewater discharges under Chapter 701, and a summary of available water quality information relating to these sites;
3. A list by geographic indicator of facilities that have hazardous waste generator identification numbers; and
4. The implications of pollutant sources for present and future water and land uses and an assessment of those implications.

Special Geologic Conditions:

1. A map of known geologic conditions, such as karst areas, buried valleys, or sand plains that may pose concerns relating to water quality or quantity; and
2. The implication of special conditions for present and future water and land uses and an assessment of those implications.

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* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 37-69.

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Table A-11
Related Land Resources*

Wetlands:

1. Maps of wetlands identified under the National Wetlands Inventory, where available;
2. A summary of plans for wetlands with controlled outlets, such as plans for draw-downs;
3. A description of the United States Army Corps of Engineers, Section 404 permit requirements affecting county waters; and
4. The implications of wetlands for present and future water uses with special consideration for water quality, flood attenuation, wildlife, and recreation, and an assessment of those implications.

Floodplains:

1. A map showing those areas delineated as floodplain by existing local ordinances or in proposed ordinances that have a due date established by the Minnesota Department of Natural Resources or the Federal Emergency Management Agency;
2. A map of areas with known flooding problems;
3. An estimate of average annual flood damages, if available; and
4. An assessment of the adequacy and enforcement of existing floodplain ordinances.

Shorelands:

1. A list of local units of government with unapproved shoreland ordinances;
2. A list of protected waters, and their shoreland classifications under Minnesota Statutes, section 105.485; and
3. An assessment of the adequacy and enforcement of the shoreland ordinances.

Water-based Recreation Lands:

1. A map and description of water-oriented recreation resources listed in the State Comprehensive Outdoor Recreation Plan;
2. A map of public water accesses;
3. A map and description of state or federally designated wild and scenic rivers and state designated canoe and boating routes; and
4. An assessment of the adequacy of water-based recreational lands for present and future use.

Fish and Wildlife Habitat:

1. A map and description of any state designated wildlife management areas and any lakes with state designated classifications for game or fish management within the county;
2. A map and description of any state designated trout lakes or trout streams within the county;
3. A list and description of the state ecological and management classifications and use attainability for lakes and streams, where available;

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4. A list and description of the conclusions and recommendations of biological surveys on reconnaissance studies, where available;
5. A description of state management plans for fish and wildlife areas, where available; and
6. An assessment of the adequacy of fish and wildlife habitat for present and future use.

Unique Features and Scenic Areas:

1. A map or description of unique features and scenic areas with relationships to water including state designated natural and scientific areas, areas containing county, state, and federal rare and endangered species, and other features such as waterfalls, springs, and historic mills; and
2. The implications of unique features and scenic areas for present and future water and land use, and an assessment of those implications of these planning elements.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 37-69.

Table A-12
Problems and Opportunities; Goals; Objectives and Actions*

Identify Problems and Opportunities: For each watershed unit and groundwater system, where appropriate, the comprehensive water plan must identify any issues relating to water quality, quantity, special land uses and conditions, and related land resources. The plan must discuss assets or opportunities, as well as problems associated with each issue. At a minimum, a county must gather information about water-related problems and opportunities in the following manner:

1. Investigate those problems and opportunities disclosed at public meetings and in written comments;
2. Investigate those problems and opportunities that affected local units of government want to be examined;
3. Assess the information gathered in Tables A-7 through A-11; and
4. Assess the status and adequacy of official controls, plans, and other local, state, or federal programs concerning water and related land resources.

Establish County Goals: The plan must state goals for present and future water and land uses to set the framework for determining plan objectives and related actions.

Establish Objectives and Action Plan: The plan must state measurable objectives and a plan of action addressing the identified problems and opportunities for each watershed unit and groundwater system, where appropriate, for each of the following categories:

1. Opportunities and problems in surface and groundwater quality and quality;
2. Opportunities and problems associated with significant special land uses and conditions that influence water quantity and quality; and
3. Opportunities and problems associated with related land resources.

Establish Priorities:

1. The county must state priorities in the plan of action relating to water quality, water quantity, special land uses or conditions that influence water quality and quantity, and related land resources.
2. The plan must reflect the urgency of the problem or opportunity identified.
3. The plan must describe those actions that will be taken by the county alone, and those actions that will require the cooperation of other local units of government or state and federal agencies, and must state whether the county board has received commitments for that cooperation.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 71-73.

Table A-13
Implementation Program*

1. The plan must state how and when the plan will be implemented to meet the objectives and carry out the actions identified in Table 15.
2. The implementation program may include data collection programs, educational programs, capital improvement projects, project feasibility studies, enforcement strategies, amendments to existing official controls, adoption of new official controls, etc. If no action is to be taken to address identified problems or opportunities, the plan must explain why actions are not needed.
3. Necessary staff and financial resources needed to carry out the plan must be stated.
4. The plan must state the time in which each of the actions contained in the implementation program will be taken.
5. If a county has made an agreement for the implementation of the plan (or portions of the plan) by a local unit of government within the county, that local unit must be specified, the responsibility indicated, and a description included as to how and when the implementation will happen.
6. If capital improvement projects are proposed to implement the comprehensive water plans, the project must be described in the

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plan. This description must include the following information:

a. the physical components of the project, including their approximate size, configuration and location;
b. the purposes of the project and their relationship to the objectives of the comprehensive plan;
c. the proposed schedule for project construction;
d. expected federal, state and local costs;
e. the types of financing proposed, such as special assessments, ad valorem taxes, and grants; and
f. the sources of local financing proposed for the project, such as subcounty, countywide, or multicounty.

* Source: Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987, at 77-81.

Long Island

The Long Island Regional Planning Board (LIRPB) evaluated the land use planning aspects of the counties and townships of Long Island to assess their water quality implications.[45] Many problems were identified in this evaluation that might be useful to state and local officials involved in NPS management activities. These include the observations listed in Table A-14.

Table A-14
Problems Identified in Long Island's Local Land Use Planning Activities[1]

1. Localities fail to consider groundwater and surface water in the site plan review process.
   a. Localities do not revise zoning and other ordinances (the basis of the site plan review process) to reflect water quality considerations in the comprehensive plan, and do not update zoning maps to reflect this water quality.
   b. Localities do not address the long-range, cumulative impacts of individual projects affecting water quality in small geographic areas.
   c. Localities fail to delegate power adequately to the reviewing agency to consider water quality issues by:

(1) not explicitly authorizing the use of the police power for water quality protection;

(2) not identifying critical water resources in zoning ordinances;

(3) not precluding many activities associated with water pollution in critical areas;

(4) not providing for proper enforcement of ordinances through the use of large enough fines, applicable to repeat violations, by both the site owner and the developer; and

(5) not developing ordinances prohibiting land clearing before the site plan has been approved.

d. Site plan ordinances are often too rigid and uniform and do not provide for flexibility to allow, for example, varying setback requirements to tailor requirements to the characteristics of the site and, in zoning coverage requirements, to take account of such constraints as steep slopes.

2. Zoning Boards of Appeals often do not have zoning variance procedures that:

a. utilize water resources protection criteria;

b. provide for coordination with planning boards; or

c. provide the information necessary to determine if the variance is compatible with state and county water quality, hazardous waste, building code, and sanitary rules and regulations.

3. The subdivision review process is often flawed because:

a. commercial and industrial subdivision plans are filed but not reviewed, municipalities waive the filing requirement for subdivisions of fewer than five lots;

b. ordinances do not include the authority to mandate clustering, and when this authority is available, it is often not utilized in sensitive areas; and

c. the design standards of some subdivision ordinances are outdated and do not provide for the maintenance of a site's existing topography, vegetation or natural drainage patterns.

4. Planning boards and zoning boards of appeals sometimes approve projects that do not meet federal, state and county laws.

5. Planning boards may grant preliminary approval of a subdivision before all required permits have been obtained and may act before receiving recommendations from citizen advisory committees or conservation advisory boards.

6. Some municipalities do not review site plans for single family homes in critical areas because the areas have not been identified and available information on how to protect these areas has not been utilized.

7. Plans are sometimes approved that are poorly designed, incomplete, or misleading; and some impacts are not taken into account because responsibilities are fragmented and coordination between departments is poor.

8. Site plan and subdivision review departments are sometimes understaffed and lack environmentally trained personnel.

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9. An established procedure for the routine collection and exchange of information between departments is often lacking; technical reviewers often function only in an advisory role; and developers often submit incomplete information on subdivisions and site plans which results in fragmented, time-consuming attempts to obtain the missing data.
10. Building permits are sometimes issued without incorporating mitigation techniques prescribed in the site plan.
11. Site owners are often allowed to sign forms stating that compliance with the site plan will occur in the future, making subsequent enforcement difficult.
12. Conservation easements are sometimes not officially recorded, making future enforcement of the covenant difficult.
13. The State Environmental Quality Review Act (SEQRA),[2] is considered by many local officials to be the most effective way to mitigate environmental impacts not covered by specific legislation and regulations; however, the coordination needed to carry out the SEQRA process is often lacking because local officials often do not have the capability or willingness to utilize the SEQRA and site plan review process fully.

[1] Source: Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, Hauppauge, New York, 1984, at 35-40 (Site Plan Review).

[2] The New York State Environmental Quality Review Act is a state law requiring compliance by all county and local agencies and the review of actions that may have a significant impact on the environment. Type I actions are those that can be expected to have significant impact on the environment and require the submission of an Environmental Assessment Form (EAF) and may require an Environmental Impact Statement. Type II actions are those actions expected to have little if any impact on the environment. Localities may identify Critical Environmental Areas which designate all development within the area a Type I action. *Id.* at 15 (Land Use).

Tables A-15 and A-16 describe the recommendations developed by the Long Island Regional Planning Board (LIRPB) for localities to use in improving the water quality protection aspects of their local land use planning tools. The Board evaluated the land use planning aspects of the counties and townships of Long Island. Many problems were identified in this evaluation.

Table A-15
LIRPB Recommendations for Land Use Controls Designed to Protect Water Quality*

1. County health departments should identify non-polluting industries to assist municipalities in decisions regarding which industries to allow in critical recharge areas and other sensitive areas in their planning, zoning, site plan and building permit review processes.
2. Counties should "develop, enact, and enforce" controls to reduce surface water and groundwater pollution from land use activities in Special Groundwater and Special Surface Water Protection Areas, additional recharge areas with high quality groundwater, and areas where nitrate concentrations "are approaching six mg/l, or organic concentrations are increasing and where additional development at the present zoning densities and/or types may be expected to cause ambient groundwater concentrations or the potable water supply to exceed groundwater quality standards."
3. Municipalities should design and adopt revisions to comprehensive plans to protect water resources incorporating the following goals and objectives:
   a. limit development (especially industrial uses) in deep recharge and critical shallow recharge areas;
   b. high density, commercial and industrial land uses should be concentrated in existing high density, commercial and industrial areas, in areas downgradient of critical groundwater recharge areas and within existing contaminant plumes;
   c. in relatively undeveloped portions of recharge areas and in areas where current groundwater usage may result in saltwater intrusion, stream flow reduction, or wetlands destruction, decrease permitted residential densities of two to ten units per acre to one unit or less per acre or open space;
   d. limit the removal of natural vegetation and the creation of lawns in critical environmental areas;
   e. include the following development guidelines in the zoning and subdivision ordinances and site plan review process:
      (1) allow development that is consistent with existing land use patterns;
      (2) use state environmental laws, county health codes, local regulations, zoning requirements and performance standards to prevent or minimize environmental impacts;
      (3) require nitrogen removal systems for septic systems;
      (4) prevent any direct discharge of stormwater or commercial or residential wastes or products to surface waters;
      (5) require development to be connected to sewage treatment plants; and
      (6) require site development and operational controls, and monitoring and enforcement requirements for industrial uses in special protection districts.

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4. Municipalities should consider the establishment of Special Groundwater Protection Areas that would comprise relatively undeveloped deep recharge areas or shallow recharge areas underlain by saltwater which would require comprehensive and coordinated state, county and town management to maintain water quality. Individual municipalities should review boundaries and recommend modifications, undertake the planning, legislative and administrative actions necessary to manage the resource, and incorporate the district designations and policies into local land use, taxation and capital improvement programs. Areas have been defined based on one or more of the following:
   a. relatively undeveloped groundwater recharge areas where withdrawals have occurred or are likely to occur;
   b. areas underlain by relatively high quality aquifers where contamination is likely if the areas are developed according to existing zoning; and
   c. areas where extensive groundwater contamination limits or can be expected to limit the potable water supply.
5. Municipalities should also consider the establishment of Special Surface Water Management Areas comprising watersheds necessary to maintain high quality surface waters to provide the rationale for the imposition of controls necessary in areas subject to future development. These controls could be in the form of performance standards and development guidelines.
6. Municipalities should revise local zoning ordinances to reflect the changes described above. The following changes are suggested:
   a. Modify use designations and zoning boundaries.
   b. Establish special overlay districts for deep aquifer recharge areas and Special Groundwater or Surface Water Protection Areas precluding intensive uses except where adequate performance standards can be met.
   c. Require environmental assessments for any changes in zoning allowing for more intensive land uses.
   d. Enact mandatory clustering and site plan review provisions as a part of zoning/subdivision regulations with appropriate criteria and standards for preserving surface water and groundwater resources.
   e. Revise zoning ordinances to establish stringent performance standards, including those covering the development and operation of industrial activities.
7. Municipalities should enact site plan review regulations as part of their zoning ordinance and site clearance requirements as part of their subdivision regulations. Site clearance permits and the preservation of natural vegetation to minimize land clearing, lawn areas and golf courses in critical environmental areas should be required.
8. Municipalities should require the dedication of conservation easements as part of the site plan review process and subdivision regulations for new development in critical environmental areas. Easements should include buffer zones of a minimum distance of

50 feet from river, stream, lake or pond banks in undeveloped or partially developed lands adjacent to surface waters.

* Source: Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, Hauppauge, New York, 1984, at 18-23 (Land Use).

Table A-16
LIRPB Recommendations to Improve the Water Quality Protection Aspects of the Site Plan and Subdivision Review Process*

1. Municipalities should consider expanding the site plan review process to include the consideration of groundwater and surface water impacts (including cumulative impacts).
   a. Municipal codes should require the consideration of groundwater (surface water) protection as a reason for the use of the police power.
   b. Consistent regulations to control nitrate loadings should be developed, including the use of estimated nitrate loadings to establish permissible densities and taking into account the contribution of septic systems (LIRPB recommends that nitrate levels in developed areas not exceed 6 mg/l or 2 to 3 mg/l for partially developed or undeveloped aquifer recharge areas, or Special Groundwater Protection Areas).
   c. Local site plan review ordinances should provide specific legal authority to consider groundwater and surface water protection in the site plan review process.
   d. Zoning and other ordinances should be revised to assure consistency with the comprehensive plan, which should reflect the guidelines of 208 Waste Treatment Management Plans, including the consideration of land use densities in sewered and nonsewered areas, as well as cumulative impacts.
   e. In critical areas, specific zoning categories not compatible with the high quality recharge (or surface water) area should be identified. Zoning ordinances should adopt appropriate performance standards and be amended to prohibit or restrict incompatible land uses.
   f. Municipalities should adopt site clearance permit ordinances to prevent clearing road rights-of-way or the whole site prior to site plan approval.
   g. Zoning ordinances should be amended to allow site plan reviewers to modify existing criteria and standards, when necessary, to require appropriate water quality protection measures (*e.g.*, vary set back requirements, revise lot coverage requirements) or to utilize new information needed to maintain

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the environmental objectives of the site plan review process.

h. Environmental ordinances should be reviewed to ensure that adequate fines are provided violators, as well as fines applicable to repeat offenders and to both the developer and site owner.

i. Local ordinances should be developed to incorporate performance standards to address the cumulative impacts of NPS loadings.

2. When considering changes in zoning, potential impacts on water quality should be considered by requiring a site plan and an Environmental Assessment Form for any changes proposed in a critical area and that any developer proposing a zoning change in the area be required to present evidence that the change will not result in increased groundwater (or surface water) contamination.

   a. The Zoning Board of Appeals (ZBA) should be prohibited from granting zoning variances in conflict with groundwater or surface water protection objectives, policies, etc.

   b. Local Planning and Environmental Agencies should advise zoning board members whether or not a proposed development is compatible with groundwater (or surface water) needs.

   c. Coordination between the ZBA and the planning board and other agencies should be improved; the ZBA should submit all variance applications affecting critical areas to the planning board for review and comment.

3. Review of commercial and industrial subdivisions should be required by law. Subdivisions of fewer than five lots should be reviewed. Outdated subdivision design standards should be reviewed and modified, if necessary, to provide adequate water quality protection, including provisions to maintain existing topography, drainage and vegetation.

4. Localities should begin the SEQRA process when the site plan review process begins and measures should be taken to ensure than the site plan conforms with any measure stipulated or otherwise indicated in the Environmental Impact Statement process.

Source: Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, Hauppauge, New York, 1984, at 42-65 (Site Plan Review). Where appropriate, additions to LIRPB recommendation are made to include the consideration of surface water quality by including (surface water) beside references to groundwater.

The LIRPB also evaluated stormwater management activities in the area and developed the recommendations for state and local stormwater management programs presented in Table A-17.

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Table A-17
LIRPB Recommendations to Improve State and Local Stormwater Management*

1. Limit development and the establishment of impermeable paving on publicly-owned lands located near surface waters and wetlands.
2. Prohibit any new direct discharge of stormwater into surface waters, freshwater or tidal wetlands. Use appropriate control measures for areas near surface waters.
3. Evaluate existing stormwater systems that currently discharge into surface water to determine whether systems can be modified to include additional control measures to minimize impacts upon surface waters and adjacent areas.
   a. Inventory direct discharges and assign remediation priority ratings based upon environmental impacts.
   b. Determine if there is sufficient land area to develop cost feasible energy dissipation areas, and sediment basins or retention areas to eliminate or reduce the direct discharge and accompanying sediment loadings into surface waters and wetlands, or to reduce peak runoff flows before discharge.
4. Acquire and maintain those streambeds and the surrounding watershed areas that have dried up due to sewering. The retention of these areas will facilitate the recharge of runoff, thus reducing the amount of streamflow following a storm and the subsequent high coliform loadings that would otherwise reach the bays.
5. Do not remove recharge basin vegetation since plant growth generally enhances infiltration. The root systems keep the soil layer loose and permeable and provide for the infiltration of water.
6. Amend local zoning ordinances to include a requirement for the establishment of adequate setbacks, 100 feet from the shoreline for areas adjacent to the edge of lakes, ponds, streams, rivers, bays, wetlands and in areas where the depth to seasonal high water table is less than three feet. Such areas should not be cleared of native vegetation except for cat briar, honeysuckle and other destructive vines. Any stormwater runoff generated from the site development upland and discharged into these areas should be discharged at a release rate that shall not exceed the stormwater runoff rate from the area in its natural state and discharged in manner so that no erosion and loss of vegetation occurs.
7. Require adherence to the following performance standards for all new site development:
   a. Protect and maintain the natural functioning of the site by maintaining the absorptive, purifying and retentive functions that existed on the site before construction began.
   b. Limit the post-construction volume and rate of runoff leaving the site to that calculated on the basis of natural or predevelopment conditions. The peak release rate of stormwater from all developments where retention is required for the designed

storm, should not exceed the peak stormwater runoff from the area in its undeveloped state for a storm of any intensity up to and including the 100 year frequency, and for rainfall during any duration. Calculations of the rate should be based upon an assumed runoff coefficient of 0.20, 0.25, and 0.35 for average slopes of 2 percent, 2-7 percent and over 7 percent respectively.

c. Design the drainage system so that the runoff release rate from natural drainage channels will not exceed the natural carrying capacity of the channel.

d. Limit the release rate for drainage systems serving new development. The volume and velocity of runoff discharge should not exceed the safe capacity of the existing drainage systems into which the discharge flows.

8. Require a stormwater management plan for any property when
   a. a plat is to be recorded.
   b. land is to be subdivided.
   c. an existing drainage system may require alteration.
   d. new development is proposed for more than one residential unit on a given plat.
   e. new development for any use other than single family residence is proposed.
   f. the rate or volume of runoff will be significantly increased.
   g. on-site water drains to a pond, stream or other surface water body or to a wetland.

Source: Koppelman, Lee E., Edith Tanenbaum and Carole Swick, *Nonpoint Source Management Handbook*, Long Island Regional Planning Board, Hauppauge, New York, 1984, at 29-31 (Stormwater Runoff).

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Notes - Appendix

1. Unless otherwise noted, the tables in this section are either taken directly from the relevant portions of the regulations or paraphrased.

2. Fla. Admin. Code 9J-5 (1986) defines "cone of influence" as "an area around one or more major waterwells the boundary of which is determined by the government agency having specific statutory authority to make such a determination based on groundwater travel or drawdown depth." Fla. Admin. Code 9J-5.003(18) (1986).

3. Fla. Admin. Code 9J-5.006(1)(a) (1986).

4. Fla. Admin. Code 9J-5.006(3)(b)(1) (1986).

5. Fla. Admin. Code 9J-5.006(3)(c)(6) (1986).

6. Fla. Admin. Code 9J-5.009(3)(c) (1986).

7. Fla. Admin. Code 9J-5.011(1)(f) (1986).

8. *See* Fla. Stat. § 186 *et seq.* (1985); Fla. Stat. § 187 *et seq.* (1985); Fla. Stat. § 163 *et seq.* (1985).

9. *See* Christie, Donna R., "Growth Management in Florida: Focus on the Coast," 3 *J. Land Use & Envtl. L.* 34-37 (1987).

10. *See generally* Fla. Stat. § 186 *et seq.* (1985).

11. Fla. Stat. § 187.201(9) (1985).

12. Fla. Stat. §§ 186.021-022 (1985); Keith M. McCannon, Florida Department of Community Affairs, March 21, 1988 (personal conversation).

13. Fla. Stat. § 186.508 (1985).

14. *See* Fla. Stat. §§ 186.502-515 (1985); Fla. Stat. § 380.06(12) (1985).

15. Fla. Admin. Code 9J-5.012(2)(d) (1986).

16. Fla. Stat. § 163.3178(1) (Supp. 1986). The requirements for the preparation of local coastal management elements are discussed below.

17. Fla. Stat. §§ 163.3177(6)(g)(1)-(10) (Supp. 1986).

18. Fla. Admin. Code 9J-5.012(2)(d) (1986).

19. Fla. Admin. Code 9J-5.012(2)(d) (1986).

20. The following discussion (notes 24-36) is based on the article cited in Christie, 1987, *supra* note 11, at 33-51.

21. *Id.* at 41-42.

22. *Id.*

23. *Id.* at 42.

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24. *Id.* at 42-43.

25. *Id.* at 43.

26. *Id.* at 43-44.

27. *Id.* at 44-45.

28. *Id.*

29. *Id.* at 45-46.

30. *Id.* at 46-47.

31. *Id.* at 47.

32. *Id.* at 47-48.

33. *Id.* at 48-49.

34. Franklin County, Florida, Ordinance No. 87-1, *Ordinance Defining and Regulating the Critical Shoreline District of Franklin County, and Adopting Maps of the Pollution Sensitive Segment Thereof*, 1987, at 1.

35. *See generally* Ordinance 87-1.

36. Ordinance 87-1(IV).

37. Ordinance 87-1(V)(1).

38. Ordinance 87-1 (V)(2).

39. Ordinance 87-1 (VI)(1-5).

40. Ordinance 87-1 (VII).

41. Ordinance 87-1 (VIII).

42. Ordinance 87-1 (VIII).

43. Ordinance 87-1 (Exhibit A).

44. The tables provided in this section are quoted or paraphrased from Minnesota State Planning Agency, *The Handbook for Comprehensive Local Water Planning Under Minnesota Statutes, Chapter 110B*, November, 1987.

45. Urban poison runoff control programs on Long Island are addressed in Chapter Four.

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